APPENDIX J

Matters of National Environmental Significance

Part 1 of 3

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

IR_1536

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Inland Rail Gowrie to Helidon EIS

Appendix J – Matters of National Environmental Significance Technical Report

Australian Rail Track Corporation

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Contents

1 **Introduction** 1

1.1 Project overview and objectives 1
1.2 Project objectives 2
1.3 Proponent 3
1.4 Scope and purpose 4
1.4.1 This report 5
1.4.2 Study area 5
1.5 Terms of reference 8
1.6 Project location and existing land use 13
1.6.1 Project alignment 14
1.7 Consequences of not proceeding with Inland Rail 15
1.7.1 Consequences of not proceeding with the Gowrie to Helidon Project 16
1.8 Project alternatives 16
1.8.1 Alternative locations and route options for Inland Rail 16
1.8.2 Alternative locations and route options for the Project 19
1.9 Project description 22
1.10 Timing 24
1.11 Design 25
1.11.1 Rail corridor 25
1.11.2 Land requirements 25
1.11.3 Tunnel infrastructure 26
1.11.4 Crossing loops 28
1.11.5 Connections 28
1.11.6 Bridges and viaducts 28
1.11.7 Drainage infrastructure 29
1.11.8 Rail interfaces 30
1.11.9 Road rail interfaces 30
1.11.10 Road network changes 31
1.11.11 Rail maintenance access road 31
1.11.12 Utility/service crossings 32
1.11.13 Fencing 32
1.12 Pre-construction phase 32
1.12.1 Ongoing activities 33
1.12.2 Early works activities 34
1.12.3 Enabling works 34
1.13 Construction 34
1.13.1 Construction schedule 35
1.13.2 Site preparation 37
1.13.3 Civil works 38
1.13.4 Tunnel construction 39
1.13.5 Commissioning and reinstatement phase 43
1.14 Operational phase 43
1.14.1 Hours of operation 43
1.14.2 Workforce 44
1.14.3 Tunnel operations 44
1.15 Decommissioning 46

1.16 Social and economic benefits 47
1.16.1 Social benefits 47
1.16.2 Economics benefits 48
1.17 Stakeholder engagement 49
1.17.1 Identification of stakeholders 49
1.17.2 Stakeholder engagement activities 53
1.17.3 Consultation themes 53
1.17.4 Consultation outcomes 54
1.18 Principles of ecologically sustainable development 56
1.18.1 Precautionary principle 56
1.18.2 Intergenerational equity 57
1.18.3 Conservation of biological diversity and ecological integrity 58
1.18.4 Improved valuation, pricing and incentive mechanisms 58

2 Legislation and policy 60
3 Assessment methodology 66
3.1 Overview 66
3.2 Desktop study 68
3.2.1 Database review 68
3.2.2 Review of existing literature and previous studies 69
3.2.3 Assessment of the likelihood of occurrence of threatened MNES species 71
3.2.4 Predictive habitat modelling for threatened flora and fauna species 72
3.2.5 Mapping of threatened ecological communities 75
3.3 Field assessments 77
3.3.1 Field assessment locations and timing 78
3.3.2 Matters of national environmental significance 87
3.3.3 Permits to conduct works 92
3.3.4 Quality assurance/quality control 92
3.3.5 Nomenclature 93
3.4 Impact assessment methodology 93
3.4.1 Magnitude of impacts 94
3.4.2 Sensitivity 94
3.4.3 Initial assessment of the significance of total impact 95
3.4.4 Assessment of the significance of impact against matters of national environmental significance significant impact guidelines 97
3.5 Cumulative impact assessment methodology 97
3.5.1 Project selection 97
3.5.2 Approach 103
3.5.3 Assessment matrix 103

4 Description of environmental values 105
4.1 Content of this section 105
4.2 Regional and local context 105
4.2.1 Topography and geology 106
4.2.2 Surface water catchment values 107
4.2.3 Groundwater values 108
4.3 Results of desktop study 108
4.3.1 Flora 109
4.3.2 Fauna 113
4.4 Existing environment 118
4.4.1 Flora 118

4.4.2 Fauna 123
4.4.3 Predicted habitat for threatened flora and fauna species 126
4.4.4 Flora and fauna habitat located within the matters of national environmental significance study area 131
4.5 Matters of national environmental significance values and matters of national environmental significance 141
4.5.1 Ecological values 141
4.5.2 Matters of national environmental significance 142

5 Potential impacts and impact mitigation 144
5.1 Description of potential impacts 144
5.1.1 Project activities 144
5.1.2 Potential impacts to matters of national environmental significance 146
5.1.3 Assessment of potential impacts to matters of national environmental significance associated with air quality, surface water and hydrology, groundwater, and noise and vibration 158
5.2 Impact mitigation 163
5.2.1 Design considerations 163
5.2.2 Proposed mitigation measures 164
5.3 Significant impact assessment 183
5.3.1 Quantification of potential magnitude of impacts 183
5.3.2 Initial assessment of impacts and mitigation measures 185
5.3.3 Significant residual impact assessment for threatened ecological communities 221
5.3.4 Significant residual impact for threatened flora 226
5.3.5 Significant impact assessment for threatened fauna 262
5.4 Biodiversity offsets for significant residual impacts 335

6 Commitments 338
7 Cumulative impact assessment 339
8 Conclusion 346
8.1 Post primary approval 348

9 References 349

Appendices

Appendix A
Predicted habitat modelling methodology

Appendix B
Species and Community Profiles

Appendix C
Herbarium Confirmation Letter

Appendix D
Database Search Results

Appendix E
Flora Species List

Appendix F

Fauna Species List

Appendix G

Predicted Habitat Mapping

Appendix H

Completed Vegetation and Fauna Assessment Proformas

Appendix I

Environmental Offset Delivery Strategy - Qld

Figures

Figure 1.1 The Melbourne to Brisbane Inland Rail Route
Figure 1.2 Location of Project and regional extent and MNES study area
Figure 1.3 Inland Rail alignment Gowrie to Grandchester - 2003 and 2010 options
Figure 1.4 Conceptual tunnel cross section sketch through the Toowoomba Range
Figure 1.5 Typical sectional diagram of rail formation showing rail maintenance access track
Figure 1.6 Schematic of the proposed western tunnel portal, with a train entering the ventilation building
Figure 3.1 Assessment methodology
Figure 3.2a-c Location of areas sampled as part of historic and concurrent works
Figure 3.3a-c Location of sampling locations within the MNES study area
Figure 3.4 Location of projects that have been included in the cumulative impacts assessment area
Figure 4.1 Topographical cross-section of G2H tunnel from eastern to western portal
Figure 4.2 Location of specimen backed records of MNES significant flora species derived from desktop assessments
Figure 4.3 Location of specimen backed records of MNES significant fauna species derived from desktop assessments
Figure 4.4 Locations of observed MNES significant flora species within the MNES study area
Figure 4.5 Extent of Threatened Ecological Communities within the MNES study area
Figure 4.6 Locations of observed threatened fauna within the MNES study area
Figure 4.7a-b Location of habitat types contained within the MNES study area

Tables

Table 1.1 Terms of Reference compliance relevant to matters of national environmental significance
Table 1.2 Key features of the Project
Table 1.3 Anticipated timing of Project phases
Table 1.4 Summary of rail bridges and viaducts
Table 1.5 Indicative construction program
Table 1.6 Identified stakeholders associated with the project
Table 1.7 Key themes raised during Project consultation activities
Table 1.8 Key consultation outcomes
Table 2.1 Commonwealth legislation and policies relevant to the Project
Table 3.1 Database review summary
Table 3.2 Assessments and reports providing ecological information for areas associated with the Project
Table 3.3 EPBC Act listed threatened ecological community assumptions used to map areas of occurrence within the matters of national environmental significance study area
Table 3.4 Timing of field investigations undertaken associated with the Project used to supplement results of the current study
Table 3.5 Field survey sites and date of assessment
Table 3.6 Criteria for magnitude

Table 3.7 Timeframes for duration terms
Table 3.8 Sensitivity criteria for sensitive values/receptors within the study area
Table 3.9 Significance assessment matrix
Table 3.10 Significance classifications
Table 3.11 Projects to be included in cumulative assessment
Table 3.12 Assessment matrix
Table 3.13 Impact significance
Table 4.1 Threatened flora species identified from database searches
Table 4.2 Threatened ecological communities identified within the matters of national environmental significance study area based on desktop mapping
Table 4.3 Threatened fauna species identified from database searches
Table 4.4 Extent of Threatened ecology communities identified within the matters of national environmental significance study area
Table 4.5 Predicted habitat for threatened flora and fauna species within the matters of national environmental significance study area
Table 4.6 Extent of flora and fauna habitat located within the matters of national environmental significance study area
Table 4.7 Identified terrestrial and aquatic ecology receptors within the matters of national environmental significance study area
Table 5.1 Description of Project related activities associated with Project delivery
Table 5.2 Assessment of potential impacts related to air quality, surface water and hydrology, groundwater, and noise and vibration upon the identified matters of national environmental significance
Table 5.3 Project impact mitigation and management measures
Table 5.4 Estimation of potential magnitude of disturbance for each of the matters of national environmental significance identified for the Project
Table 5.5 Initial impact assessment of the Project upon identified matters of national environmental significance – Threatened Ecological Communities
Table 5.6 Initial impact assessment of the Project upon identified matters of national environmental significance – threatened flora
Table 5.7 Initial impact assessment of the Project upon identified matters of national environmental significance – threatened fauna
Table 5.8 Assessment of the Lowland Rainforest of Subtropical Australia TEC against the EPBC Act matters of national environmental significance significant impact criteria for Critically Endangered Threatened Ecological Communities
Table 5.9 Assessment of the Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD TEC against the EPBC Act matters of national environmental significance significant impact criteria for Critically Endangered Threatened Ecological Communities
Table 5.10 Assessment of the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC against the EPBC Act matters of national environmental significance significant impact criteria for Critically Endangered Threatened Ecological Communities
Table 5.11 Summary of the results of the significant impact assessment for matters of national environmental significance flora species
Table 5.12 Assessment against the significant impact criteria: King blue-grass (*Dichanthium queenslandicum*)
Table 5.13 Assessment against the significant impact criteria: Wandering pepper-cress (*Lepidium peregrinum*)
Table 5.14 Assessment of status of vulnerable flora species population against matters of national environmental significance Guidelines criteria
Table 5.15 Assessment against the significant impact criteria - *Grevillea quadricauda*
Table 5.16 Assessment against the significant impact criteria – Blunt-leaved leionema
Table 5.17 Assessment against the significant impact criteria – *Paspalidium grandispiculatum*
Table 5.18 Assessment against the significant impact criteria – Hawkweed
Table 5.19 Assessment against the significant impact criteria – Austral cornflower

Table 5.20 Assessment against the significant impact criteria – Blotched sarcochilus
Table 5.21 Assessment against the significant impact criteria – Brush sophora
Table 5.22 Summary of the results of the significant impact assessment for matters of national environmental significance fauna species
Table 5.23 Assessment against the significant impact criteria – Regent honeyeater
Table 5.24 Assessment against the significant impact criteria – Australasian bittern
Table 5.25 Assessment against the significant impact criteria - *Calidris ferruginea*
Table 5.26 Assessment against the significant impact criteria – Swift parrot
Table 5.27 Assessment against the significant impact criteria – Australian painted snipe
Table 5.28 Assessment against the significant impact criteria - Spotted-tail quoll
Table 5.29 Assessment against the significant impact criteria – Condamine earless dragon
Table 5.30 Assessment of status of vulnerable fauna species population against Guideline criteria
Table 5.31 Assessment against the significant impact criteria - Collared delma
Table 5.32 Assessment against the significant impact criteria - Red goshawk
Table 5.33 Assessment against the significant impact criteria – Grey falcon
Table 5.34 Assessment against the significant impact criteria – Murray cod
Table 5.35 Assessment against the significant impact criteria: Greater glider
Table 5.36 Koala habitat assessment tool (DotE 2014) - Project area
Table 5.37 Assessment against the significant impact criteria - Koala
Table 5.38 Assessment against the significant impact criteria – Long-nosed potoroo
Table 5.39 Assessment against the significant impact criteria - New Holland mouse
Table 5.40 Matters of national environmental significance significant residual impact criteria – Grey-headed flying-fox
Table 5.41 Matters of national environmental significance significant residual impact criteria - Black-breasted button-quail
Table 5.42 Quantification of anticipated significant residual impacts to matters of national environmental significance
Table 7.1 Cumulative impact assessment of magnitude for ecological matters of national environmental significance
Table 7.2 Significance assessment of cumulative impacts within the cumulative impact area

Abbreviations

Abbreviation	Explanation
AoLA	Atlas of Living Australia
ARTC	Australian Rail Track Corporation Limited
AUSRIVAS	Australian River Assessment System
B2G	NSW/QLD Border to Gowrie Project
BAMM	Biodiversity Assessment and Mapping Methodology
Biosecurity Act	*Biosecurity Act 2014* (Qld)
BPA	Biodiversity Planning Assessment
CE	Critically Endangered
CEMP	Construction Environmental Management Plan
Cth	Commonwealth
DAF	Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and the Environment
DEHP	Department of Environment and Heritage Protection (former, now DES)
DELWP	Australian Department of Environment, Land, Water and Planning
DES	Department of Environment and Science
DEWHA	Department of the Environment, Water, Heritage and the Arts (former, now DAWE)
DNRME	Department of Natural Resources, Mines and Energy (former, now the Department of Resources)
DotE	Department of the Environment (former, now DAWE)
DotEE	Department of the Environment and Energy (former, now DAWE)
DSITI	Department of Science, Information Technology and Innovation (former, now DES)
E	Endangered
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994 (Qld)*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
FFJV	Future Freight Joint Venture
G	Ground stratum
G2H	Gowrie to Helidon
GDE	Groundwater Dependent Ecosystem
GDR	Great Dividing Range
GIS	Geographic Information System
H2C	Helidon to Calvert Project
ha	hectare
HES	High Ecological Significance
HVR	High Value Regrowth
IAS	Initial Advice Statement
Inland Rail	Melbourne to Brisbane Inland Rail
kg/m	kilogram/metre
km	kilometre
km^2	square kilometre

Abbreviation	Explanation
LC	Least concern
M	Migratory
m	metre
MPa	megapascals
mm	millimetre
MNES	matters of national environmental significance
NRM	Natural Resource Management
NSW	New South Wales
OC	Of Concern
PMST	Protected Matters Search Tool
Project	Gowrie to Helidon Project
QLD	Queensland
QR	Queensland Rail
RCBC	Reinforced concrete box culvert
RCP	Reinforced concrete pipe
RE	Regional Ecosystem
SDPWO Act	*State Development and Public Works Organisation Act 1971* (Qld)
SEQ	South East Queensland
SPP	State Planning Policy 2017
SPRAT	Species Profile and Threats database
tal	Total axle load
TBM	tunnel boring machine
TEC	Threatened Ecological Community
Threatened	Critically endangered, Endangered and Vulnerable
ToR	Terms of Reference
TSRC	Toowoomba Second Range Crossing project
V	Vulnerable
VM Act	*Vegetation Management Act 1999* (Qld)
WoNS	Weeds of national significance
WQO	Water Quality Objective

Glossary

Term	Explanation
Adverse impact	Adverse impacts are defined as those impacts that result in an unwanted and/or unanticipated result of taking a particular action. In an environmental context, an adverse impact means any change in the physical or biological conditions of the natural environment that results in a detrimental effect upon flora, fauna, air, water, minerals or other natural characteristic of the area.
Anthropogenic	Associated with or relating to human influence (or impact) on the environment.
Aquatic ecosystems	The physical and chemical environment that contains a community of organisms (plants, animals, and microbes) and ecological processes within rivers and their riparian zones and reservoirs, lakes, wetlands and their fringing vegetation.
Arable	Capable of producing crops or grazing land.
Biocondition	The degree to which the attributes of a patch of vegetation differ from the attributes of the same vegetation in its reference (undisturbed) state.
Biodiversity	The biological diversity of life is commonly regarded as being made up of the following three components: ■ Genetic diversity – the variety of genes (or units of heredity) in any population ■ Species diversity – the variety of species ■ Ecosystem diversity – the variety of communities or ecosystems.
Biodiversity Planning Assessments (QLD) (BPAs)	BPAs have been prepared for each of Queensland's bioregions based on the methodology outlined in the Biodiversity Assessment and Mapping Methodology (BAMM) (Queensland Government 2002a). The BPAs draw upon the DES certified Regional Ecosystem (RE) mapping, database information, and expert panel reports and incorporate information about threatened ecosystems and/or species, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, as well as buffers to wetlands or other types of important areas for ecological processes. There are three biodiversity significance levels to which an area can be assigned: ■ State significance – areas assessed as being significant for biodiversity at the bioregional or State scales ■ Regional significance – areas assessed as being significant for biodiversity at the sub-bioregional scale ■ Local significance and or other values – local values that are of significance at the local government scale. All remnant vegetation will qualify into one of the above three categories.
Biodiversity offsets	Biodiversity offsets are measures that benefit biodiversity by compensating for the adverse impacts elsewhere of an action, such as clearing for development. Biodiversity offsets work by protecting and managing biodiversity values in one area in exchange for impacts on biodiversity values in another. In Queensland, the term used is 'environmental offsets'.
Bioregion	A bioregion as defined in An Interim Biographic Regionalisation of Australia (Thackway and Cresswell (1995)). The Project is located within the Brigalow Belt and South East Queensland bioregions.
Biosecurity Act 2014 (Qld) *(*Biosecurity Act*)*	The Biosecurity Act lists declared plants and animals that have, or could have, serious economic, environmental or social impacts and are targeted for control. There are legal obligations associated with the control supply, sale, keeping and transport of declared species. Where these exotic pests and weeds are encountered, landholders have an obligation under the Biosecurity Act to control the declared weeds and pest animals, in accordance with relevant guidelines and local government area pest management plans. There are seven categories for restricted matter defined in the Biosecurity Act: ■ Categories 1 and 2 are restricted matters that have specific urgent reporting requirements ■ Categories 3, 4, 5, 6 and 7 relate to restricted matter that is in a person's possession, under their control and are also about not feeding restricted matter. Several restriction categories apply to some restricted matter. In such cases, you would need to follow the requirements of all restriction categories for these restricted matter listings.

Term	Explanation
Conservation significant	A collective term used with reference to species that are listed as Critically endangered, Endangered or Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) (refer EPBC Act conservation significance for more details)).
Controlled action	A proposed action designated under the controlling provisions of the Environment Prote*ction and Biodiversity Conservation Act 1999* (Cth) that is likely to have a significant impact on a matter of national environmental significance, the environment or Commonwealth land (even if the action is taken outside Commonwealth land).
Controlling provision	Under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), an action that a person proposes to take is a *controlled action* if the taking of the action by the person without approval under Part 9 for the purposes of a provision of Part 3 would be (or would, but for section 25AA or 28AB, be) prohibited by the provision. The provision is a *controlling provision* for the action.
Critical habitat (also referred to as *Habitat critical to the survival of the species*)	The whole or any part or parts of an area or areas of land comprising the habitat of an Endangered species, an Endangered population or an Endangered ecological community that is critical to the survival of the species, population or ecological community. Critical habitat is defined within the Commonwealth's *EPBC Act Significant Impact Guidelines 1.1* and relevant species recovery plans.
Critically Endangered	Designated as Critically Endangered under the EPBC Act. Refer to definition of EPBC Act conservation status for meaning of Critically endangered under the Act.
Cumulative impacts	The impacts that result from the incremental impact of an activity when it is added to past, present and reasonably foreseeable future activities. Cumulative impacts arise when several developments may have insignificant effects but when taken together have a significant effect.
Direct impacts	Impacts that result from a direct interaction between integral Project activities and the MNES (e.g. land clearing resulting in vegetation and habitat loss).
Disturbance footprint	The disturbance footprint is the surface area subject to direct disturbance (both temporary and permanent) associated with the Project.
Ecological community	An assemblage of species occupying a particular area.
Ecological MNES	An ecological value or group of ecological values that has the potential to be adversely impacted by Project related activities.
Ecologically sustainable development	Using, conserving and enhancing the community's resources so that ecological processes are maintained and the total quality of life, both now and in the future, can be increased.
Endangered	Designated as Endangered under the EPBC Act. Refer to definitions of EPBC Act conservation status for meaning of Endangered.
Endemic	Native to a country or a locality, although also found elsewhere.
EPBC Act conservation status	Under the EPBC Act, listed species and threatened ecological communities are assigned a conservation status of Extinct in the wild, Critically Endangered, Endangered or Vulnerable. Definitions of these terms under the Act are as follows: **Extinct in the wild** ▪ It is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range ▪ It has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a timeframe appropriate to its lifecycle and form **Critically Endangered** ▪ It is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria **Endangered** ▪ It is not Critically Endangered ▪ It is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria **Vulnerable** ▪ It is not Critically Endangered or Endangered ▪ It is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.

Term	Explanation
	Migratory Migratory species are those animals that migrate to Australia and its external territories or pass through or over Australian waters during their annual migrations. Examples of migratory species include birds such as albatrosses and petrels, mammals such as whales or reptiles. Listed migratory species appear in the: ■ Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) ■ China-Australia Migratory Bird Agreement (CAMBA) ■ Japan-Australia Migratory Bird Agreement (JAMBA) ■ Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).
Environmental values	Desirable characteristics, properties and behaviours or an aspect of the environment.
Ephemeral	Relates to the amount of time that surface water persists in a watercourse or wetland; ephemeral watercourses flow only during significant rainfall events and for a short time following rainfall events.
Habitat	An area or areas permanently, periodically or occasionally occupied by a species, population or ecological community, including any and all biotic and abiotic features of the area or areas occupied.
High constraint area	The environmental value is at risk from the Project activity. The activity will only be allowed with a specific set of stringent mitigation measures.
High Value Regrowth	Under the VM Act, High Value Regrowth vegetation is defined as native woody **vegetation** that has not been cleared since 31 December 1989, and forms an endangered, of concern or least concern regional ecosystem (refer to definition of Regional Ecosystem for further information)
Indirect impacts	Impacts that are not a direct result of Project activities but are encouraged to occur away from the original impact area via a complex pathway (e.g. soil disturbance during construction promoting weed and/or pest invasion that reduces habitat quality). In accordance with the EPBC Act, indirect impacts include the following: ■ Downstream or downwind impacts, such as impact on wetlands or ocean reefs from sediment, fertilisers or chemical which are washed or discharged into river systems ■ Upstream impacts such as impacts associated with the extraction of raw materials and other inputs which are used to undertake the action. Facilitated impacts which result from further actions (including actions by third parties) which are made possible or facilitated by the action.
Intergenerational equity	The principle of intergenerational equity is that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.
Helidon Hills	Used to describe the area to the north of Helidon which encompasses several reserves including Lockyer National Park, Lockyer State Forest and Lockyer Resources Reserve
Matters of national environmental significance (MNES)	The nine MNES protected under the EPBC Act are: ■ World Heritage properties ■ National Heritage places ■ Wetlands of international importance (listed under the Ramsar Convention) ■ Listed threatened species and ecological communities ■ Migratory species protected under international agreements ■ Commonwealth marine areas ■ The Great Barrier Reef Marine Park ■ Nuclear actions (including uranium mines) ■ A water resource, in relation to coal seam gas development and large coal mining development.
Microchiropteran bats	This report uses the term Microchiropteran bats to refer to small, mostly insectivorous bats that use echolocation to navigate and find food.
Migratory	Species listed as Migratory under the EPBC Act. Refer to definitions of EPBC Act conservation status, for meaning of migratory under the Act.

Term	Explanation
MNES study area	The MNES study area is an approximately 2 km wide study area, 1 km either side of the proposed rail alignment. The study area includes the disturbance footprint, which encompasses all areas where works are proposed, including both permanent and temporary works. Investigations for the purposes of this EIS and ongoing engineering design, including field surveys, were generally undertaken within the EIS investigation corridor (or as required by the individual technical assessments) to ensure a robust assessment and to allow for potential future design changes. Some technical assessments used a different study area to the EIS investigation corridor depending on the requirements of the environmental aspect being assessed.
Naturalness and ecological condition	The apparent naturalness or health/condition of an ecological community, as assessed against the following criteria: ■ Disturbance — described in terms of its cause (natural or human), its degree or severity, its extent and distribution within the community ■ Weed content — description of species abundance, horizontal and vertical distribution of each species ■ Ecological viability — measure of a community's ability to survive in the longer term ■ Ecological health — measure of regeneration, size, structure and number of dead or dying plants within a community ■ Ecological relationships — the sequential relationship of one community to another, such as diurnal systems.
Non-remnant vegetation	Vegetation that is not mapped as remnant vegetation and/or which fails to meet the criteria for remnant vegetation (refer definition of remnant vegetation, below). This includes regrowth, heavily thinned or logged vegetation and significantly disturbed vegetation that fails to meet the structural and/or floristic characteristics of remnant vegetation. It also includes urban and cropping land (refer to definition of Remnant vegetation for the antonym of Non-remnant vegetation).
Of concern	Designated as Of concern under the VM Act. Refer to definition of VM Act status for meaning of 'Of concern' under the Act.
Permanent impact	The impact will last indefinitely
Precautionary principle	The precautionary principle stipulates that 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. Section 391(2) EPBC Act states: "*The precautionary principle is that lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage*"
Pre-clearing Regional Ecosystems (Pre-clearance REs)	Pre-clearing Regional Ecosystem are defined as the vegetation or regional ecosystem present before clearing. This generally equates to terms such as 'pre-1750' or 'pre-European' used elsewhere
Project cumulative impact area	The Inland Rail Project cumulative impact area encompasses the Inland Rail Project disturbance footprint and extends 50 km beyond the Project disturbance footprint boundary.
Project disturbance footprint	The Project disturbance footprint is the area subject to direct disturbance (both temporary and permanent) associated with the Project (refer Figure 1.2).
Project works	Project works include early works and pre-construction activities, works described as pre-construction, construction and commissioning works. Project works exclude enabling works.
Qualitative	Relating to or concerned with quality or qualities, rather than quantity or measured value.
Quantitative	An assessment based on quantities or quantifiable data.
Ramsar wetland	An area designated as a wetland of international importance under the Ramsar Convention (also known as the Convention on Wetlands of International Importance signed by Australia in 1971) because of its role in preserving biological diversity, or because it is a representative, rare or unique wetland type.
Rare	Defined as "not occurring very often"

Term	Explanation
Regional Ecosystem (RE)	A vegetation community, within a bioregion, that is consistently associated with a particular combination of geology, landform and soil (Young et al. 1999). REs are mapped by the Queensland Government and are defend by the Regional Ecosystem Description Database (REDD). The RE codes are applicable to mapping from Remnant vegetation, High value regrowth and pre-clearing REs that are not considered remnant. REs may be classified under schedules 1 to 3 of the Vegetation Management Regulation as Endangered, Of concern or Least concern. Refer to VM Act conservation status for meaning of Endangered, Of concern and Least concern under the Act. These terms in reference to REs in this report refers to the RE status under the Act.
Regrowth vegetation	As defined under the VM Act (Qld), regrowth is any vegetation that is not 70% of height of an equivalent community of undisturbed vegetation or 50 % of what would be undisturbed foliage cover and a mix of species represented in undisturbed communities.
Remnant vegetation	Remnant woody vegetation is defined as vegetation where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy (Neldner et al. 2012).
Significant impact	An impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts.
Spatial extent	Impacts are considered with respect to the biologically meaningful spatial extents of local, regional, State, and national/international.
Threatened	A collective term used with reference to species that are listed as Critically endangered, Endangered or Vulnerable under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) (refer EPBC Act conservation significance for more details))
Vulnerable	Designated as Vulnerable under the EPBC Act. Refer to definitions of EPBC Act conservation status for meaning of Vulnerable under this Act.
Weeds of National Environmental Significance (WoNS)	Thirty-two (32) species of weeds are declared to be weeds of national significance, based on their invasiveness, potential for spread and environmental, social and economic impacts. The State Government is responsible for the legislation and administration of WoNS in Queensland and landholders are responsible for managing WoNS. The Australian Weeds Strategy provides a framework for establishing consistency between all stakeholders and identifies priorities for national weed management with the aim of minimizing the environmental, social and economic impacts of weeds. A National Management Group has been established for each of the WoNS to manage the implementation of the respective National Strategic Plans.
Wetland	■ Areas shown on the *Map of Referable Wetlands* which is a document approved by the chief executive on 4 November 2011 and published by the department, as amended from time to time by the chief executive under section 144D of the *Environmental Protection Regulation 2008* (Qld); and ■ Are wetlands as defined under the Queensland Wetlands Program as areas of permanent or periodic/intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 m, and possess one or more of the following attributes: – At least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their lifecycle; or – The substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers; or – The substratum is not soil and is saturated with water, or covered by water at some time.
Wetland of high ecological significance	Otherwise known as a high conservation value wetland, is a wetland that meets the definition of a wetland (above) and that is shown as a wetland of high ecological significance or high conservation value wetland on the *Map of Referable Wetlands*
Wildlife corridor	Habitat linked to other habitats (often remnant patches) to allow natural migration or movement of wildlife.

Executive summary

The Australian Government has committed to delivering Inland Rail, an interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland (QLD). Inland Rail is significant national transport infrastructure which will enhance Australia's existing rail network and serve the interstate freight market.

The Inland Rail route, which is approximately 1,700 kilometres (km) long, and is divided into 13 sections to assist with the delivery of the Inland Rail Program (Inland Rail), will provide a safe and sustainable solution to Australia's freight challenge. The Program will also provide significant social and economic benefits and opportunities, while implementing mitigation, management and offset measures that result in acceptable environmental, social and economic outcomes.

The Australian Rail Track Corporation Limited (ARTC), the proponent, proposes to construct and operate the Gowrie to Helidon Project (the Project) which consists of approximately 28 km of single track dual gauge railway between Gowrie and Helidon. The Project will contain a 6.24 km undrained tunnel crossing of the Toowoomba Range and substantial viaduct structures and earthworks to facilitate the required gradient across the undulating topography. The Project will accommodate a range of train services, including 1,800-metre (m) long double-stacked trains.

The Project is a more efficient and direct route through the Toowoomba Range compared to the existing railway, which commenced operation in the 1870s and provides link between the adjacent Inland Rail Projects of:

- Border to Gowrie (B2G) to the west, where B2G connects to the West Moreton System rail corridor between the Kingsthorpe and Gowrie
- Helidon to Calvert (H2C) to the east, where H2C connects to the West Moreton System rail corridor north-west of Helidon.

The Project will also provide interoperability between the Inland Rail and Queensland Rail (QR) networks, which will benefit all rail operators, with connections at Gowrie and Helidon, along with a spur line to allow access to and from Toowoomba.

The Project has been aligned to maximise the usage of existing rail corridors, wherever possible. As a consequence, approximately 5.6 km is positioned within existing West Moreton System rail corridor. The other 22.4 km is regarded as a 'greenfield' alignment, requiring new rail corridor to be established. The greenfield section is generally aligned with the existing Gowrie to Grandchester future State transport corridor protected under the *Transport Planning and Coordination Act 1994* (Qld) in 2005.

The brownfield portion is located in agricultural lands along the Gowrie Creek floodplain which have been subject to extensive historical land management practices, including clearing and grazing and more recently to urban development. East of Gowrie the Project is predominantly in tunnel under the Toowoomba Plateau, passing under Cranley, Mount Kynoch and Ballard. The eastern tunnel portal is located in forested areas of Ballard, southwest of Mt Kynoch. The extends east through steep undulating terrain associated with the eastern slopes of the Great Dividing Range and the GDR escarpment, crossing over Lockyer Creek before tying into the West Moreton System.

The corridor is of sufficient width to accommodate future possible upgrades of the track, including a future possible requirement to accommodate trains up to 3,600 m in length. The land requirement for the Project will comprise a corridor with minimum width of 40 m, widened to accommodate earthworks, drainage structures, rail infrastructure, access tracks and fencing. The Project was referred to the Department of the Environment and Energy (DotEE) (now the Department of Agriculture, Water and the Environment (DAWE)) for determination under s75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Minister for the Environment determined the Project a 'controlled action' on 17 March 2017 (EPBC 2017/7882), requiring assessment and approval under the EPBC Act.

The controlling provision for the controlled action is:

- 'Listed threatened species and communities'.

The Project was declared a 'coordinated project' for which an Environmental Impact Statement (EIS) is required under the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act), on the 16 March 2017. This declaration initiates the statutory environmental impact assessment procedure detailed in Part 4 of the SDPWO Act, which requires a proponent to prepare an EIS for the Project in accordance with the *Terms of Reference for an environmental impact statement: Inland Rail – Gowrie to Helidon project* issued 9 August 2017 by the Coordinator-General.

The SDPWO Act EIS process has been accredited under the Queensland and Commonwealth governments EPBC Act assessment bilateral agreement for the assessment of the Project under the EPBC Act. The Project will be assessed under the terms of this bilateral agreement. This Matters of National Environmental Significance (MNES) Technical Report has been prepared to address the matters set out in the section 11 of the ToR.

The Project is situated within the South East Queensland (SEQ) and Brigalow Belt South bioregions, which have experienced a long history of human disturbance as a result of agricultural practices urban development and resource development. At a regional level, large tracts of remnant vegetation are typically fragmented, occurring on the areas that are less attractive to development (i.e. rocky ranges, sloping topography) and roadside vegetation, or as relatively small isolated patches subject to edge related impacts.

The MNES study area provides habitat for a number of threatened species listed under the EPBC Act and their associated habitat. There are three Threatened Ecological Community (TECs) under the EPBC Act within the MNES study area, though there are no TECs located within the Project disturbance footprint.

The Project assessment framework has been designed to provide an objective approach to identifying the Project's environmental constraints and potential impacts to MNES.

Based on literature review, database searches, and field surveys supporting habitat modelling, habitat for 37 threatened flora (16 species) and fauna (21 species) was confirmed within the MNES study area, with 31 of these species (ie 12 flora and 19 fauna) having habitat contained within the Project disturbance footprint. This includes significant habitat in the Toowoomba Range and critical habitat within the Project disturbance footprint for several species including Brush sophora (*Sophora fraseri*), Collared delma (*Delma torquata*), Koala (*Phascolarctos cinereus*) and Black-breasted button-quail (*Turnix melanogaster*).

The construction and operation and decommissioning of the Project has the potential to impact on MNES through:

- Habitat loss and degradation from vegetation clearing/removal
- Fauna species injury or mortality
- Reduction in biological viability of soil to support growth due to soil compaction
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation.

To determine the significance of potential impacts of the Project upon the identified MNES, sensitivity categories were applied to each of the MNES. The sensitivity of the MNES was grouped into three distinct categories: high, moderate and low. These groupings were based on factors including, but not limited to, legislative status, resilience and representation in the broader landscape.

In addition to sensitivity, the magnitude of each potential impact was assigned based on the extent, duration and resultant change to the MNES. The magnitude of impact was grouped into five categories: major, high, moderate, low and negligible. Both the sensitivity of a MNES and the magnitude of the potential impact were used to determine the significance of a potential impact.

The proposed mitigation measures for the Project were considered in order to reduce the initial magnitude and ultimately the significance of the potential impacts upon the listed threatened species and communities. Project mitigation measures included (but were not limited to):

- Reducing the Project disturbance footprint as far as reasonably practical
- Development and implementation of a Flora and Fauna Sub-plan as a component of the draft Outline Environmental Management Plan (draft Outline EMP)
- Development and implementation of a Biosecurity Management Plan as a component of the draft Outline EMP
- Development and implementation of a Soil Management Plan, including erosion and sedimentation controls, as a component of the draft Outline EMP
- Identification and implementation of fauna movement features to reduce barrier effects associated with the Project and enable fauna passage
- Development and implementation of a Reinstatement and Rehabilitation Plan
- Development and implementation of the draft Outline EMP.

Following the implementation of a range of mitigation measures and management plans including, but not limited to, avoidance, minimisation and mitigation, the magnitude of residual impacts to the listed threatened species were generally reduced, followed by a subsequent reduction in the significance of the impact. However, the loss of habitat from vegetation clearing/removal upon most of the terrestrial MNES was not predicted to significantly reduce in magnitude of impact following the implementation of Project mitigation measures. In addition, whilst measures will be implemented to reduce impacts due to fragmentation associated with barrier effects (e.g. the provision of crossing structures to facilitate fauna passage), terrestrial species such as Koala (*Phascolarctos cinereus*) are still likely to be subject to adverse impacts.

Based on assessment against the Significant Impact Guidelines for MNES, a significant residual impact is likely to occur to the following listed threatened species:

- Flora
  - Brush sophora (*Sophora fraseri*) – 2.36 ha to *Habitat critical to the survival of the species* and 28.69 ha of *potential habitat*
- Fauna
  - Collared delma (*Delma torquata*) – 197.41 ha to *important habitat*
  - Spotted-tail quoll (*Dasyurus maculatus maculatus*) – total potential impact of 24.46 ha to *Habitat critical to the survival of the species* and 129.53 ha of *potential habitat*
  - Koala (*Phascolarctos cinereus*) – 189.01 ha to *Habitat critical to the survival of the species* and 70.6 ha of *potential habitat*
  - Grey-headed flying-fox (*Pteropus poliocephalus*) – total potential impact of 201.19 ha to *Habitat critical to the survival of the species*
  - Black-breasted button-quail (*Turnix melanogaster*) – 9.18 ha to *Habitat critical to the survival of the species*
  - Red goshawk *(Erythrotriorchis radiatus)* – total potential impact of 84.79 ha to *Habitat critical to the survival of the species* and 3.98 ha of *potential habitat*
  - Swift parrot *(Lathamus discolor)* – total potential impact of 8.54 ha to *Habitat critical to the survival of the species* and 180.47 ha of *potential habitat*

- Australian painted snipe (*Rostratula australis*) – total potential impact of 8.9 ha to *Habitat critical to the survival of the species*

The Project may also potentially have a significant residual impact on the following listed threatened species:

- Flora
  - Four-tailed grevillea (*Grevillea quadricauda*) – total potential impact of 1.02 ha to *potential habitat*
  - Hawkweed (*Picris evae*) – total potential impact of 31.88 ha to *potential habitat*
  - *Paspalidium grandispiculatum* (a grass) – total potential impact of 156.25 ha to *potential habitat*
  - Austral cornflower (*Rhaponticum austral*) – total potential impact of 73.98 ha to *potential habitat*
  - Blotched sarcochilus (*Sarcochilus weinthalii*) – total potential impact of 3.14 ha to *potential habitat*
- Fauna
  - Long-nosed potoroo (*Potorous tridactylus tridactylus*) – total potential impact of 156.25 ha of *potential habitat*
  - New Holland mouse (*Pseudomys novaehollandiae*) – total potential impact of 156.25 ha of *potential habitat*
  - Condamine earless dragon *(tympanocryptis condaminensis)* - total potential impact of 16.22 ha of *potential habitat*

A key reason for disturbance is the potential loss of habitat. Habitat loss may result from the Project disturbance footprint (primarily temporary construction footprint). The Project may also result in permanent barrier effects and habitat fragmentation. During the detailed design phase, the extent of the clearing will be confirmed, along with the implementation of design solutions to mitigate barrier effects (e.g. fauna fencing and fauna passageways which will facilitate the movement of wildlife across the alignment).

A cumulative impact assessment was carried out including all relevant projects within a 50 km radius of the current Project disturbance footprint. The significance of the predicted cumulative impact as a result of the Project and other similar projects are likely to be higher on the following ecological MNES flora and fauna species:

- *Paspalidium grandispiculatum* (a grass)
- Brush sophora *(Sophora fraseri)*
- Regent honeyeater (*Anthochaera phrygia*)
- Collared delma (*Delma torquata*)
- Red goshawk *(Erythrotriorchis radiatus)*
- Grey falcon (*Falco hypoleucos*)
- Swift parrot (*Lathamus discolor*)
- Spotted-tail quoll (*Dasyurus maculatus maculatus*)
- Koala (*Phascolarctos cinereus*)
- Long-nosed potoroo (*Potorous tridactylus tridactylus*)
- Grey-headed flying-fox (*Pteropus poliocephalus*).

MNES identified through the Project EIS will be subject to further investigations and surveys during the detailed design phase. This will refine the current proposed works and determine whether these species actually occur and if so, the magnitude of the significant residual impacts upon the listed threatened species and communities. The specific mitigation measures will then be applied to ensure that the significance ratings of any potential impacts are classified as low as reasonably practicable.

There is the potential for some Project activities (e.g. vegetation clearing) to have a cumulative, irreversible and/or permanent impact upon some ecological MNES, even after the implementation of all project mitigation measures. In these cases, the compensation for the residual impact will need to occur. An Environmental Offset Delivery Plan will be prepared in consultation with the relevant State and Commonwealth agencies and will comply with the relevant offsets policies. Strategic offsets will be provided in accordance with Commonwealth and State based policies. These will be in the form of direct land based contributions and financial settlements. The Environmental Offset Management Plan will be developed and implemented during the detailed design phase and prior to any construction works commencing.

1 Introduction

1.1 Project overview and objectives

The Australian Government has committed to delivering Inland Rail, an interstate freight rail corridor between Melbourne and Brisbane, via central-west New South Wales (NSW) and Toowoomba in Queensland (QLD). Inland Rail is significant national transport infrastructure which will enhance Australia's existing rail network and serve the interstate freight market.

The Inland Rail route, which is approximately 1,700 kilometres (km) long, will involve:

- Using the existing interstate rail corridor through Victoria and southern NSW
- Upgrading approximately 400 km of existing corridor, mainly in western NSW
- Providing approximately 600 km of new corridor in northern NSW and South East Queensland (SEQ).

The Inland Rail Program (Inland Rail) has been divided into 13 separate projects to assist with the delivery of the Inland Rail Program of works (refer Figure 1.1).

The Australian Rail Track Corporation Limited (ARTC) proposes to construct and operate the Gowrie to Helidon (G2H) Project (the Project), which consists of approximately 28 km of dual gauge track with three crossing loops to accommodate double stacked freight trains up to 1.8 km long.

The Project is predominately a greenfield track which generally aligns with the Gowrie to Grandchester future State transport corridor, including the construction of an approximately 6.24 km long undrained tunnel through the Toowoomba Range to facilitate the required gradient across the undulating topography. The corridor will be of sufficient width to accommodate future possible upgrades of the track, including a future possible requirement to accommodate trains up to 3.6 km in length.

The Project is a more efficient and direct route through the Toowoomba Range compared to the existing railway, which commenced operation in the 1870s. The Project is identified as a priority development within the Inland Rail Program and for future growth through the region.

Further information on the Inland Rail Program can be found at **inlandrail.artc.com.au**.



Figure 1.1 **The Melbourne to Brisbane Inland Rail Route**

1.2 Project objectives

The objectives of the Project are to:

- Provide rail infrastructure between Gowrie and Helidon that meets the Inland Rail Program service offering
- Provide a more efficient route through the challenging terrain of the Toowoomba Range, along with interoperability between the Inland Rail and Queensland Rail (QR) networks, which will benefit all rail operators
- Minimise the potential for adverse environmental, social and economic impacts.

The objectives of Inland Rail as a whole are to:

- Provide a rail link between Melbourne and Brisbane that is interoperable with train operations to Perth, Adelaide, and other locations on the standard gauge rail network, to serve future rail freight demand and stimulate growth for inter-capital and regional/bulk rail freight
- Provide an increase in productivity that will benefit consumers through lower freight transport costs
- Provide a step-change improvement in rail service quality in the Melbourne to Brisbane corridor and deliver a freight rail service that is competitive with road

- Improve road safety, ease congestion and reduce environmental impacts by moving freight from road to rail
- Bypass bottlenecks within the existing metropolitan rail networks and free up train paths for other services along the coastal route
- Act as an enabler for regional economic development along the Inland Rail corridor.

1.3 Proponent

Australian Rail Track Corporation (ARTC) was created in 1997 after the Australian and State governments agreed to the formation of a 'one stop shop' for all operators seeking to access the national interstate rail network. ARTC is the Project proponent and is a Commonwealth Government Business Enterprise as prescribed by section 5(2) of the *Public Governance Performance and Accountability Rule 2014* (Cth).

Today, ARTC plays a critical role in the transport supply chain and in the overall economic development of Australia. The ARTC network supports industries and businesses that are vital to the nation's economy by facilitating the movement of a range of commodities including general freight, coal, iron ore, other bulk minerals and agricultural products.

Across the network, ARTC is responsible for:

- Selling access to train operators
- Developing new business
- Capital investment in the network
- Managing the network
- Infrastructure maintenance.

As the operator and manager of Australia's national rail freight network, ARTC has successfully delivered more than $5 billion in capital upgrades to the national rail freight network. Having emerged from this period of significant investment and network growth, ARTC has now been tasked with developing a program to deliver Inland Rail under the guidance of the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications.

ARTC has incurred two penalties in NSW relating to minor environmental incidents including:

- NSW Environmental Protection Authority Penalty Notice to ARTC dated 29 May 2012 for discharge of sediment-laden water at Allandale (Maitland to Minimbah Third Track Project) = $1,500
- NSW Environmental Protection Authority Penalty Notice to Transport Express Joint Venture (operating under ARTC Environment Protection Licence) dated 5 March 2012 for sediment and erosion control issues at Sawtell = $1,500.

ARTC has not incurred any other environmental prosecutions within the last 10 years.

ARTC has also previously entered into a Voluntary Enforceable Undertaking with the Commonwealth Department of the Environment (DoE) (currently known as the Department of Agriculture, Water and the Environment (DAWE)) under the *Environment Protection Biodiversity Conservation Act 1999* (Cth) (EPBC Act), in 2011.

Contact details for ARTC Inland Rail are:

Inland Rail
Australian Rail Track Corporation
ABN: 75 081 455 754
Level 16, 180 Ann Street
PO Box 2462 Queen Street
Brisbane QLD 4001
Telephone: 1800 732 761

The ARTC Environmental Policy provides a framework for continual improvement of ARTC's Environmental Management System and sets out commitments for managing potential environmental risks. ARTC is committed to best-practice environmental management and reducing environmental impact in all ARTC activities. ARTC also implements a 'no harm' policy in regard to workplace health and safety.

Further information on ARTC and Inland Rail can be found at www.artc.com.au and www.inlandrail.com.au respectively. ARTC's corporate policies can also be found at EIS Appendix G: Corporate Policies.

The Environmental Impact Statement (EIS) study team is made up of personnel from Future Freight Joint Venture (FFJV), ARTC and various technical specialist service providers.

1.4 Scope and purpose

The Project was referred to the Department of the Environment and Energy (DotEE) (now called the Department of Agriculture, Water and the Environment (DAWE)) for determination under s75 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Minister for the Environment determined the Project a 'controlled action' on 17 March 2017 (EPBC 2017/7882), requiring assessment and approval under the EPBC Act. The controlling provision for the controlled action is:

- Listed threatened species and communities (sections 18 and 18A).

Assessment of the Project against the requirements of the EPBC Act will occur in accordance with the bilateral agreement with the State of Queensland. To enable this, the draft EIS must address the controlling provision for the Project and describe the particular aspects of the environment and the Project that are subject to the controlled action decision.

A principal purpose of the EIS is to provide sufficient information to enable the Coordinator-General (State Government) and the Commonwealth Minister for the Environment (Commonwealth Government) to evaluate and assess the Project under the SDPWO Act and EPBC Act respectively, and to state conditions and make recommendations regarding approvals required by the Project under other legislation.

At the conclusion of the SDPWO Act EIS process, the Commonwealth Minister for the Environment will receive a copy of the Coordinator-General's Evaluation Report and will take the Coordinator-General's Evaluation Report into account when making a decision under the EPBC Act. The Commonwealth Minister for the Environment will decide on whether to approve the Project with or without conditions.

The Environmental Impact Statement (EIS) process for the Project under Section 45 of the EPBC Act has been conducted under the Bilateral Agreement between the Commonwealth and the State of QLD. The EIS must address the controlling provision for the Project and describe the particular aspects of the environment and the Project that are subject to the controlled action decision as detailed above.

A principal purpose of the EIS is to provide sufficient information to enable the Coordinator-General and the Commonwealth Minister for the Environment to evaluate and assess the Project under the *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act) and EPBC Act respectively.

The Project proponent is still required to obtain all other secondary development approvals from local authorities as required (e.g. waterway barrier works permit under the *Fisheries Act 1994* (Qld)). Secondary approvals are listed in EIS Chapter 3: Project Approvals.

The conditions of primary approval in the Coordinator-General's report on the EIS only gains legal effect when attached to a development approval given by an assessment manager under other specific legislation. The Project proponent is still required to obtain all other secondary development approvals from local authorities (e.g. for a material change of use) and QLD Government departments (e.g. an environmental authority under the *Environmental Protection Act 1994* (EP Act) (Qld)).

Assessment managers (associated with secondary approvals) ultimately decide whether development approvals are granted for projects. These assessment managers:

- Must attach the Coordinator-General's conditions to any development approval that is granted
- Are not limited in their ability to refuse a project, even if the Coordinator-General's report on the EIS has recommended the project be approved
- Can impose additional conditions on the development approval, provided they are not inconsistent with the conditions stated in the Coordinator-General's report.

1.4.1 This report

This technical report has been prepared in accordance with Sections 11.1 – 11.35 of the *Terms of Reference for an environmental impact statement: Inland Rail - Gowrie to Helidon Project* (ToR) issued on 9 August 2017 by the Coordinator-General. It has been prepared as a "stand-alone" document that assesses potential impacts on listed threatened species and communities under the EPBC Act during construction, operation and decommissioning of the Project.

Furthermore, this report draws on other impact assessments completed for this EIS as relevant to listed threatened species and communities, including air quality, surface water and hydrology, groundwater, and noise and vibration. These investigations were generally undertaken at a similar or larger scale to that described in Section 1.4.2.

1.4.2 Study area

For the purpose of this report, the assessment of potential impacts was focussed on the Project disturbance footprint and matters of national environmental significance (MNES) study area presented in Figure 1.2

- Project disturbance footprint, comprising:
  - Permanent disturbance footprint (approximately 354 hectares (ha) in size):
    - Within the greenfield corridor (excluding the tunnel), the rail corridor is a minimum of 62.5 m wide, which is of a sufficient width to allow operation and maintenance of the Project, including drainage structures and fencing, along with additional land required for infrastructure at the western and eastern tunnel portal areas, and the intermediate ventilation shaft at Cranley.

      Preservation of an underground corridor of approximately 50 m wide and approximately 28 ha in area for the tunnel has also been considered where applicable (i.e. disturbance calculations for land use, agricultural land and vegetation communities do not include this area as there is no surface disturbance proposed).
    - Within sections of brownfield rail development, reasonable endeavours have been made to remain within the existing Queensland Rail West Moreton System rail corridor, widening the corridor only where required to accommodate safe operation of the Project and existing QR operations. The Project has also considered land requirements for the proposed road network changes required to facilitate the Project. The land requirements will be confirmed during the detailed design of the Project.
  - Temporary disturbance footprint (approximately 100 ha in size), which includes the following temporary areas required for construction purposes:
    - Five metre buffer areas outside the rail corridor for fencing construction
    - Laydown areas and site offices
    - Construction access roads where these lie outside the permanent disturbance footprint
    - Utilities works due to relocation/removal of services crossing the rail corridor

- Erosion and sediment controls including sediment ponds
- Works associated with local road realignments and/or the construction of new roads.

- MNES study area: the study area comprises the Project disturbance footprint, including the temporary construction disturbance footprint and the permanent disturbance footprint, with a buffer zone of approximately 1 kilometre (km) either side of the proposed rail alignment. The study area is slightly wider around Chainage (Ch) 5 km to Ch 15 km to accommodate the options analysis undertaken for the Toowoomba Range crossing and to allow for the varied topography. The maximum width of the study area from the alignment is 3.4 km in this range. The MNES study area was used to identify MNES that are located in proximity to the Project and therefore relevant to the assessment of potential impacts.

Though technically a permanent disturbance the properties that overlie the Toowoomba Range tunnel have been considered separately. This area, approximately 28 ha in area comprises the operating tunnel, along with a provisional area to protect the tunnel from future development (total width of 50 m). These properties will be subject to volumetric acquisition where the existing rights and interests of the respective aboveground surface areas are retained by each respective. As such estimation of direct impacts the Project disturbance footprint does not include the surface area associated with the rail tunnel where the alignment intersects a portion of the Toowoomba Range as no surface disturbance is predicted. However, impacts associated with the construction and operation the tunnel (e.g. ground-borne noise, vibration and groundwater drawdown) have been assessed within this document.

This information was used to undertake an impact assessment in accordance with the *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance* (MNES Guidelines) (DotE 2013a), to determine which MNES were likely to be subject to significant residual impact as a result of the Project:

- An assessment of direct impacts from the Project (immediate impacts from Project activities such as vegetation clearing and fauna injury) and indirect impacts (offsite and/or longer term impacts resulting from Project activities such as impacts to surface water quality and barriers to fauna movement) on each MNES
- Identification of mitigation measures for each potential impact/MNES and the Project as whole to avoid, minimise and mitigate the impact.

The EPBC Act Offsets Policy states: ‘Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures’. In accordance with this policy, an offset strategy has been developed for the Project (refer Appendix I) for any residual impacts on MNES, where appropriate (as not all impacts can be offset).

It is acknowledged that, whilst migratory species, as listed under the EPBC Act, are MNES, they have not been identified as a controlling provision for the Project. Therefore, migratory species have been excluded from this technical report. However, in order to suitably inform the EIS, migratory species have been incorporated into EIS Chapter 11: Flora and fauna, and its associated EIS Appendix I: Terrestrial and aquatic ecology technical report.

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

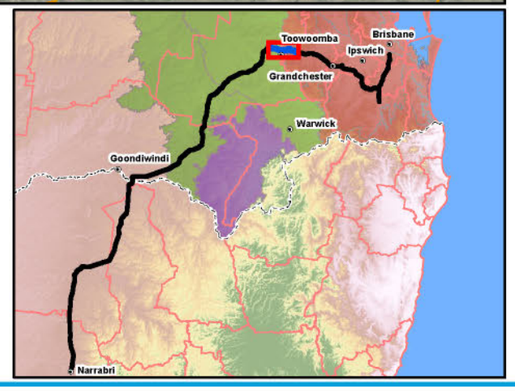
Map by: MF/GN/KG/LT Z:\GIS\GIS_3200_G2H\Tasks\3320-EAP-20200513123_G2H_Ecology_Figures\3320-EAP-20200513123_MNES_Fig1-2_ProjectLocation_v4.mxd Date: 24/03/2021 14:16

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Bioregions

- Brigalow Belt South
- Nandewar
- South Eastern Queensland



A3 scale: 1:80,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 24/03/2021 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 1.2: Location of Project and regional extent and MNES study area

1.5 Terms of reference

Table 1.1 provides a list of the requirements relevant to MNES as outlined in the ToR issued on 9 August 2017 by the Coordinator-General and as they are presented in this report, associated Appendices and related Project Chapters and documents.

Table 1.1 Terms of Reference compliance relevant to matters of national environmental significance

Flora and fauna Terms of Reference requirement		Report section
Information requirements		
Matters of national environmental significance – background and context		
11.1	This section should provide a stand-alone description and detailed assessment of the impacts of the project on the controlling provision for the project under the EPBC Act inclusive of any avoidance, mitigation and offset measures.	
11.2	The Commonwealth Minister for the Environment and Energy (the Commonwealth Minister) has determined that the project (EPBC 2017/7882) is likely to impact upon listed threatened species and communities (sections 18 and 18A of the EPBC Act).	
11.3	The EIS must be prepared in accordance with the bilateral agreement between the Commonwealth of Australia and the State of Queensland relating to environmental assessment. This will enable the EIS to meet the impact assessment requirements under both Commonwealth and Queensland legislation.	
11.4	The statutory obligations for conduct of the EIS process under the bilateral agreement are set out in Part 13 of the State Development and Public Works Organisation Regulation 2010.	
11.5	Once the draft EIS has been prepared to the satisfaction of the Coordinator-General and MNES addressed to the satisfaction of the Australian Government Department of the Environment and Energy, the draft EIS will be made available for public comment.	
11.6	The proponent may be required by the Coordinator-General or the Department of the Environment and Energy to provide additional material to address matters raised in submissions on the EIS	
11.7	At the conclusion of the environmental assessment process, the Coordinator- General will provide a copy of the report evaluating the environmental impacts of the project to the Commonwealth Minister.	
11.8	After receiving the evaluation report and sufficient information about the relevant impacts of the action, the Commonwealth Minister for the Environment and Energy has 30 business days to consider whether the impacts of the proposal are acceptable, or not, and to decide whether or not to approve each controlling provision.	
11.9	The Commonwealth Minister's decision under Part 9 of the EPBC Act is separate to the approval decisions made by Queensland State agencies and other agencies with jurisdiction on State matters.	
Information Requirements		
11.10	Consideration must be given to any relevant policy statements available from www.environment.gov.au, including: a) *Matters of National Environmental Significance: Significant impact guidelines 1.1* b) *Environment Protection and Biodiversity Conservation Act 1999* Environmental Offsets Policy and c) any approved conservation advice, recovery plans and threat abatement plans (as relevant) for listed threatened species and ecological communities.	Guidelines and plans – Sections 5.3.3, 5.3.4 and 5.3.5 and Appendix B Offsets – Section 5.4 and Appendix I EIS Chapter 11: Flora and Fauna, Sections 11.4, 11.11.1, 11.11.2 and 11.12

Flora and fauna Terms of Reference requirement		Report section
11.11	The EIS must: a) assess all the relevant impacts that the action has, will have or is likely to have, including on receiving environments of the project b) provide enough information about the action and its relevant impacts to allow the Commonwealth Minister to make an informed decision on whether or not to approve the action c) address the matters set out in Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth) (EPBC Regulations).	Project description – Section 1.9 to 1.15 EIS Chapter 6 – Project Description Impacts – Section 5.1 and 5.3 throughout relevant EIS chapters Mitigation – Sections 5.2 and 5.4 and throughout relevant EIS Chapters EIS Chapter 3 – Project Approvals Environmental record - EIS Chapter 1: Introduction Information sources – Appendix B EIS Chapter 11: Flora and Fauna, Sections 11.7 to 11.11
11.12	The MNES section of the EIS should bring together assessments of impacts from other chapters and produce a stand-alone assessment in a format suited for assessment under the EPBC Act.	Sections 5.1.2, 5.1.3 and 7
11.13	The project should initially be assessed in its own right followed by an assessment of the cumulative impacts related to existing major projects and/or development that is progressing through a publicly available planning and approval process. Cumulative impacts not solely related to the project development should also be described.	Sections 3.5 and 7 EIS Chapter 22 Cumulative Impacts EIS Chapter 11: Flora and Fauna, Sections 11.5 and 11.13
11.14	Predictions of the extent of threat (risk), impact and the benefits of any mitigation measures proposed, should be based on sound science and quantified where possible. All sources of information relied upon should be referenced.	Mitigation – Sections 5.1 to 5.3 Information sources – Appendix B EIS Chapter 11: Flora and Fauna, Sections 11.7 to 11.11
11.15	An estimate of the reliability of any predictions should be provided.	Appendix A
11.16	Any positive impacts of the Project should be identified and evaluated.	Section 1.16 EIS Chapter 2: Project Rationale EIS Chapter 16: Social
11.17	The extent of any new field work, modelling or testing should be commensurate with risk and should be such that when used in conjunction with existing information, provides sufficient confidence in predictions that well-informed decisions can be made.	Sections 3.2 and 3.3 EIS Chapter 11: Flora and Fauna, Section 11.5
11.18	In accordance with Schedule 4 of the EPBC Regulations, feasible project alternatives must be discussed, including: (a) if relevant, the alternative of taking no action (b) a comparative description of the impacts of each alternative on the triggered MNES protected by the controlling provision (c) sufficient detail to make clear why any alternative or option is preferred to another.	Section 1.8 EIS Chapter 2: Project rationale Sections 2.4 to 2.7
11.19	Short, medium and long-term advantages and disadvantages of the alternatives or options must be discussed.	Sections 1.7 and 1.8 EIS Chapter 2: Project rationale, Sections 2.4 to 2.7

Flora and fauna Terms of Reference requirement		Report section
11.20	The information provided must include details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against: (a) the person proposing to take the action (b) for an action for which a person has applied for a permit, the person making the application. If the person proposing to take the action is a corporation, details of the corporation's environmental policy and planning framework must also be included.	Section 1.3 EIS Chapter 1: Introduction
11.21	The economic and social impacts of the action, both positive and negative, must be summarised. Matters of interest should include: (a) consideration at the local, regional and national levels (b) any public consultation activities undertaken, and their outcomes (c) any consultation with indigenous stakeholders (d) identification of affected parties and communities that may be affected and a description of the views of those parties and communities (e) project economic costs and benefits of the project and project alternatives, including the basis for their estimation through cost/benefit analysis or similar studies; and (f) employment and other opportunities expected to be generated by the project in each of the construction and operational phases.	Section 1.16 and 1.17 EIS Chapter 2: Project rationale, Sections 2.3 to 2.5 EIS Chapter 5: Stakeholder engagement, Sections 5.6 to 5.7 EIS Chapter 16: Social, Section 16.9 to 16.12 EIS Chapter 17, Sections 17.8 to 17.12
11.22	The EIS must provide background to the action and describes in detail all components of the action for example (but not limited to), the construction, operation and (if relevant) decommissioning components of the action. This must include the location of all works to be undertaken (including associated offsite works and infrastructure), structures to be built or elements of the action that may have impacts on MNES.	Sections 1.9 to 1.15 EIS Chapter 6: Project Description
11.23	The description of the action must also include details on how the works are to be undertaken (including stages of development and their timing) and design parameters for those aspects of the structures or elements of the action that may have relevant impacts.	Sections 1.9 and 1.10 EIS Chapter 6: Project Description
11.24	The EIS must also provide details on the current state of groundwater and surface water in the region as well as any use of these resources.	Section 4.2 EIS Chapter 11: Flora and Fauna, Section 11.6.1 EIS Chapter 13: Surface water and hydrology, Sections 13.7.1 to 13.7.6 EIS Chapter 14: Groundwater, Section 14.6 EIS Appendix L: Surface water quality technical report, Sections 5 and 6 EIS Appendix N: Groundwater technical report, Sections 4 to 7
Listed threatened species and communities		
11.25	The EIS must describe the listed threatened species and ecological communities identified below (including EPBC Act status, distribution, life history and habitat).	Sections 5.1, 5.2, 5.3.3, 5.3.4 and 5.3.5 and Appendix B EIS Chapter 11: Flora and Fauna, Section 11.6
11.26	The EIS must consider and assess the impacts to the listed threatened species and ecological communities identified in section 11.29 and 11.30 (including EPBC Act status, distribution, life history and habitat and any others that are found to be or may potentially be present in areas that may be impacted by the project. Impacts from each component of the project of relevance to each listed threatened species or ecological community should be identified. Impacts may result from: (a) a decrease in the size of a population or a long-term adverse effect on an ecological community	Sections 5.1, 5.2, 5.3.3, 5.3.4 and 5.3.5 and Appendix B EIS Chapter 11: Flora and Fauna, Sections 11.9, 11.12.1 and 11.12.2

Flora and fauna Terms of Reference requirement		Report section
	(b) reduction in the area of occupancy of the species or extent of occurrence of the ecological community (c) fragmentation of an existing population or ecological community (d) disturbance or destruction of habitat critical to the survival of the species or ecological community (e) disruption of the breeding cycle of a population (f) modification, destruction, removal, isolation or reduction of the availability or quality of habitat to the extent that the species is likely to decline (g) modification or destruction of abiotic (non-living) factors (such as water, nutrients or soil) necessary for the ecological community's survival (h) the introduction of invasive species that are harmful to the species or ecological community becoming established (i) interference with the recovery of the species or ecological community.	
11.27	The EIS should describe any mitigation measures proposed to reduce the impact on the listed threatened species and ecological communities and proposed mitigation measures. Supporting evidence should be provided to demonstrate the appropriateness of mitigation measures proposed. Where the likely success of mitigation measures cannot be supported by evidence, identify contingencies in the event the mitigation is not successful.	Sections 5.2 and 5.3.2 EIS Chapter 11: Flora and fauna, Sections 11.9 and 11.10
11.28	The EIS should describe any offsets proposed to compensate for residual impacts.	Section 5.4 and Appendix I EIS Chapter 11: Flora and fauna, Section 11.13
List of potential listed threatened species and their status		
11.29	The EIS must address impacts on, but not limited to, the following listed threatened species for the proposed action: (a) Regent Honeyeater (*Anthochaera phrygia*) – critically endangered; (b) Australasian Bittern (*Botaurus poiciloptilus*) – endangered; (c) Curlew Sandpiper (*Calidris ferruginea*) – critically endangered; (d) Coxen's Fig-Parrot (*Cyclopsitta diophthalma coxeni*) – endangered; (e) Eastern Bristlebird (*Dasyornis brachypterus*) – endangered; (f) Red Goshawk (*Erythrotriorchis radiatus*) – vulnerable; (g) Squatter Pigeon (southern subspecies) (*Geophaps scripta scripta*) – vulnerable; (h) Painted Honeyeater (*Grantiella picta*) – vulnerable; (i) Swift Parrot (*Lathamus discolor*) – critically endangered, marine; (j) Eastern curlew, Far Eastern Curlew (*Numenius madagascariensis*) – critically endangered, marine, migratory; (k) Black-throated Finch (southern) (*Poephila cincta cincta*) – endangered; (l) Australian Painted Snipe (*Rostratula australis*) – endangered, marine; (m) Black-breasted Button-quail (*Turnix melanogaster*) – vulnerable; (n) Large-eared Pied Bat (*Chalinolobus dwyeri*) – vulnerable: (o) Corben's Long-eared Bat; South-eastern Long-eared Bat (*Chalinolobus dwyeri*) – vulnerable; (p) Northern Quoll (*Dasyurus hallucatus*) – endangered; (q) Spotted-tail Quoll (SE mainland population) (*Dasyurus maculatus*) – endangered; (r) Greater Glider (*Petauroides Volans*) – vulnerable; (s) Brush-tailed Rock-wallaby (*Petrogale penicillata*) – vulnerable; (t) Koala (*Phascolarctos cinereus*) (combined population of Queensland, New South Wales and the Australian Capital Territory) – vulnerable; (u) Long-nosed Potoroo (SE mainland) (*Potorous tridactylus tridactylus*) – vulnerable; (v) New Holland Mouse (*Pseudomys novaehollandiae*) – vulnerable; (w) Grey-headed Flying-fox (*Pteropus poliocephalus*) – vulnerable; (x) Collared Delma (*Delma torquata*) – vulnerable (y) Yakka Skink (*Egernia rugosa*) – vulnerable; (z) Dunmall's Snake (*Furina dunmalli*) – vulnerable;	Species relevance to Project - Sections 4.3 and 4.4 Impacts relevant to species – Sections 5.1 and 5.3.2 EIS Chapter 11: Flora and fauna, Sections 11.6.2 to 11.6.8, 11.7, 11.9, 11.10 and 11.11

Flora and fauna Terms of Reference requirement		Report section
	(aa) Condamine Earless Dragon (*Tympanocryptis condaminensis*) – endangered; (bb) Five-clawed Worm-skink, Long-legged Worm-skink (*Anomalopus mackayi*) – vulnerable; (cc) Murray Cod (*Maccullochella peelii*) – endangered; (dd) Hairy-joint Grass (*Arthraxon hispidus*) – vulnerable; (ee) Satin-top Grass (*Bothriochloa bunyensis*) – vulnerable; (ff) Miniature Moss-orchid, Hoop Pine Orchid (*Bulbophyllum globuliforme*) – vulnerable; (gg) Stream Clematis (*Clematis fawcettii*) – vulnerable; (hh) King Blue-grass (*Dichanthium queenslandicum*) – endangered; (ii) Bluegrass (*Dichanthium setosum*) – vulnerable; (jj) *Grevillea quadricauda* – vulnerable (kk) Tall Velvet Sea-berry (*Haloragis exalata* subsp. *velutina*) – vulnerable; (ll) *Leionema obtusifolium* – vulnerable; (mm)Wandering Pepper-cress (*Lepidium peregrinum*) – endangered; (nn) Macadamia nut (*Macadamia integrifolia*) – vulnerable; (oo) a grass (*Paspalidium grandispiculatum*) – vulnerable; (pp) Mt Berryman Phebalium (*Phebalium distans*) – critically endangered; (qq) Hawkweed (*Picris evae*) – vulnerable; (rr) Austral Cornflower, Native Thistle (*Rhaponticum australe*) – vulnerable; (ss) Quassia (*Samadera bidwillii*) – vulnerable; (tt) Waxy Sarcochilus, Blue Knob Orchid (*Sarcochilus hartmannii*) – vulnerable; (uu) Blotched Sarcochilus, Weinthal's Sarcanth (*Sarcochilus weinthalii*) – vulnerable; (vv) *Sophora fraseri* – vulnerable; (ww) Austral Toadflax, Toadflax (*Thesium australe*) – vulnerable.	
11.30	The EIS must address how the impacts to each of the listed species is not inconsistent with relevant recovery plans, threat abatement plans and conservation advices.	Sections 5.3.4 and 5.3.5 EIS Chapter 11: Flora and fauna, Sections 11.11.1 and 11.11.2
List of potential listed threatened communities		
11.31	The EIS must address impacts on the following listed threatened ecological communities for the proposed action: (a) Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions – endangered; (b) Lowland Rainforest of Subtropical Australia – critically endangered; (c) Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland – critically endangered; (d) Weeping Myall Woodlands – endangered; (e) Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions – endangered; and (f) White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (also known as Box-Gum Grassy Woodland and Derived Grassland) – critically endangered.	TEC relevance to Project – Sections 4.3.1.2 and 4.4.1.3 Impacts relevant to TEC – Sections 5.1, 5.3.2 and 5.3.3 EIS Chapter 11: Flora and fauna, Sections 11.5 to 11.7 11.9, 11.10 and 11.11.1
11.32	The EIS must address how the impacts to each of the listed communities is not inconsistent with relevant recovery plans, threat abatement plans and conservation advices.	Section 5.3.3 and Appendix B EIS Chapter 11: Flora and fauna Section 11.11.1
Offsets		
11.33	The EIS must describe any significant adverse residual impacts of the action for each relevant matter protected by the EPBC Act, after all proposed avoidance and mitigation measures are considered.	Sections 5.3.3, 5.3.4 and 5.3.5 EIS Chapter 11: Flora and fauna, Section 11.11

Flora and fauna Terms of Reference requirement		Report section
11.34	The EIS must propose offsets for all residual impacts to matters protected by the EPBC Act consistent with the Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy.	Section 5.4 and Appendix I EIS Chapter 11: Flora and fauna, Section 11.12.3
Conclusion		
11.35	The EIS must include an overall conclusion for the action describing the acceptability of the impact of undertaking the action in the manner proposed on the protected matters, in the context of: (a) the requirements of the EPBC Act; (a) the principles of ecologically sustainable development and the precautionary principle; and (b) the proposed avoidance, mitigation measures, and if relevant, offsets measures proposed to address any residual impacts.	Section 8 EIS Chapter 11: Flora and fauna, Section 11.5.4, 11.5.8, 11.11, 11.12.3 and 11.14

1.6 Project location and existing land use

The Project is located within the Toowoomba Regional Council and Lockyer Valley Regional Council local government areas (LGAs) in the Brigalow-belt (BB) and SEQ bioregions.

The Project is co-located with the existing West Moreton System and will generally be located within the existing Gowrie to Grandchester future State transport corridor protected under the *Transport Planning and Coordination Act 1994* (Qld) in 2005.

The Project provides a link between the adjacent Inland Rail Projects of:

- Border to Gowrie (B2G) to the west, where B2G connects to the West Moreton System rail corridor between the Kingsthorpe and Gowrie
- Helidon to Calvert (H2C) to the east, where H2C connects to the West Moreton System rail corridor north-west of Helidon.

The MNES study area includes a broad range of landscapes, from developed urban areas, industrial and waste management precincts, isolated rural settlements, open woodland, pastoral and agricultural landscapes to the undulating and vegetated foothills of the Great Dividing Range. Extensive areas within the MNES study area have been cleared for agricultural purposes and for the development of residential communities. These areas include typical built infrastructure such as powerlines, landfills, water treatment plants and pipelines.

In the western part of the MNES study area, large areas of land have been cleared for pasture, agricultural production and for rural and urban residential settlements. The Project is co-located with the West Moreton System within the western extent and is parallel to Gowrie Creek, before diverging from the rail corridor east of Gowrie. Gowrie Creek and the associated floodplain is a key feature of the area. Within this area the InlerLinkSQ intermodal facility is currently being constructed on high industrial zoned lands.

The Project passes in tunnel under the Toowoomba plateau, passing under the localities of Cranley, Mount Kynoch, and Ballard and emerging on the eastern side of the Toowoomba Range near Mt Kynoch. The area above the tunnel includes the Toowoomba Bypass and the West Moreton System along with the Toowoomba waste management centre, Wetalla Wastewater Treatment Facility and a light industrial area. Gowrie Creek and the associated floodplain is a key feature of the area. There are also a number of large rural blocks in this area, with residential housing located near the tunnel alignment, west of the New England Highway.

The eastern extent of the MNES study area is characterised by large tracts of remnant vegetation and steep, hilly landscapes of the Great Dividing Range and Helidon Hills. The undulating uplands of these ranges are a dominant feature in the landscape that separates the fertile arable floodplains of the Lockyer Valley from the Toowoomba plateau. The Toowoomba Bypass is a key feature of the landscape, with the Project intersecting and paralleling this road at a number of locations.

The largest settlement in the MNES study area is the regional city of Toowoomba, situated on an escarpment on the western side of the Great Dividing Range, approximately 700 m above sea level and 130 km west of Brisbane with a population of 160,779 (Australian Bureau of Statistics 2016). The suburbs of Harlaxton, Cotswold Hills and Wilsonton Heights are all considered part of Toowoomba along with the adjacent suburbs of Cranley (1,446) and Mount Kynoch (237). These suburbs are either impacted by Project infrastructure (including the intermediate ventilation building) or have potential views towards the Project.

Smaller rural settlements and localities within the MNES study area include Kingsthorpe, Murphys Creek, Withcott and Helidon, which have populations of 224, 221, 1,844 and 1,059 respectively (Australian Bureau of Statistics 2016). There are also several areas of acreage estates and emerging residential communities within the vicinity of Kingsthorpe, Gowrie, Cotswold Hills, Blue Mountain Heights, Withcott, Postmans Ridge and Helidon Spa.

The Project does not intersect any protected areas under State and/or Commonwealth legislation, but it does intersect parts of the GDR which is an area of local, regional and State significance.

1.6.1 Project alignment

The significant vertical difference (350 metres (m)) between Gowrie at 500 m relative level (RL) and the base of the Toowoomba Range, part of the wider Great Dividing Range (GDR) at 150 m RL at Lockyer Creek creates a significant challenge for the rail alignment design in producing a safe and efficient route for trains to traverse the range. From the western tunnel portal to east of Lockyer Creek, the rail alignment is at a constant grade of 1:64 (or 1.55 per cent). This is achieved via the tunnel, along with a series of viaducts, cuts and embankments. A schematic of the Project alignment relevant to the local topography is provided in Figure 1.4, while long sections of the Project alignment are provided in EIS Appendix C: Design drawings.

The Project alignment begins approximately 3.7 km west of Gowrie, at Charlton where it connects with the eastern end of New South Wales/Queensland (QLD) Border to Gowrie (B2G) Inland Rail project. It then runs east, parallel (southern side) to the existing West Moreton System rail corridor (Western Line), for approximately 4.8 km before diverging from the West Moreton System rail corridor and passing into the proposed western tunnel portal within the vicinity of Boundary Street and the Toowoomba Bypass interchange at Gowrie Junction.

A 500 m spur line linking the western tunnel portal to the West Moreton System to allow rail traffic access to and from Toowoomba is also proposed.

The alignment then continues through the Toowoomba Range via an approximately 6.24 km long tunnel with an intermediate ventilation shaft (and associated infrastructure) at Cranley. On the eastern side of the tunnel, the alignment exits the range through the eastern tunnel portal at Ballard, approximately 1.6 km southeast of Mount Kynoch. This area is recognised under the State Planning Policy (SPP) as a key resource area (KRA) (i.e. Harlaxton).

The alignment deviates to the northeast across the northwest corner of the former Rifle Range at Mount Lofty, before extending across the Roma Brisbane Gas Pipeline and Wallens Road. The alignment crosses over Jones Road and Oaky Creek on viaduct approximately 0.7 km long and 42 m in height. The alignment then extends eastwards via a series of viaducts, cuts and embankments for approximately 3 km across an undulating landscape parallel to and south of the Toowoomba Bypass and north of Rocky Creek to McNamaras Road.

The alignment then extends northwest under McNamaras Road via a proposed road over rail bridge before crossing over the Toowoomba Bypass and Gittins Road via an approximately 1 km long viaduct up to 20 m above the road surface, east of Wards Hill. The alignment then loops around Wards Hill, approximately 3 km in length, before extending southeast parallel and in some instances adjoining the Toowoomba Bypass to the north for 2 km before crossing over Murphys Creek Road. The alignment which is primarily on viaduct (approximately 1.79 km) passes to the south of Squires Road and deviates to the southeast avoiding the main operational area of Withcott Seedlings and the two storage dams, past Ashlands Drive.

The Project crosses the Roma Brisbane Gas Pipeline, Lockyer Creek and the West Moreton Rail System (Main Line) via a 500 m long viaduct after which it again runs parallel (northern side) for 800 m to the existing West Moreton System rail corridor (Main Line) to connect with the Helidon to Calvert (H2C) Inland Rail project, to the north-west of Helidon.

The Project design has responded to key environmental features and community/land issues and has been developed in line with engineering constraints for a feasible rail design. The rail design is based on balancing environmental impact, disturbances to existing infrastructure and communities and achieving engineering design criteria.

The changes have resulted in the Project alignment deviating outside of the Gowrie to Grandchester future State transport corridor from Project Chainage (Ch) 26.0 km to Ch 28.0 km.

The location of the Project alignment, including the Project disturbance footprint, which includes the combined permanent operational and temporary construction disturbance footprints is shown in Figure 1.2.

The intended land use for the Project is rail and associated infrastructure, including road realignments, grade separations and ancillary infrastructure. An area within close proximity of the western portal of the tunnel, adjacent to the existing railway near Hermitage Road, Cranley, has been identified as the potential location for the intermediate tunnel ventilation infrastructure.

1.7 Consequences of not proceeding with Inland Rail

Not progressing with Inland Rail would potentially have significant negative impacts on the future growth of the national economy.

Without Inland Rail, road would increasingly become the dominant mode with rail becoming less relevant. A continued over-reliance on road transport to meet the future east coast freight task will increase the vulnerabilities to demographic changes which are, even today, driving shortages of long-distance truck drivers and increasing costs.

More specifically, if investment in the east coast freight corridor is not undertaken to increase capacity and minimise supply chain costs, the following risks are highly likely to eventuate:

- National productivity and economic growth will be constrained
- Freight companies and the consumers of products transported along the corridor are expected to experience excessive freight costs
- There will be an increase in congestion on both rail and road networks, given the reliance on shared freight/passenger corridors
- There will be an increase in the number of trucks on urban and regional roads required to move the rising freight volumes
- Larger trucks (i.e. B-doubles, B-triples) will be mixing with smaller passenger vehicles on major highways
- Governments will be required to make significant investments in major arterial and regional roads to ensure they can support the increase in the number and size of heavy vehicles
- There will be a deterioration of safety on the road network with existing infrastructure not supportive of changes in vehicle mix
- Ongoing fuel use and emissions discharged from an increased number and size of heavy vehicles will have environmental impacts
- An increase in freight road traffic will have major impacts on urban and regional communities on the freight route such as congestion, amenity and noise, resulting in safety and environmental issues
- Significant economic impacts associated with the inability of the freight network to meet the demand for goods and services.

1.7.1 Consequences of not proceeding with the Gowrie to Helidon Project

On a Project scale, the consequences of not proceeding with the Project, will require the upgrade of the existing QR rail network and/or alternative mechanisms (road transport) to move freight between Toowoomba and Brisbane. Both options would potentially impact on the Inland Rail Program's objective of providing a road competitive service that will see freight delivered from Melbourne to Brisbane, in less than 24 hours with reliability, pricing and availability that is equal to, or better than road.

QR has undertaken works to improve the efficiency and capacity of the Toowoomba Range section of the West Moreton System as per the West Moreton System Information Pack (QR 2016). However, despite these works, additional upgrades of the existing rail network would be required to accommodate the rail traffic generated by Inland Rail because:

- The existing track is narrow gauge which limits the type of locomotives and rolling stock that can be used
- The rolling stock planned for the Project will not be able to use the narrow gauge track, as the Project design incorporates a dual gauge track which allows for connections between the Inland Rail and QR Networks
- The existing West Moreton System supports low axle limits (15.75 tonne axle load (TAL) and less), with the Inland Project catering for 25 TAL, with capacity to increase to 30 TAL
- The existing track has a maximum design speed of 80 kilometres per hour (km/hr) compared to 115 km/hr for the Project. Though, it should be noted that the topography traversed by both alignments, limits the operating speeds.
- The existing rail tunnels are of sufficient capacity to accommodate 40 foot containers but would not be able to accommodate double-stacked freight. In addition, the existing rail tunnels are heritage listed having been constructed in the 1860s which will also constrain any future upgrades.
- The sidings and crossing loops associated with the existing rail network are designed for a smaller train consists (~ 673 m) compared to the train consists proposed on Inland Rail (up to 1,800 m)
- The existing track was impacted by floods in 2011, which is one of the reasons the current alignment was adopted for the Project (Inland Rail Implementation Group 2015).

The Melbourne–Brisbane Inland Rail Alignment Study noted that the termination of Inland Rail at Toowoomba would require a longer pickup and delivery time by road from Toowoomba to Brisbane (approximately 125 km, or 2 to 3 hours) and would have a negative impact on estimated coal freight demand and a halving of the expected inter-capital tonnage. This resulted in a 60 per cent decrease in below rail revenue, while the economic benefit cost ratio decreased by around 80 per cent relative to the full Melbourne-Brisbane scenario, indicating lower efficiency of expenditure.

1.8 Project alternatives

1.8.1 Alternative locations and route options for Inland Rail

The development of an inland railway between Melbourne and Brisbane has been considered for more than a hundred years, first being formally considered in 1902 (ARTC 2015). Inland Rail was initiated in 2006, as a safe, sustainable solution to the freight challenge that will transform the way freight is moved around the country.

Since 2006, two major studies have been commissioned in relation to the development of an inland rail route between Melbourne and Brisbane. The first study, the *North-South Rail Corridor Study* (Department of Transport and Regional Services 2006) examined the adequacy of the existing Melbourne to Sydney to Brisbane rail corridor to meet future freight demand. The study also examined different options for an enhanced, existing coastal route or alternative inland routes. Key issues identified in the study included infrastructure links, engineering, environmental, urban and regional planning issues. A financial and economic analysis was also undertaken on each of the route options. The study identified the 'far western corridor' through Parkes as the preferred corridor.

The purpose of the second study, the *Melbourne-Brisbane Inland Rail Alignment Study* (ARTC 2010), was to evaluate route options within the 'far western sub-corridor'. Two key criteria – capital cost and journey time – were used to establish a shortlist of route options between Melbourne and Parkes, Parkes and Moree, and Moree and Brisbane. The shortlist of route options was then subject detailed to technical, financial and economic assessment, focussing on:

- Environmental and land issues
- Railway operations considerations
- Engineering assessments
- Capital cost estimates.

The preferred alignment for Inland Rail, between South Dynon in Melbourne and Acacia Ridge in Brisbane, incorporated:

- Melbourne to Parkes – 670 km of existing track and 37 km of new track on a greenfield alignment from Illabo to Stockinbingal, bypassing Cootamundra and the Bethungra spiral
- Parkes to North Star – 307 km of upgraded track, and 291 km of new track on a greenfield alignment from Narromine to Narrabri
- North Star to Acacia Ridge – 271 km of new track on a greenfield alignment, 119 km of existing track upgraded from narrow gauge to dual gauge, and 36 km of the existing coastal route.

The North Star to Acacia Ridge alignment included the Toowoomba route which was preferred to the routes via Warwick, with the Toowoomba route having stronger economic merit. Although the Warwick routes were shorter faster than the Toowoomba options, they were also significantly more expensive.

The study also concluded that the Queensland Transport Gowrie to Grandchester future State transport corridor identified in 2003 and protected in 2005 under the *Transport Planning and Coordination Act 1994* (TPC Act) as a future public passenger transport corridor was not the optimum solution for the inland railway. The preferred route through the Toowoomba Range was via Murphys Creek due to a shorter tunnel length and the preference of the study to follow existing rail corridors.

The Murphys Creek option design paralleled the existing West Moreton System rail corridor (to the north) and Gowrie Creek from the tie in the NSW/QLD Border to Gowrie (B2G) project for approximately 4.2 km. The route then deviated to the north-east through a tunnel (at Birnam (East)), for approximately 4.5 km, under the localities of Birnam (East), Highfields, Ballard before exiting between the West Moreton System at Spring Bluff and Mt Ben Lomond in the locality of Murphys Creek. The route then followed Murphys Creek Road for approximately 4.8 km before tying into the existing West Moreton System to the north-west of Murphys Creek township. The route was generally co-located, for approximately 12 km with the existing West Moreton System to Airforce Road where it tied into the Helidon to Calvert (H2C) project.

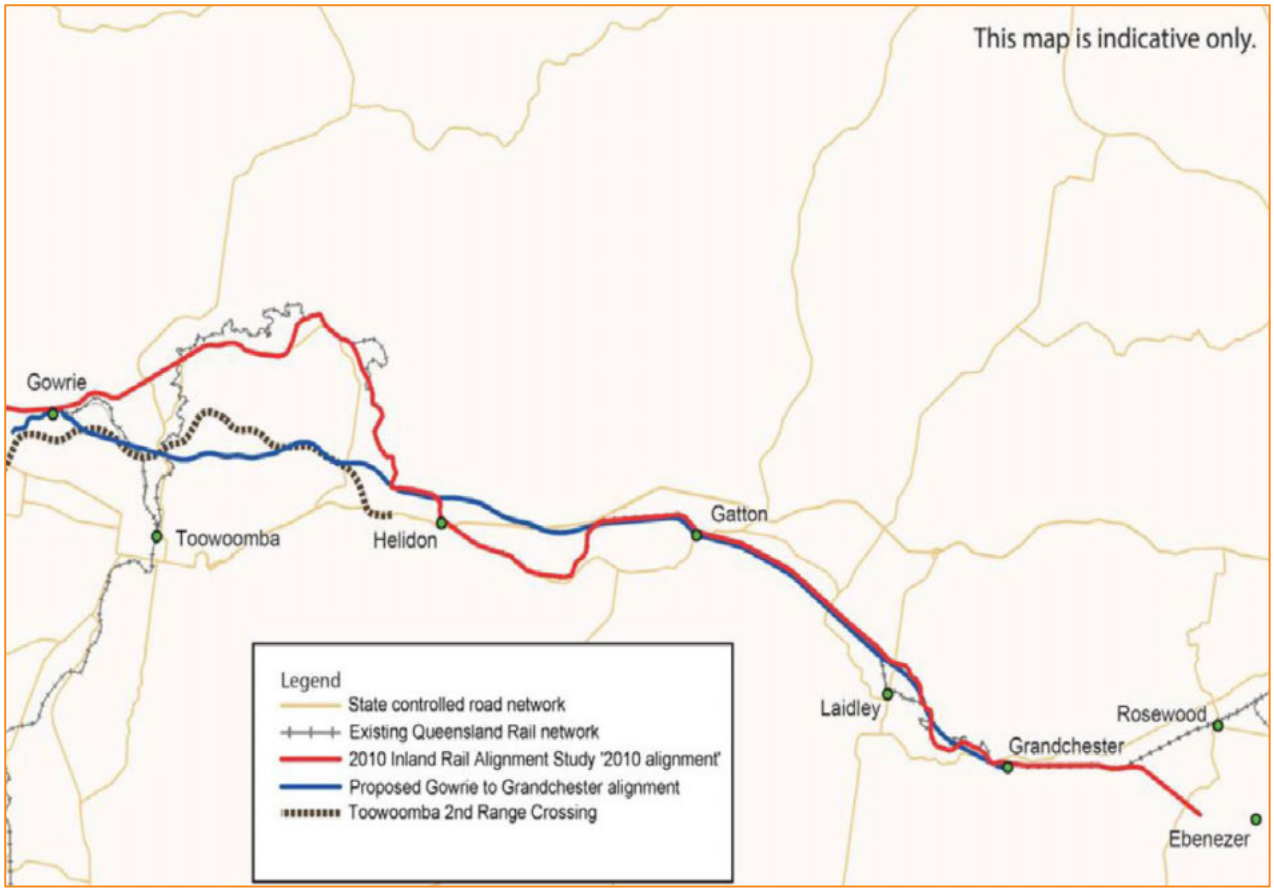


Figure 1.3 **Inland Rail alignment Gowrie to Grandchester - 2003 and 2010 options**

Source: Inland Rail Implementation Group 2015

The Murphys Creek alignment and Grandchester future State transport corridor are illustrated in Figure 2.2. Noting that the Murphys Creek option is presented by the 2010 alignment and the Grandchester future State transport corridor by the 2003 alignment.

The study also noted that some QR maintenance costs could be avoided by closing the existing Toowoomba Range crossing. This is estimated to average $7.2 million per annum, covering routing maintenance for sleepers, ballast, track, structures, but excluding one-off projects.

To progress Inland Rail in late 2013, the Inland Rail Implementation Group (IRIG) was established. The IRIG prepared a report for the Australian Government in 2015, which set out a strategic analysis of the need for Inland Rail as one potential solution to the future freight task along the Melbourne-Brisbane corridor and included the main features of Inland Rail Programme Business Case (ARTC 2015).

The IRIG noted that further engineering, hydrological and geotechnical assessments were required between North Star and Toowoomba which may result in a deviation of the alignment in this section.

The report endorsed the adoption of the Queensland Transport Gowrie to Grandchester corridor (i.e. Gowrie to Grandchester future State transport corridor) that was protected in 2005 under the TPC Act in preference to the Murphys Creek option, due to the following:

- Using the existing corridor would result in a significant time saving (around two years) relative to proceeding through the statutory processes to formally identify a new corridor for the 2010 alignment and removes a significant element of planning risk
- Substantial elements of the 2003 alignment had already been acquired by the Queensland Government (33 out of 133 properties)
- Community severance and disruption, noise and dust through Helidon, Murphys Creek valley and in the vicinity of Gowrie Junction would be minimised by using the 2003 alignment

- The 2003 alignment was substantially a greenfield development which minimised impacts on the existing operating QR corridor.

In addition, the Murphys Creek alignment was significantly impacted by the 2011 floods through the Lockyer Valley and to a lesser degree in the Gowrie area.

This alignment for Inland Rail, including the Gowrie to Grandchester future State transport corridor was endorsed by the Inland Rail Implementation Group in 2015 as the base case alignment.

More detail on alternative locations and route options for Inland Rail is available in EIS Chapter 2: Project rationale.

1.8.2 Alternative locations and route options for the Project

Following from the IRIG Report, ARTC's task as the delivery agent for Inland Rail was to examine whether there were cost-effective opportunities to improve upon the 2015 IRIG alignment in order to improve outcomes beyond the Inland Rail Service Offering. An option was assessed to the point where it was determined that it was either too expensive or degraded the Service Offering.

In all instances, the guiding principles of ecologically sustainable development have been factored into the assessment and selection of corridor and alignment options for the Project. These guiding principles, as established in the National Strategy for Ecologically Sustainable Development (Ecologically Sustainable Development Steering Committee 1992), are as follows:

- Decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations
- Where 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
- The global dimension of environmental impacts of actions and policies should be recognised and considered
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised
- The need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised
- Cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms
- Decisions and actions should provide for broad community involvement on issues which affect them.

1.8.2.1 Deviation at Wards Hill

This section discusses the proposed deviation outside of the Gowrie to Grandchester future State transport corridor.

As noted above the Gowrie to Grandchester future State transport corridor was the preferred alignment between Gowrie and Helidon. This corridor was identified as the preferred alignment for possible future high speed (200 km/h where feasible) railway by QR and Queensland Transport (now DTMR) in 2003 (i.e. Gowrie to Grandchester rail corridor study (QR and Queensland Transport 2003)). The evolution of this corridor, along with a description of the alignment is outlined in EIS Chapter 2: Project rationale.

In 2016 a robust multi-criteria analysis process was undertaken to provide a preferred alignment and an associated study area for Gowrie to Helidon. The MCA process also provided an opportunity to re-assess the Gowrie to Grandchester future State transport corridor based on the following:

- Addressing business continuity / flood immunity challenges
- Providing route clearance for double-stack containers

- Changes in constraints
- Capital cost reduction.
- Refining the route for improved outcomes
- Amending the alignment to reduce environmental and other impacts.

The MCA was undertaken in consultation with DTMR, TRC and LVRC and was supported by technical assessments including noise monitoring and ecological investigations.

It was determined that the MCA would only consider the Helidon tunnel through Wards Hill between the Toowoomba tunnel and Helidon where the alignment was proposed to be 1 in 60 grade. Noting that there were no critical drivers to assess the western tunnel portal or the tunnel alignment.

Four options were considered:

- Option 1: This option is the Base Case, Gowrie to Grandchester future State transport corridor. The alignment is 4.5 km in length, all of which is greenfield, and includes a short tunnel (190 m).
- Option 2: This route utilises the natural terrain on the northern side of the ridge near Howmans Road and provides the opportunity to flatten the 1:60 grade. Following the natural topography around Wards Hill north of the Base Case allows for the reduction in the viaduct length across Six Mile Creek. Importantly, it also allows the rail line to cross over the Toowoomba Bypass close to perpendicular, rather than on an acute skew angle, this may provide improved design and installation of piers near the Toowoomba Bypass if required. There is also a short (170 m) tunnel required.
- Option 3: This alignment is similar to option 1 Base Case, however, this option removes the tunnel and replaces it with a large cut (41 m deep).
- Option 4: This route utilises the natural terrain on the northern side of the ridge near Howmans Road, the same as the option 2. However, this option removes the tunnel and replaces it with a large cut (21 m deep).

These options were comparatively assessed using a multi-criteria analysis (MCA), which considered:

- Technical viability
- Safety
- Operational constraints
- Constructability and schedule
- Environmental constraints (including MNES)
- Community and property issues
- Approvals and stakeholder concerns.

The outcome of the MCA showed that option 3 received a marginally better score relative to all the other options, with a saving of $21 million compared to the Base Case, making it preferable to the Base Case.

Although, option 4 scored lower in the MCA relative to the Base Case, it provides the opportunity for significant cost savings of the order of $46 million. The savings are a result of an improved earthworks balance, reduction in construction complexity by adopting a cut instead of a tunnel and a reduction in major structure length. The lower MCA score for option 4 resulted from the following key issues when compared to the Base Case:

- The alignment does not achieve the future proofing requirement for horizontal geometry.
- There is a small potential increased travel time due to the increased length.
- The route has more direct property impacts
- The corridor deviates from the Base Case alignment which will likely impact approvals timeframes and does not meet the specifications for a high speed passenger (160 km/hr)

Option 4 scored higher than the Base Case in the following areas:

- Better constructability.

The significant potential cost savings achieved with option 4 when compared to the MCA score made this option the preferred.

This alignment was the subject of the Initial Advice Statement (IAS) and the EPBC Referral submitted for the G2H Project in early 2017 (ARTC 2017b and 2017a, respectively).

1.8.2.2 Design refinements

In 2016, a concept design was produced for the G2H Project alignment, which was generally within the Gowrie to Grandchester future State transport corridor, with the Project alignment deviating outside of the Gowrie to Grandchester future State transport corridor to the north of Wards Hill while the Gowrie to Grandchester future State transport corridor is located to the south of Wards Hill (refer Section 1.8.2.1). This alignment was the subject of the Initial Advice Statement (IAS) and the EPBC Referral submitted for the G2H Project in early 2017.

ARTC has further advanced the rail alignment design between Gowrie and Helidon to satisfy the Inland Rail service offering and basis of design (refer EIS Chapter 6: Project description), along with minimising impacts to landholders and the environment.

This section provides a summary of the main alignment option assessments that were undertaken during the reference design and EIS development phase of the Project, from 2018 to 2020.

The main overarching principles that were applied in positioning the alignment for the reference design were:

- Maximise the use of existing rail corridors
- Outside of existing rail corridors, seek to maximise co-location with existing linear transport infrastructure.

Through considering and applying these principles, additional considerations needed to be optimised through the design process. These included, but were not limited to:

- The nature of the terrain in these areas (e.g. steep grades and/or the need to wind through such areas are not desirable due to the size and weight of the trains)
- Flooding and hydrology (e.g. ensure a 98 per cent level of serviceability for Inland Rail, so the corridor needs to be developed to withstand flood conditions)
- Environmental, social and heritage constraints (e.g. vegetation communities, sensitive receptors, waterway crossings, registered heritage sites)
- Cost (e.g. due to the physical construction requirements in some locations, critical construction constraints exist)
- Travel time (e.g. ARTC has a service offering requirement of less than 24 hours between Melbourne and Brisbane express)
- Constructability (e.g. some locations will make construction more difficult)
- Easement setback requirements (e.g. a number of minimum clearances required from road, power and other public utility easements must be met).

1.8.2.3 Tunnel flood immunity

Further refinement and development of the design determined that the tunnel, in particular the western tunnel portal did not meet the 1 in 10,000 year flood immunity design requirement. ARTC identified a number of alternative options, noting that the rail alignment could not be steepened (i.e. the rail alignment climbs for 22 km at a constant grade of 1:64 (or 1.55 per cent)). While it was possible to flatten the grade, this would significantly lengthen the tunnel and impact on how the Project could tie into the existing QR West Moreton System at Gowrie and Helidon.

An MCA was undertaken to assess two alternative options to overcome this constraint, with the MCA not only assessing the tunnel alignment, but also the section of the Project alignment between the eastern tunnel portal and McNamaras Road to identify any flow on impacts from changes to the vertical and/or horizontal alignment of the tunnel.

- Option 1: This alignment was presented in the G2H IAS (ARTC 2017) and follows the Gowrie to Grandchester corridor except for the area around Wards Hill. The flood immunity of this alignment did not meet the required flood immunity at the western tunnel portal location.
- Option 2: This alignment was developed to resolve the flood immunity issue at the western tunnel portal. The horizontal and vertical alignment through the tunnel was different to option 1 with new portal locations, all outside the Gowrie to Grandchester corridor. The western tunnel portal location was shifted 600 m to the south-west and the eastern tunnel portal 100 m to the north, closer to the Roma Brisbane Gas Pipeline and in relatively similar vegetation to option 1 and option 3. The new tunnel portal locations achieved a flatter tunnel grade of approximately 1 in 74 and total tunnel length of approximately 6.4 km.
- Option 3: This option was developed to resolve the flood immunity issue at the western tunnel portal whilst also reducing tunnel length. The alignment followed the horizontal alignment of option 1 through the tunnel, but the western tunnel portal entrance was relocated to the east along the alignment to an existing high point to improve flood immunity. The vertical alignment was raised by approximately 7 m to meet this high point. East of the tunnel the alignment was refined to balance cut/fill, noting that the earthworks volumes were greater than option 1 to accommodate the change in the vertical alignment which resulted in the alignment moving outside of the Gowrie to Grandchester future State transport corridor. For option 3 approximately 6 km of tunnel and 4.8 km of viaduct was proposed, with an alignment grade of 1 in 64.

Overall, option 3 was determined as the optimal option for the future design of the tunnel due primarily to the alignment complying with the required 1 in 10,000 year flood immunity requirements, as well as requiring a shorter tunnel length.

The other two optioneering assessment were localised and aimed to minimise impacts on proposed and existing built infrastructure

- The InterLinkSQ project is a master-planned at Charlton, intermodal freight terminal linking rail, road, air and sea in SEQ. Two options were developed in accordance with ARTC's design standards to minimise impacts on InterLinkSQ and the Western Line along with tie-ins between the projects.
- Three alternative alignments were developed in accordance with ARTC's design standards to resolve conflict with the Withcott Seedling Farms evaporation ponds and operations

Additional site-specific information on alternative locations and route options for the Project is provided in Chapter 2: Project rationale.

1.9 Project description

Key elements of the Project design have responded to environmental and engineering constraints to produce a feasible rail design. The Project design is based on minimising environmental and social impacts, minimising disturbance to existing infrastructure and meeting engineering design criteria.

The Project consists of the following key permanent and temporary features listed in Table 1.2. A detailed description of what is constitutes the Project is provided in Section 1.13, 1.14 and 1.15.

Table 1.2 Key features of the Project

Aspect	Description
Permanent features	
New track	■ Approximately 28 km of new single-track dual gauge railway
Rail corridor	■ Establishment of approximately 22.4 km of new "greenfield" rail corridor ■ Development of approximately 5.6 km of "brownfield" rail corridor ■ The land required for the Project comprises a corridor with a minimum width of 62.5 m. A reduced corridor is required where the Project is co-located with the existing rail corridor or for the tunnel. ■ The rail corridor will be of sufficient width to allow future crossing loop extensions to accommodate trains of up to 3,600 m in length ■ The rail corridor will include land associated with the intermediate tunnel ventilation shaft and supporting infrastructure, access roads and other supporting infrastructure (e.g. water pipelines)
Tunnel	■ Construction of an approximately 6.24-km long undrained tunnel through the Toowoomba Range including expanded corridor to accommodate tunnel portal infrastructure (e.g. tunnel operations facilities and tunnel material stockpile at the western tunnel portal) ■ Intermediate ventilation shaft (which draws in air to ventilate the tunnel) and associated infrastructure to be established at Cranley ■ Land acquisition (volumetric) for the tunnel will include a provisional area around the tunnel to protect the asset from future development
Crossing loops and turnouts	■ Crossing loops are placed on a single-line track where trains in opposing directions can pass each other ■ Three crossing loops will be constructed as part of the Project, each a minimum of 2,200 m in length ■ Turnouts allow the train to be guided from one section of track to another. Turnouts that tie-in to the existing QR West Moreton System rail corridor will be incorporated as part of the Project. There are 16 turnouts proposed along the alignment, including those associated with: – Crossing loops – Maintenance sidings – Cross overs between Inland Rail and the existing QR West Moreton System rail corridor – Connection to the proposed InterLinkSQ facility – Connection provided at the western tunnel portal to the QR West Moreton System rail corridor to allow for train movements between Brisbane and Toowoomba
Bridges and viaducts	■ Bridges and viaducts to accommodate topographical variation, crossings of waterways or other infrastructure such as roads ■ There are 13 new bridge and viaduct structures, totalling approximately 6.7 km in length, proposed for the Project, comprising: – Two rail-over-waterway viaducts – Three rail-over-terrain-and-waterway viaducts – Four rail-over-terrain-road-and-waterway viaducts – One rail-over-road-rail-and-waterway viaduct – One rail-over-waterway bridge – One road-over-rail-and-waterway bridge – One road-over-rail bridge ■ Instream structures and scour protection measures associated with waterway crossings where relevant
Drainage	■ Reinforced concrete pipe culverts and reinforced concrete box culverts. Scour protection measures will generally be installed around culverts and other drainage structures to minimise the potential for erosion
Rail crossings	■ Rail crossings including grade separations/rail or road overbridges, occupational/private crossings and fauna crossing structures

Aspect	Description
Embankments and cuttings	■ Embankments and cuttings will be required along the length of the alignment which includes road and rail infrastructure within the alignment such as crossing loops and road over rail bridges ■ The total length of embankments required for the Project will be in the order of 15.4 km with a maximum embankment height of 33.3 m ■ The total length of cut for the Project will be in the order of 6.65 km with a maximum cut depth of 45.7 m
Ancillary works	■ Associated rail infrastructure including maintenance sidings, Safeworking Systems and signalling infrastructure ■ Ancillary works include signalling and communications, signage and fencing, drainage works, establishment and/or reinstatement of access roads, and installation or modification of services and utilities ■ Road closures and realignments; including closure of an existing level crossings on the QR West Moreton System rail line at Gowrie
Environmental treatments	■ Potential noise barriers, fauna crossing structures, instream structures and fish passage design, fauna exclusion fencing, and rehabilitation and landscape treatments
Temporary features	
Land	■ Temporary access tracks will be used to access construction sites. Where required, they will be retained to serve as rail maintenance access roads (RMAR) during the operation of the Project ■ Land requirements for construction will include temporary workspace, site offices and laydown facilities ■ Laydown areas will be located approximately every 5 to 10 km (avoiding 1% annual exceedance probability (AEP) floodplains where possible). Laydown areas will be required for activities such as tunnel construction, flash butt welding, concrete batching, water treatment facilities and rail assembly. ■ Approximately 2,500 square metres (m^2) of laydown areas to support bridge construction (where practicable, smaller in sensitive habitats)
Material sourcing	■ Identification, and lawful use, of established quarries for sourcing construction materials

Subject to approval of the Project, construction of the Project is planned to start in 2022 and is expected to be completed in 2027.

1.10 Timing

Subject to approval of the Project under the SDPWO Act and the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act), construction is planned to commence in 2022 and is expected to be completed and the Project commissioned in 2027. The anticipated timing of phases for the Project are shown in Table 1.3.

Table 1.3 Anticipated timing of Project phases

Project phase	2021				2022				2023				2024				2025				2026				2027			
Detailed design																												
Pre-construction and early works																												
Construction																												
Commissioning																												
Operation																												

A construction contractor is expected to be appointed in the second half of 2021, with this also coinciding with the commencement of the detailed design phase of the Project. The Toowoomba Range tunnel is the longest single construction task associated with the Inland Rail Program, with a construction duration closely approaching four years.

Train operations are not anticipated to commence until all 13 sections of the Inland Rail Program are completed in 2027. However, subject to relevant infrastructure access agreements there is the potential for West Moreton System rail traffic to access the alignment prior to the completion of the Inland Rail Program.

1.11 Design

The key characteristics of the Inland Rail Program service offering are reliability, price, transit time and availability. To help achieve this service offering, ARTC have developed a consistent set of design requirements and parameters to be applied across the Inland Rail Program. Establishing consistent design criteria will normalise designs, delivering an asset that meets the business and operational requirements, is consistent along its length, and subsequently simplifies asset maintenance.

The performance specifications are detailed in EIS Chapter 6: Project description with the medium speed alignment standards (mountainous terrain) applicable to the greenfield area of the Project.

1.11.1 Rail corridor

The Project requires establishment of approximately 22.4km of new rail corridor (greenfield) and utilisation of approximately 5.6 km of existing rail corridor (brownfield), specifically the Western Line and the Main Line which are components of QR's West Moreton System.

The greenfield corridor generally follows the Gowrie to Grandchester future State transport corridor under the Public Passenger Transport Guideline (No. 1) 2019 made under the TPC Act) (Qld) in 2005. This aligns with the direction from the Queensland Government to follow the future State transport corridor.

Further, the Project design corridor is designed for freight and but does not preclude high-speed passenger services at a future date along this corridor. The land and infrastructure requirements (e.g. stations) for the possible future passenger transport service are excluded from this Project and would be progressed by DTMR.

1.11.2 Land requirements

Land requirements for the Project vary depending on whether the land is located in the greenfield corridor (i.e. new rail corridor between Morris Road and Lockyer Creek), or in the brownfield corridor (i.e. co-located with the existing West Moreton System), or in tunnel, and also whether the land is required on a temporary or permanent basis. Ultimately, land will be required for the purposes of either rail or road infrastructure, with some of the land requirements associated with existing rail or road corridors. The land requirements have also considered the future proofing, that is sufficient area to allow for the upgrade of the crossing loops from 2,200 m to that a length required to accommodate a 3,600 m train.

The Project disturbance footprint is approximately 454 hectares (ha) and it is assumed that all lands within the footprint will be directly impacted by the Project, including land clearing, ground disturbance and land acquisition. This will be confirmed during detailed design in consultation with the construction contractor and the constructing authority and in response to the findings of baseline surveys (e.g. ecological studies, cultural heritage assessments), recommendations from the EIS and any relevant approval conditions.

Within sections of brownfield development, reasonable endeavours have been made to remain within the existing rail corridor, widening the corridor only where required to accommodate new rail infrastructure to support the Project or to accommodate the relocation of existing services associated with the QR Network (e.g. road maintenance access roads). The permanent disturbance footprint also incorporates the existing West Moreton System rail corridor.

The Project rail corridor is a minimum of 62.5 m wide through the greenfield area of the alignment (excluding the tunnel), to accommodate earthworks, drainage structures, rail infrastructure, access tracks and fencing. The maximum width of the corridor also varies in response to the undulating terrain of Lockyer Valley due to earthwork requirements and the location of RMARs, with the maximum width being approximately 300 m.

Changes to the existing road networks as a result of the Project are also considered as part of the permanent disturbance footprint. Reasonable endeavours have been made to ensure that the changes remain within the existing road reserves wherever possible. Following construction, these roads will be managed by the relevant road authority (i.e. DTMR or local council).

Excluding untenured land including waterways and road reserves the Project will directly impact 151 land parcels, 94 land parcels within the Toowoomba Regional Council LGA and 57 land parcels within Lockyer Valley Regional Council LGA, along with 41 interests (e.g. easements, strata parcels etc). Some of the land parcels have been acquired by the DTMR, including land for the Toowoomba Bypass or are owned by QR.

Of the 151 land parcels, 82 land parcels (~54 per cent) are located within the Gowrie to Grandchester future State transport corridor with an additional 10 land parcels within the West Moreton System rail corridor. There are then land parcels located in both the Gowrie to Grandchester future State transport corridor and QR West Moreton System rail corridor.

Of the 151 land parcels, 109 will be acquired (full or partial) for the purposes of railway land or road infrastructure, with an additional 30 land parcels subject to volumetric resumption (i.e. no change to tenure of the overlaying land or land use) for the purposes of the Toowoomba Range Tunnel. An additional 12 land parcels are required for construction purposes only. The acquisition process will be undertaken by the constructing authority through agreed negotiation or resumption for the freehold land parcels (123) under the *Acquisition of Land Act 1967* (Qld). State land (28 excluding roads and waterways) land parcels will be managed under the *Land Act 1994* (Qld).

It is expected that the impacted properties will be acquired (freehold) or leased (State land) by the relevant constructing authority, converted to Unallocated State Land and dedicated as ‘railway corridor land’ under the TI Act, or in some cases a road under the Land Act. The land acquired for ‘railway corridor land’ will be subject to similar lands lease tenure arrangements to that of the existing West Moreton System rail corridor (e.g. head lease between ARTC and the DTMR).

1.11.3 Tunnel infrastructure

The Project proposes a 6.24 km long undrained tunnel through the Toowoomba Range (refer to Figure 1.4 for a sketch of the conceptual Toowoomba Range tunnel). The tunnel is oriented west-north-west to east-south-east at an approximate grade of 1 in 64.

The western tunnel portal (Ch 4.10 km) is located within the Gowrie to Grandchester future State transport corridor near the Boundary Street/Toowoomba Bypass interchange and has been designed to ensure a flood immunity of 1:10,000 AEP (refer EIS Chapter 2: Project rationale). The surface level is 510 m AHD and the rail level is 490 m AHD. The approximate 600 m long western approach box cut will be up to 26 m in height at the western tunnel portal face, gradually reducing in height towards the west.

The eastern tunnel portal, location with the Gowrie to Grandchester future State transport corridor south-west of Mount Kynoch, involves a 100 m long cut and a portal face that approximately 13 m in height. The portals are drained and there is the potential for groundwater inflows during construction and operations (refer EIS Chapter 14: Groundwater).

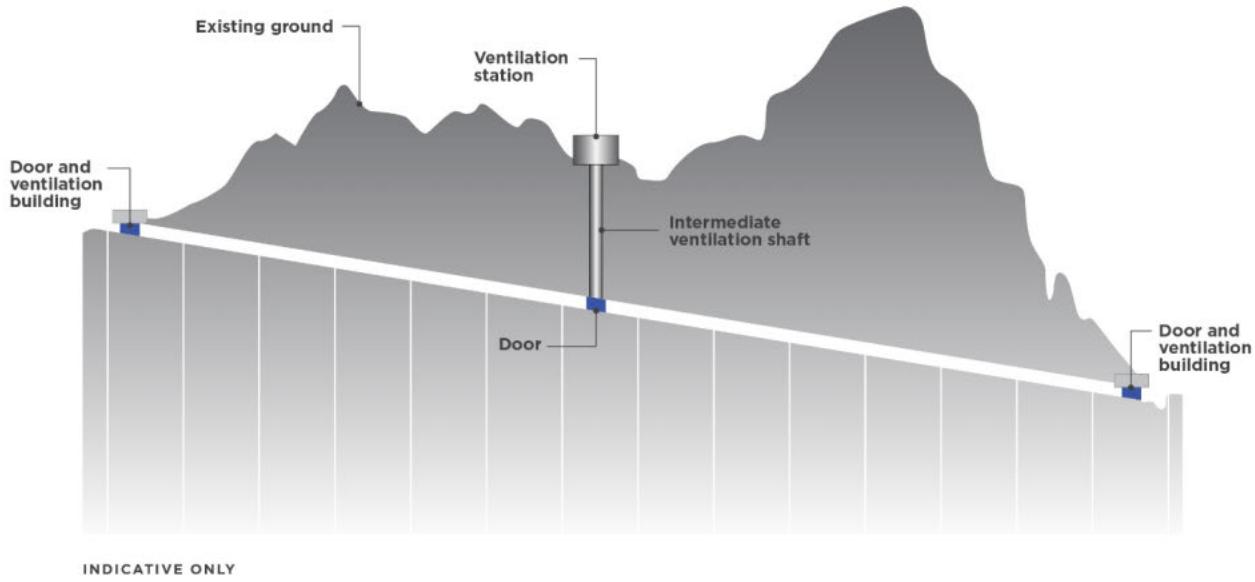


Figure 1.4 Conceptual tunnel cross section sketch through the Toowoomba Range

The tunnel would have a bored diameter of approximately 12.2 m and a finished internal diameter of approximately 10.8 m, with a cross-section area of 73 m^2. The tunnel will include rail tracks, emergency systems and services such as communication and overhead lines. An intermediate ventilation shaft at Cranley, approximately 100 m deep and approximately 17 m in diameter is also proposed as part of the tunnel ventilation system.

The water collected inside the tunnel (groundwater, storm water carry-in, wash-down, firefighting etc) would be collected through a common tunnel drain and stored in a sump at the eastern portal. This water would likely be processed through a water treatment plant and include hydrocarbon and first flush separation. The tunnel alignment grades stormwater towards the western portal which would need to be collected as clean prior to the portal and diverted or pumped to a nearby drainage lines.

The alignment on approach and through the tunnel includes a constant 22 km sustained grade of 1:64.7 from Helidon to the west of the tunnel. This presents significant challenges for rail operations and tunnel ventilation to aspirate the locomotives on the climbing grade in the tunnel and to purge the tunnel of heat and emissions. The ventilation option report identified that a free cross-sectional of 60 square metres (m^2) in the tunnel would provide sufficient train cooling with the assistance of portal doors.

There are three ventilation buildings for the tunnel, one at each portal and one at the intermediate ventilation shaft. The portal ventilation buildings sit directly over the track and house the smoke control fans and longitudinal egress passage (maintenance and evacuation route) fans. The intermediate ventilation shaft building houses both smoke control fans and purge fans.

The tunnel ventilation system would provide purging capability to flush pollutants from the tunnel after passage of the up-grade heavy freight trains. The purge cycle would occur within the stringent requirement of 6 minutes which would require significant fan and power infrastructure. The ventilation system would also provide bidirectional smoke control in the event of a train fire in the tunnel. The same fan system would be used to provide ventilation for maintenance activities but at a reduced air flow.

In case of the train stopping in the tunnel due to fire or other emergency, the tunnel fire and life safety strategy requires a Longitudinal Egress Passage (LEP) as a conventional evacuation passage for passengers, drivers and crew. The LEP would provide for egress every 240 m and communication facilities to contact the operator at the Network Control Centre.

The water collected inside the tunnel (e.g. groundwater seepage, stormwater carry-in, wash-down, firefighting) will be collected through a common tunnel drain and stored in a sump at the eastern portal. This water will be processed through a water treatment plant and discharged to a tributary of Oaky Creek. Stormwater will be collected into a sump prior to the western portal so that it does not flow down the tunnel and will be treated prior to discharge.

1.11.4 Crossing loops

The Project incorporates three new crossing loops, designed to accommodate a 1.8 km train length, with consideration of future provision for 3.6 km train length. The proposed locations of the crossing loops are:

- The western end of the Toowoomba Range tunnel
- The eastern end of the Toowoomba Range tunnel
- Postman's Ridge – located approximately 9.4 km east of the tunnel portal.

The loops would be constructed as new sections of track parallel to the new track. The loops range in length to accommodate the surrounding area and topography and are a minimum of 2.2 km to fit the initial design length of the train.

1.11.5 Connections

Connections are provided to allow trains to move between the existing QR Network (narrow gauge) and Inland Rail (dual gauge). A connection is also proposed with the InterLinkSQ facility. The anticipated locations for connections for the Project are:

- InterLinkSQ connection to the Project approximately 1 km east of Draper Road, Gowrie Junction
- West Moreton System connections to the Project at:
  - Approximately 1 km west of Gowrie Junction Road, Gowrie Junction
  - Spur line, approximately 1.5 km east of Gowrie Junction Road, Gowrie Junction (allowing trains to access Toowoomba)

1.11.6 Bridges and viaducts

There are no existing bridges that require reinstatement or reconstruction along the alignment as a result of the Project.

The Project traverses the steep slopes through the Toowoomba Range at Ballard, Withcott and Lockyer, which requires significant earthworks and structures to maintain the operational gradient. The Project requires 13 new bridge and viaduct structures comprising 10 viaducts and three bridges.

Viaducts are a certain type of bridge that are made up of multiple small spans that cross waterways, terrain, roads or transport infrastructure. Bridges, within the context of this Project, are shorter structures with a simpler design that span waterways, roads or rail, but not terrain.

Bridge and viaduct structures also allow drainage across the corridor; access for roads and rail, farm tracks, stock crossings or pedestrians; span waterways, riparian zones and large valleys; provide for native fauna connectivity; and replace large height embankments where required to reduce the operational footprint.

Bridge and viaduct superstructures are typically formed from pre-stressed precast concrete girders with in-situ decks incorporating walkways, guardrails and barriers as appropriate. The bridges and viaducts are of various lengths and spans to suit the alignment and topography.

The structures are typically founded on driven precast or bored in-situ piled foundations supporting in-situ reinforced concrete substructures. For structures with very tall piers in valleys with rough steep terrain, longer span structural options have been investigated and compared with recommendations made for each location.

New rail bridges are proposed to cross watercourses or roads, or a combination of both, and are summarised in Table 1.4.

Table 1.4 Summary of rail bridges and viaducts

Chainage (Ch)	Bridge name	Type	Crossing type	Length (m)	Maximum height (m)
Ch 1.93 km	Gowrie Junction road bridge	Road bridge	Road, rail and waterway	311	12
Ch 3.40 km	UT1 Gowrie Creek rail bridge	Rail bridge	Watercourse	56	4
Ch 11.63 km	Oaky Creek viaduct	Rail viaduct	Terrain, road and watercourse	736	41
Ch 12.83 km	Withcott viaduct 1	Rail viaduct	Waterway	261	16
Ch 13.64 km	Withcott viaduct 2	Rail viaduct	Terrain and waterway	322	35
Ch 14.12 km	Withcott viaduct 3	Rail viaduct	Terrain and waterway	174	23
Ch 15.15 km	Withcott viaduct 4	Rail viaduct	Waterway	145	24
Ch 15.54 km	McNamaras road bridge	Road bridge	Rail	74	17
Ch 15.89 km	TSRC and Six Mile Creek viaduct	Rail viaduct	Terrain, road and watercourse	966	45
Ch 18.44 km	Postmans Ridge viaduct	Rail viaduct	Terrain, road and watercourse	644	35
Ch 20.98 km	Murphys Creek Road viaduct	Rail viaduct	Terrain, road and watercourse	690	36
Ch 21.84 km	Withcott Seedlings viaduct	Rail viaduct	Terrain and watercourse	1,794	35
Ch 24.45 km	Lockyer Creek viaduct	Rail viaduct	Road, rail and watercourse	506	28

1.11.7 Drainage infrastructure

Cross-drainage structures have been incorporated into the design where the alignment intercepts existing drainage lines and watercourses. The type of cross-drainage structure in the design depends on various factors such as the natural topography, rail formation levels, design flow and soil type. The type of cross-drainage structure may also be dependent on the requirement to facilitate fish passage through a culvert in order to minimise environmental impacts where possible.

As described in Section 1.11.6, viaducts and bridges are proposed over all major waterway crossings intersected by the rail alignment (i.e. Gowrie Creek, Oaky Creek, Six Mile Creek and Lockyer Creek) to avoid disturbance to the existing riverine system.

Cross drainage structures, including culverts, have been designed to meet the design criteria of 1% AEP event. Culverts are structures that allow water (in a watercourse or drainage line/overland flow) to pass under the rail line.

There are 23 reinforced concrete pipe (RCP) culvert locations (with multiple cells in certain locations) and 11 reinforced concrete box culvert (RCBC) identified for the Project (refer EIS Appendix C: Design drawings and EIS Appendix M: Flooding and hydrology). The location of the new culverts has been selected to maintain the existing flow paths and minimise the potential impacts to flood depths upstream and downstream of the culverts. The cross-drainage structures have been designed in accordance with the relevant industry standards.

Where the Project is co-located with the West Moreton System rail corridor the following is proposed:

- The existing culverts under the Western Line at Ch -1.42, Ch 1.46 and Ch 2.41 km will be extended under the Project alignment
- The existing culverts under the Western Line at Ch -0.25, Ch 0.11, Ch 0.21 and Ch 1.03 km will be upgraded (number of cells or size) and extended under both alignments. This aims to improve the flood immunity of the Western Line during a 1% AEP flood event (refer EIS Chapter 13: Surface water and hydrology).

- Culverts will also be provided under the Project alignment Ch -1.76 km and on the spur line connection, with no change to the QR drainage infrastructure under the Western Line proposed
- An existing culvert under the QR Main Line will be upgraded and extended under both alignments (i.e. at Ch 25.94 km an existing RCBC (1 cell) will be upgraded to 5 cells).
- A new culvert under the Project alignment is also proposed at Ch 25.31 km, with no change to the QR drainage infrastructure under the Main Line proposed.

The proposed changes to the road network will also require new drainage structures (e.g. East Paulsens Road). Scour protection measures will generally be installed around culvert entrances and exits and on disturbed stream banks to avoid erosion.

The Project will include the following types of longitudinal drainage:

- Cess drains running directly adjacent to the rail formation in cuts
- Embankment drains – longitudinal drains adjacent to the track in embankment conditions
- Catch drains – longitudinal drains on the uphill side of cuttings.

Longitudinal drainage will also be included to new and or upgraded roads to connect with the existing drainage environment.

1.11.8 Rail interfaces

In addition to the connections outlined in Section 6.2.5, the Project will involve grade separation (i.e. Lockyer Creek Viaduct) over the West Moreton System between Lockyer Creek and Airforce Road, Helidon. The Toowoomba Range tunnel will also cross under, at a depth of over 100 m, the Western Line at Cranley and the Main Line at Ballard. Details of the rail interfaces are provided in Appendix C: Design drawings.

1.11.9 Road rail interfaces

In assessing the need for an interface and their final treatment, the approach is for elimination by not providing a crossing, consolidating crossings, diverting roads or by grade separation. Where this is not possible, a level crossing is proposed. A total of 53 road rail interfaces have been identified within the Project, being 17 public and 36 private interfaces.

Treatments for public road rail interfaces can be categorised as:

- Grade-separated crossings—road and rail cross each other at different heights so that traffic flow is not affected. Grade separations are either road over rail, or rail over road. The design has also ensured that the relevant separation distance between the formation of the rail and the roads surface level is sufficient for current and future traffic
- Crossing consolidation, relocation, diversion or realignment—existing road rail interfaces may be closed, consolidated into fewer crossing points, relocated or diverted. The road network alterations would mainly consist of road realignment whereby existing traffic patterns will be maintained. This is envisaged not to have an impact on existing traffic operations whereby existing geometric lane configurations can be maintained within the newly proposed road realignments.
- Grade-separated crossings—road and rail cross each other at different heights so that traffic flow is not affected. Grade separations are either road over rail, or rail over road.
- Road closures – Roads will only be closed where the impact of diversions or consolidations is considered acceptable, or the existing location is not considered safe and cannot reasonably be made safe. Approval for closures, where required, will be progressed in accordance with the requirements of the relevant legislation ARTC will request, under the Land Act, for the road to be closed and re-gazetted as part of the railway corridor.

It should be noted that there are no level crossings associated with the Project. One existing level crossing has been eliminated through the Gowrie Junction Road grade separation.

1.11.10 Road network changes

To facilitate the Project, changes to the local road network are required to safely accommodate the railway and maintain local and regional connectivity. The majority of road network changes are within Gowrie Junction, with the road authority being TRC. The proposed road network changes will be undertaken in accordance with relevant DTMR, TRC or LVRC design standards.

The elimination of the existing Paulsens Road level crossing which is in line with Queensland Level Crossing Safety Strategy 2012-2021 (DTMR 2012), requires a new grade separated crossing to maintain north-south connectivity. To safely meet road and rail standards, Gowrie Junction Road would be realigned (~500 m) with a road over rail bridge proposed approximately 400 m west of the existing level crossing. The new grade separation will encroach onto private land and will cross over the existing rail corridor, along with the Project's rail alignment, Paulsens Road, a realigned section of Morris Road and Gowrie Creek. The bridge is approximately 350 m in length and provides a minimum clearance between 5.4 m and 7.1 m.

1.11.11 Rail maintenance access road

A rail maintenance access road (RMAR) is required to facilitate maintenance for critical infrastructure (e.g. turnouts), and to provide access for emergency recovery. Formation level access has been proposed for all turnout locations, and, where reasonably practical, for the full extent of crossing loops.

RMARs will also be provided following natural surface level where deemed necessary outside of critical infrastructure locations. It is proposed that access points to RMARs will be provided at the frequent locations and connecting directly with the public road network.

A hyrail is a road vehicle that is also capable of travelling on rail due to being fitted with special retractable steel flanged wheels. Hyrail access locations have been proposed at:

- Both tunnel portals
- On the mainline mid-way between the eastern tunnel portal crossing loop and the Postmans Ridge crossing loop, at McNamaras Road
- At the eastern extent of the Project close to the tie-in point with the H2C project.

Due to the steep terrain and remote location of the rail alignment east of the Toowoomba Range tunnel, the design of the RMAR was investigated to determine where the terrain was too steep for a surface level RMAR. In these instances, the formation has been widened to accommodate a formation level RMAR, with the aim of providing a road of suitable standard, minimising construction effort and minimising corridor width while achieving the required corridor access.

A diagram showing the typical positioning of a formation level RMAR is shown in Figure 1.5.

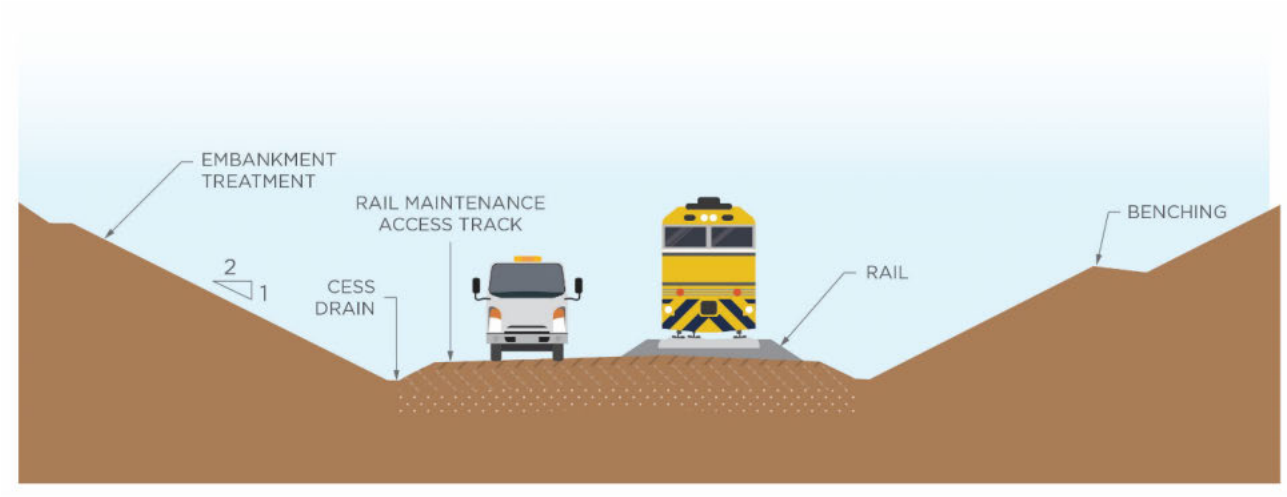


Figure 1.5 **Typical sectional diagram of rail formation showing rail maintenance access track**

1.11.12 Utility/service crossings

A total of 184 utilities located within the Project disturbance footprint have been identified as potentially clashing with the rail line and associated infrastructure.

Utility owners have different requirements and drivers related to treating impacted assets. It is also common for impacted assets owned by the same utility owner to have varying requirements depending on the characteristics and criticality of each asset to the owner. As such, consultation has commenced with the various utility providers regarding their requirements for relocation or protection of the services impacted by the Project.

1.11.13 Fencing

Fencing will be provided for the extent of the Project alignment (excepted where noted otherwise). Fencing is to extend between the corridor and the lands of owners or occupiers adjoining the railway, with any specific requirements associated with the neighbouring land use to be undertaken in consultation with the adjoining landowner.

As the Project comprises greenfield works in forested, rural areas east of the Toowoomba Range tunnel and semi-rural areas west of the Toowoomba Range tunnel, standard rural fencing will typically be provided. In areas of higher ecological significance, fauna exclusion fencing will be used to prevent access to the operational rail corridor and guide fauna to safe crossings such as underpasses at viaducts and bridges.

The location of the fauna fencing and fauna passages will be confirmed during detailed design following comprehensive fauna surveys and further consultation with DTMR. Consultation with DTMR is required around the Project interfaces with the Toowoomba Bypass in the Lockyer Valley. This includes the potential for existing fencing to be removed and reinstated, ensuring that planning considers fauna movement strategies across both features, including utilising the existing structures under the Toowoomba Bypass and ensuring that passages do not result in fauna being directed to isolated patches of vegetation/habitat. Where superior fencing is required (for example where tracks are in close proximity to roads and/or communities, or where trespass is anticipated to occur), a 1.8 m chain link boundary fence may be provided. Typical fencing design is provided in EIS Appendix C: Design drawings.

Gates will be provided at suitable corridor entry/exit locations to allow convenient access to infrastructure for maintenance purposes, and at private stock crossings.

1.12 Pre-construction phase

Pre-construction activities are required to enable construction of permanent infrastructure components of the Project to commence. The location and extent of pre-construction activities and early works will be subject to confirmation during the detailed design phase, when detailed design has been substantially progressed. Detailed design is expected to be conducted before the beginning of pre-construction activities; however, elements of detailed design may continue into the pre-construction phase. Pre-construction activities are expected to include such works as:

- Early works
- Enabling works that are undertaken by or on behalf of a third party, in accordance with the relevant legislative requirements, independent of the EIS process.

1.12.1 Ongoing activities

1.12.1.1 Corridor acquisition

The majority of land required for the rail corridor will be acquired through negotiation by a constructing authority that has compulsory acquisition powers. Where compulsory acquisition of land is required, the process outlined in the *Acquisition of Land Act 1967* (Qld) (AL Act) will be followed.

Arrangements between ARTC and a constructing authority are yet to be finalised. Temporary and permanent access to State land tenures such as USL, reserves and roads will be undertaken in accordance with the

AL Land Act. The extent of property impacts will be refined and confirmed during detailed design in consultation with landholders, construction contractor and the constructing authority.

Further information on land acquisition is provided in EIS Chapter 8: Land Use and Tenure.

1.12.1.2 Baseline surveys

ARTC is committed to undertaking a number of environmental studies, including pre-clearing ecological surveys in accordance with Queensland and/or Commonwealth guidelines, soil surveys, surface water monitoring and groundwater monitoring.

These surveys will supplement the surveys undertaken as part of the EIS and will inform such matters as water quality objectives, design and environmental and planning approvals and rehabilitation requirements and performance indicators. Further information on the proposed baseline surveys required for the Project is provided in the relevant technical chapters and reports.

1.12.1.3 Environmental and planning approvals

Following approval under the SDPWO Act and the EPBC Act, the Project will be required to obtain secondary environmental and planning approvals, licences and permits under relevant State legislation to enable works to lawfully proceed. The applications for these approvals will be required to be supported by further information based on the detailed design of the Project along with associated detailed environmental studies and assessments. These approvals include, for example, environmental authorities for environmentally relevant activities and operational work permits. The majority of approvals will be required to be obtained prior to the commencement of construction or ground disturbance activities.

A summary of the potential post-EIS approvals is in EIS Chapter 3: Project Approvals. These approval requirements are subject to change during refinement of the construction approach and the detailed design process and will need to be reviewed further at that stage.

Unless determined by the construction contractor, all construction activities, including pre-construction and early works, will remain within the Project disturbance footprint. If works outside the disturbance footprint are required, the contractor will be responsible for undertaking further investigations of the disturbance area, obtaining relevant owners' consent and securing all necessary approvals or changes to approvals before scheduling any ground disturbance.

1.12.1.4 Survey and geotechnical investigations

The construction of all infrastructure requires the adherence to survey control plans and procedures to ensure spatial correctness and quality reporting. The implementation of this survey scheme will require engaging reputable and competent surveying teams. These teams will, among other responsibilities, control and guide the following:

- All elements of survey and survey control
- Survey mark preservation and compliance with mark destruction legislation in Queensland

- Development and nomination of survey control points to feed into inspection and test plans for delivery, including:
  - Topsoil stripping
  - Quantity measurement (usually before and after all materials are used)
  - Setting out of all alignment and structural elements.

1.12.2 Early works activities

Early works are required for construction mobilisation and to support the permanent infrastructure components. These activities are expected to include, for example:

- Establishment of access tracks
- Utility or service relocations (excluding those undertaken as enabling works)
- Installation of temporary fencing
- Establishment of site compounds
- Delivery of materials to site.

These works may require clearing of vegetation and other ground disturbance activities and will need to comply with relevant legislative requirements, approvals conditions and other overarching guidelines and plans. Pre-construction activities may be scheduled before the main construction works or undertaken under a separate contract and be managed under the Construction Environmental Management Plan (CEMP).

The pre-construction activities may also include works within the local road reserves, including establishing new access points and/or to facilitate the future upgrades and road closures subject to agreement between ARTC and the relevant local councils.

1.12.3 Enabling works

Enabling works are not considered to be part of the Project, with the works to be undertaken by or for third parties, primarily for the relocation or re-provision of public utilities, or existing QR rail assets. These works may be undertaken by the asset owner, or under a separate contract, and are required to comply with the relevant environmental or regulatory framework applicable to the works or public utility.

For example, Powerlink has undertaken a feasibility study to relocate a section of the Middle Ridge and Tarong transmission line east of Wards Hill, with the study determining that the transmission line towers can be raised to mitigate any interactions. Further, it has been confirmed that the works can also occur within the existing easement and will be subject to Powerlink's existing environmental management systems and approval processes. Similar assessments to identify potential amendments to other existing assets, together with required approval pathways, costs and land requirements have also been undertaken by Energex, Ergon, TRC and the APA Group.

1.13 Construction

Construction of the Project will commence once the detailed design is complete and all the necessary approvals have been obtained. The construction phases are discussed in detail in the sections below.

The construction program defines a number of stages and activities. These comprise:

- Civil works including bulk earthworks, construction of cuts and embankments, construction of tunnel portals and the tunnel, installation of permanent drainage controls, bridge and watercourse crossing construction
- Track works, including the installation of ballast, sleepers and rails

- Rail systems infrastructure and wayside equipment, including signals, turnouts and asset monitoring infrastructure
- Commissioning, integration testing and handover process to achieve operational readiness.

1.13.1 Construction schedule

Construction of the Project will commence once the detailed design is complete and all the necessary approvals have been obtained. The following broad milestone dates for construction are proposed at this stage:

- Construction commences: 2022
- Target completion of construction: 2027
- Six months testing and commissioning phase.

The tunnel construction timeline of approximately four years includes the procurement and set up of the tunnel boring machine (TBM) which is approximately 12 months. The construction phase of the tunnel including cut and cover, mined tunnel construction (at the eastern tunnel portal) and operation of the TBM is expected to be approximately to be 24 months. Following the tunnel construction phase, decommissioning of the TBM and fit out of the tunnel and associated buildings will occur.

An indicative construction program for the Project is shown in Table 1.5 and is subject to change during the detailed design and construction phases as a result of:

- Land acquisition processes
- Weather conditions
- Changes to construction methods, materials and land requirements
- Unexpected finds, such as threatened species or cultural heritage values
- The need for additional or different mitigation measures that result in changes to the construction program.

Table 1.5 Indicative construction program

Construction stage	2021		2022				2023				2024				2025				2026				2027			
Contractual and Project approvals																										
Site establishment																										
Earthworks																										
Tunnel																										
Structures																										
Drainage																										
Rail civil works																										
Road civil works																										
Rail systems commissioning																										
Finishing works and demobilisation																										

1.13.2 Site preparation

1.13.2.1 Vegetation clearing and installation of construction infrastructure

The site clearing includes the sequential removal of vegetation and debris. Site clearing will occur prior to mobilisation of the main earthworks construction teams. The clearing of vegetation will be undertaken in accordance with the Construction Environmental Management Plan (CEMP) which will include any permit requirements. All turf (where occurring), topsoil and other organic and unsuitable material will be stripped from the site. Wherever possible and appropriate, such material will be stockpiled and recycled within the immediate construction footprint.

The clearing and grubbing activities would commence on multiple work fronts and will be ahead of the primary earthworks operations, but not so far ahead that exposed soil is left open for long periods of time. Clearing and grubbing activities will be preceded by:

- Development of a Project-specific Environmental Offset Proposal
- Development of an Environmental Offset Delivery Plan and Offset Area Management Plans prior to commencement of construction
- Obtaining any required vegetation clearing approvals
- Threatened flora and fauna surveys
- Appropriate flora and fauna treatments/re-locations (e.g. spotter catcher works under the Flora and Fauna Sub-plan, relevant damage mitigation permit and Species management programs (SMP))
- Identification of any underground utilities
- Appropriate utility works (i.e. protection/re-location)
- Clear demarcation of required clearing limits to avoid unnecessary vegetation/habitat clearing
- Any requirements under the Cultural Heritage Management Plan (CHMP)
- Installation of erosion and sediment control measures, including proposed sediment basins.

The clearing and grubbing operation will be performed across the proposed earthworks footprint. Protective measures will be enabled around creek and riverbanks to ensure that the existing profiles are preserved. Cleared vegetation ready for mulching will be stockpiled outside the earthworks footprint but inside the Project disturbance footprint ready for mulching. The mulched material will be stockpiled and managed to facilitate re-use, and to prevent combustion. Possible alternatives to mulching of vegetation matter will be considered and appropriately assessed as part of the detailed design and construction phases.

Utility relocations

Utilities and services such as water, sewer, electricity and telecommunications will need to be supplied to each of the laydown areas and construction compounds for use in site offices and amenities. Where these utilities are located close to construction sites, opportunities to connect to existing sources will be explored with relevant service providers. Where utilities are not located in close proximity to the site offices and amenities electrical generators and portable amenities will be used.

Where feasible, the Project will share power, water, sewage, construction materials and communications infrastructure with the adjacent H2C project.

Corridor acquisition and access

The Project traverses multiple lots. ARTC will be undertaking the acquisition of land together with the State government prior to construction. The extent of property impacts will be refined and confirmed during detailed design in consultation with property owners.

Temporary access tracks will be required along the alignment to allow drainage, earthworks and bridge structure crews to access work fronts. The temporary access roads will utilise the future RMARs where possible, or be designed, constructed or upgraded with appropriate consideration to minimising disruption to landholders, public infrastructure, and environmental matters.

Construction access is proposed to be provided adjacent to all working fronts along the Project corridor and will be sized to allow free flow and unhindered access for all construction and support traffic vehicles.

Access tracks will be developed as part of the early works to facilitate access to the laydown and construction sites located along the length of the Project. These access tracks will be developed with a proposed pavement treatment suitable for the material type to be stored at each location and vehicle type required to access the location.

1.13.3 Civil works

The activities that will be undertaken during civil works include:

- Bulk earthworks, such as the construction of embankments and excavation cuttings
- Permanent drainage controls
- Construction of temporary haul roads
- Bridge construction
- Roadworks
- Rail corridor works
- Tunnel and portal construction.

1.13.3.1 Bulk earthworks

The construction of the foundation of the railway line will require earthworks and engineering fill to provide a platform designed for the rail construction. The earthworks will predominantly be made up of constructing embankments and excavating cuttings. This work will be carried out using heavy earthmoving plant and equipment.

Where required, material stockpiles will be located within the Project disturbance footprint, outside flood prone areas, and will be neatly formed to prevent erosion. Spoil management, reuse and disposal will be addressed in accordance with the Project Spoil Management Strategy.

1.13.3.2 Permanent drainage controls

The Project crosses a number of drainage features of different catchment areas that contribute flows to the cross-drainage structures. Cross drainage structures will be constructed where the rail intercepts existing drainage lines. The type of cross drainage structure depends on various factors such as the natural topography, rail formation levels, design, design flow and soil type. Cuts and embankments will also require drainage treatments such as catch drains, diversion drains and culverts.

The cross-drainage structures will incorporate the installation of permanent drainage controls as they cross the floodplain areas and drainage lines. Construction of these drainage structures will require several full-time installation crews throughout the construction period. Longitudinal drainage including embankment drains and catch drains will be constructed to protect the rail formation from surface runoff.

The construction will be a mix of installation before and after the bulk earthworks, so as not to delay the overall earthmoving program. It will also be necessary to capture overland flow and transfer it to the cross-drainage structures. The sizing of the longitudinal drainage will be dependent upon the hydrology and it is important that these drains are capable of efficiently moving overland flow to dedicated drainage lines to reduce the likelihood of water ingress to the permanent works.

1.13.3.3 Bridge construction

Bridge and viaduct structures are proposed along the Project to allow drainage across the corridor; allow access for roads and rail, farm tracks, stock crossings or pedestrians; to span across large valleys; allow for native fauna connectivity; and replace large height embankments where required to reduce the operational footprint.

The Project requires 13 new bridge and viaduct structures comprising 10 viaducts and three bridges. As a number of these bridges also interact with public roads and rail, the construction will be subject to traffic management and temporary works restrictions to ensure the safety of the travelling public and workforce.

All bridge and viaduct structures will be formed from precast prestressed concrete and in-situ concrete with galvanised steel ancillary elements. Structure foundations are proposed as either bored cast in place or driven piles based on the anticipated subsurface profiles. It is envisaged that all materials will be delivered by road.

The anticipated methodology and approach is outlined as follows:

- Establishment of bridge and viaduct construction access tracks and laydown areas
- Construction of working platforms for access, piling rigs and cranes
- Substructures:
  - Large diameter bored cast in place or driven piles to be installed
  - Plant required will include trucks, excavators and roller compactors for working platforms for piling and piling rigs, cranes and concrete delivery trucks for cast in-situ piles
- Pile caps and piers: Conventional construction of reinforced concrete structures in successive lifts using re-usable forms, cranes, concrete pumps and trucks
- Headstock and abutment construction using re-usable forms and conventional reinforced concrete
- Superstructure and deck construction.

1.13.3.4 Roadworks

Due to the location of the Project alignment, there are a number of road rail interfaces identified that will require consideration.

The road authorities are either local council (Toowoomba and Lockyer Valley Regional Councils) or the Department of Transport and Main Roads (DTMR). Construction works on these roads will comply with the asset owners approved safety requirements and temporary works procedures. The highest standard to be complied with will be the DTMR Manual of Uniform Traffic Control Devices. For works on, over or adjacent to DTMR roads, such as the Toowoomba Bypass and Six Mile Creek Viaduct, the proposed construction methodology and traffic management arrangements will be approved by DTMR prior to works commencing.

1.13.3.5 Rail corridor works

Key interfaces with existing Queensland Rail (QR) corridors are required as part of the Project and scope. Of the total 28 km of the Project alignment, approximately 5.6 km of the alignment runs adjacent to the existing QR West Moreton System rail corridor. The staging of the works and their associated impacts will be the subject of an interface agreement between ARTC and QR. Coordination with QR will be necessary to maintain access to existing assets for maintenance.

1.13.4 Tunnel construction

The proposed tunnel will be constructed through the Toowoomba Range and will be approximately 6.24 km long and has a maximum cover of approximately 220 m. The tunnel has a bored diameter of approximately 12.2 m and a finished internal diameter of approximately 10.8 m.

The Toowoomba Range Tunnel will intersect the following geological units:

- Tertiary age Main Range Volcanics (MRV) consisting mainly of basalt
- Undifferentiated Tertiary Sediments
- In-filled Paleo Valley sediments consisting of basalts, tuffs, sandstones to mudstones
- Jurassic sandstones and siltstones of the Koukandowie Formation
- Basaltic colluvium mainly on the eastern side of the range and
- Quaternary alluvium.

The suitability and extent of the material intercepted by the Toowoomba Range Tunnel cannot be estimated with accuracy due to the variable nature of basalt flows deposited on the undulating Jurassic sedimentary paleo topography.

The construction methodology is based on a shielded TBM, allowing for undrained construction. The methodology is based on the following:

The construction methodology is based on a shielded tunnel boring machine (TBM). A cut and cover and mined tunnel (roadheader and drill and blast) will initially be used at the eastern tunnel portal prior to the TBM. The methodology is based on the following:

- TBM is estimated to provide a faster program with less schedule risk compared to mined tunnel techniques (e.g. excavation rate for a mined tunnel is in the order of 50 m week, while for a TBM is up to 80 m/week for a single shield)
- The geology and hydrogeology of the area is a significant challenge and a TBM is considered more favourable than mined tunnel techniques (roadheader or drill and blast)
- Construction of an undrained lining is facilitated by the TBM possessing a segmental lining erection system. Construction of an undrained lining with mined tunnel techniques is more difficult and involves a time delay between the initial, primary support and the subsequent secondary support.
- A mined tunnel uses the open face method which drains groundwater during construction prior to construction of the waterproofing and secondary lining. A TBM can be closed face using face pressure to minimise groundwater disturbance during segment erection.

It is expected that the TBM will be driven from west to east mainly due to availability of early access to the portal, an appropriate road network, and the availability of power supply. The western tunnel portal is also located in terrain more conducive to the use of a TBM as the land can readily accommodate the setup and operation of the TBM. During operation the TBM requires a large worksite to accommodate materials storage including tunnel segments, spoil handling and storage, temporary ventilation equipment, and TBM launching requirements.

The presence of the colluvial sediments at the eastern tunnel portal represents a significant risk for the construction of the tunnel, and therefore a mined tunnel and cut and cover construction method is anticipated. This approach will establish the portal and a section of tunnel (less than 500 m) before the TBM finishes the tunnel.

The cut and cover approach is preferred due to the steep terrain and presence of colluvium geometry, with a driven tunnel requiring longer and wider excavations to obtain a stable face, which will also be prone to future landslides, compared to the cut and cover approach. The cut and cover section will include contiguous bored pile walls and a roof slab, with seepage likely to occur (i.e. drained structure).

The mined tunnel and cut and cover construction method approach will establish the eastern tunnel portal and a section of tunnel (approximately 700 m) before the TBM finishes the tunnel. That is the TBM will breakthrough into the mined tunnel and continue to erect the segmental lining as it pushes forward with the annulus between the segmental lining and the mined tunnel to be grouted as soon as possible to provide support and waterproofing. The TBM is planned to be removed following construction.

The duration of the tunnelling activities, particularly for the TBM is not known at this stage of the Project and will be dependent on the type of TBM procured for the Project during detailed design.

Excavation by TBM's in Sydney Sandstone (double shield) resulted in an average advance rate in the order of 15-20 m/day with peak performances up to 30 m/day (Camus et al 2015). When crossing underneath the Sydney Harbour (clay with high water pressure), the average advance rate reduced to 8 m/day (www.tunneltalk.com). Jain et al. (2013) noted low advance rates in porphyritic basalt (7 m/day) due to their very high strength, which have similar properties to the basalts likely to be encountered during the excavation of the Toowoomba Range tunnel.

For the purposes of the EIS it is assumed that a slurry TBM will be used due to the groundwater conditions and that the excavation rate for the TBM is 10.5 m/day and 1.7 m/day for the mined tunnel area.

1.13.4.1 Intermediate tunnel ventilation shaft

The intermediate tunnel ventilation shaft connected to the tunnel at Cranley, approximately 17 m internal diameter and 100 m deep will be excavated prior to the tunnel construction.

A conventional shaft sink construction method has been adopted with staged excavation through the MRV, UTS and Jurassic materials. Temporary supports will be installed from the top down, with a permanent reinforced concrete lining constructed from the bottom up. Extensive ground treatment such as grouting may be required to achieve the allowable inflow of 0.0062 L/sec, with the tunnel to intersect several water tables (e.g. shallow and deep MRV) and stabilise the ground.

A ventilation infrastructure operations building along with car park facilities will also be provided at this location.

1.13.4.2 Tunnel lining

The design of the Toowoomba Range Tunnel is undrained. Undrained tunnels are designed as watertight structures, which aim to limit groundwater ingress into the tunnel and minimise groundwater level drawdown, as a result of the tunnel operation, via diminished groundwater seepage allowed into the tunnel. Undrained tunnels constructed by mined tunnel methods typically comprise a groundwater resisting membrane and cast in-situ reinforced concrete lining. To withstand the hydraulic pressures from the groundwater on the watertight tunnel lining, undrained tunnels are typically circular in cross section, or some form of elliptical shape with significant amounts of reinforcement required.

The proposed tunnel requires TBM and mining (road header) techniques. A single pass precast reinforced concrete segmental lining will be used for support of an excavated tunnel constructed by a shielded TBM.

It is likely a flexible sheet type water resistant membrane will be used to waterproof the tunnel. The purpose of the waterproof membrane is to assist with the long-term durability of the concrete secondary lining, including all fixings installed into the concrete.

1.13.4.3 Tunnel portals

The western tunnel portal involves a 400 m long box cut and up to 26 m in height at the western tunnel portal face, gradually reducing in height towards the west. The portal is likely to be constructed using conventional mining technique and potentially some blasting. The eastern tunnel portal involves a 100 m long cut and a portal face that is approximately 13 m in height.

The portals are drained and there is the potential for groundwater inflows during construction and operations (refer EIS Chapter 14: Groundwater).

1.13.4.4 Water management and treatment

The Toowoomba Range tunnel will be designed as undrained however some groundwater ingress is expected during construction. The cut and cover and mined tunnel, approximately 700 m will be drained, while the TBM is based on an undrained construction. Similarly, the intermediate ventilation shaft will also be constructed based on an undrained approach.

Based on the groundwater modelling (refer EIS Appendix N: Groundwater technical report) there is the potential for up to 1,700 ML of groundwater to inflow into the Toowoomba Range tunnel (including the portals and intermediate ventilation shaft) during the construction period. The majority of the groundwater inflow is associated with the following aquifer types, MRV (50 per cent), Colluvium (40 per cent) and Koukandowie Formation (10 per cent). This water will need to be captured for reuse during construction and/or diverted to the surrounding environment.

The extent of treatment of the water from the tunnel will depend greatly on the quality of the groundwater and the environmental value adopted for the discharge of water to the local receiving environment.

During construction, water treatment facilities will be constructed to support the tunnelling operations. The water treatment facilities design is likely to include, for example:

- Screening treatment
- Detention tanks
- Aeration/flocculation tanks
- Chemical treatment, where required
- Water pumping facilities
- Material separation
- Residual excavated material storage.

As part of detailed design, the water treatment facilities will be investigated for potential use during both construction and operation of the Project.

The presence of the colluvial sediments at the eastern portal represents a significant risk for the construction of the tunnel, and therefore a mined tunnel and cut and cover construction method is anticipated

The water collected inside the tunnel (groundwater seepage, storm water carry-in, wash-down, firefighting etc.) will be collected through a common tunnel drain and stored in a sump at the eastern portal. This water will be processed through a water treatment plant and discharged to a tributary of Oaky Creek. Stormwater will be collected into a sump prior to the western portal so that it does not flow down the tunnel and will be treated prior to discharge.

The temporary tunnel support generally consists of temporary rock bolts and sprayed concrete that may be reinforced with fibres or steel mesh. In poor ground conditions steel sets, forward rock reinforcement and canopy tubes can be used. Permanent support would generally consist of a cast in-situ unreinforced concrete lining. For unreinforced cast in-situ concrete linings, a suitably high strength, low shrinkage, dense concrete mix with minimum strength of 40 megapascals (MPa) is recommended to meet the durability and design life requirements of tunnels.

1.13.4.5 Construction and workforce hours

The Project is part of the larger Inland Rail Program. Inland Rail is expected to generate 16,000 jobs with an average of 800 jobs per annum over the 10-year construction period. The Project is expected to generate an average of 264 full time equivalent (FTE) construction jobs over the full construction period.

Construction work would be undertaken during the following primary Project construction hours:

- Monday to Friday - 6.30 am to 6.00 pm
- Saturday - 6.30 am to 1.00 pm
- The following additional hours for general construction/surface works activities where the works comply with the performance criteria set out in Section 23.15.8.2 of the draft Outline EMP (refer EIS Chapter 23: Draft Outline Environmental Management Plan):
  - Monday to Friday – 6.00 pm to 10.00 pm
  - Saturday 1.00 to 5.00 pm

- No work on Sundays or public holiday
- Tunnel construction activities
  - 24 hours a day, 7 days a week.
- Track possessions and tunnelling activities will proceed on a 24/7 calendar.

QR and ARTC track possessions will generally be allocated over weekend periods, with extended track possession occurring over holiday periods.

Where work outside the standard hours, including night works, will be required, for example the delivery of materials, the works will only proceed where consultation with the local community has been undertaken. Furthermore, a site-specific noise risk assessment will be undertaken to identify the environmental risks associated with the works, action required to mitigate these risks and justification as to why the works are required out of standard hours.

1.13.5 Commissioning and reinstatement phase

Testing and commissioning (checking) of the rail line and communication/signalling systems will be undertaken to ensure that all systems and infrastructure are designed, installed, and operating according to ARTC's operational requirement.

All Project construction sites, compounds and access routes will be returned to no worse than the existing condition, unless otherwise agreed with the relevant landowner. Site reinstatement and rehabilitation will be undertaken progressively during the works and will include the following activities:

- Demobilise site compounds and facilities
- Remove all materials, waste and redundant structures from the works sites
- Decommission all temporary work site signs
- Remove temporary fencing
- Establish permanent fencing
- Decommission site access roads that are no longer required
- Restoration of disturbed areas as required, including revegetation where required

Site rehabilitation will be undertaken in accordance with the Reinstatement and Rehabilitation Plan.

1.14 Operational phase

Operational phase activities will include the use of the railway for freight purposes and potential future use for passenger services provided by a third party operator, operation and maintenance of tunnel ventilation and safety systems, signalling, and general track and infrastructure maintenance.

The Inland Rail Program as a whole will be operational once all 13 sections are complete, however existing QR Network traffic may utilise the Project alignment, subject to relevant infrastructure agreements, if the alignment is completed prior to the other 13 sections of the Inland Rail Program.

Road network changes as a result of the Project will be managed and maintained by the relevant local road authority (i.e. TRC and LVRC).

1.14.1 Hours of operation

The hours of operation are anticipated to be 24 hours a day, 7 days a week on a variable schedule.

1.14.2 Workforce

It is anticipated that the operational phase will require a workforce of approximately 20 FTE. As with the construction phase, the workforce will likely be sourced locally.

1.14.2.1 Train operations

Inland Rail will be an open access rail service, meaning ARTC will not run trains directly but will allow access to the rail line by rail operators. Operational train modelling for the Project estimates that the Gowrie to Helidon section of Inland Rail will involve an annual average of approximately 33 train services per day in 2027. This is likely to increase to approximately 47 train services per day in 2040.

These numbers include existing traffic on the West Moreton System, which currently accounts for 26 trains per day. The majority (24) of these current train services per day services consist of coal trains with two freight services from the South Western System (i.e. do not operate on the Western Line).

It is expected that the source of the train services will be evenly split across both the ARTC and QR Networks in 2040. This is in response to the Project alignment catering for larger train sizes and axle loads, reducing the likely number of coal services per day, while allowing for additional agricultural rail movements long the QR Network.

Train services will be provided by a variety of rail operators and will be a mix of grain, bulk freight, livestock, coal, other general transport services, along with the Westlander passenger service.

Train control will be managed via ARTC's existing control centres, with a new control centre proposed at the western tunnel portal to manage tunnel operations. Train movements within this section of the QR Network are controlled and communicated via QR's Control Centre in Brisbane, while the corresponding signalling system is Direct Traffic Control.

1.14.3 Tunnel operations

The following infrastructure will support the operation of the tunnel:

- Tunnel control system
- Fire pumps and tanks
- Substation, backup generator and transformer
- Ventilation fans
- Water treatment plant
- Workshops and other amenities.

During the operational phase, tunnel operations will require power and water supply for ventilation and fire safety. Lighting will be limited around tunnel portals and associated infrastructure.

1.14.3.1 Tunnel control system

The tunnel plant will be controlled by programmable logic controllers collecting information of all the plant equipment including instruments, ventilation equipment, lighting control, dewatering, security, train detection, power supply monitoring, metering and fire indication panels.

During normal operation, the tunnel control system will be designed to operate in automatic mode and will require minimal input from the control room operators (e.g. at the western tunnel portal control centre). Operators will be notified of any abnormal/emergency situation by means of incident prompts (system generated alerts/alarms) generated by the control system.

1.14.3.2 Ventilation

As outlined in Section 1.11.3, the tunnel ventilation system includes portal doors located at both ends of the tunnel and at the intermediate shaft location. This allows one door to be closed during train movement to maintain the airflow across the locomotives in normal operations and allows the intermediate shaft door to close earlier after the train passes the mid-point and start the purge for the first tunnel section during purging operations.

Three smoke control ventilation buildings are proposed, one at each portal location and one at the intermediate shaft located at Cranley. These ventilation buildings will provide sufficient velocity for purging of the tunnel during operations. Refer Figure 1.6 for a schematic of the proposed western tunnel portal, showing a train entering the ventilation building.



Figure 1.6 Schematic of the proposed western tunnel portal, with a train entering the ventilation building

Future stages of the Project design development may be further optimised to remove the requirement for the intermediate ventilation shaft and supporting aboveground infrastructure. If further tunnel ventilation design optimisations occur during the detailed design phase, additional assessment of the associated environmental aspects at the tunnel portals would be required to assess if any potential negative impacts are likely to occur and if so, develop appropriate mitigating design requirements and environmental management strategies.

1.14.3.3 Water collection and treatment

The design allows for groundwater and stormwater to be diverted away from the tunnel portals to the surrounding environment. Where water cannot be diverted away from the tunnel portals the water will be collected by sumps, which will include hydrocarbon separators and ‘first flush’ tanks.

Groundwater inflow at the western tunnel portal will be diverted directly to a tributary of Gowrie Creek downstream near the UT1 Gowrie Creek Rail Bridge, with the predicted inflows up to 80 ML per annum from the MRV. The water quality of the groundwater is considered suitable to be directly ‘discharged’ into this tributary, which has been assessed to be a moderately to highly disturbed ecosystem, with the groundwater from the MRV also known to influence water quality and environmental flows of Gowrie Creek. Groundwater inflow, from the Colluvium, at the eastern tunnel portal is predicted to be 0.7 ML per annum and will be diverted to a drainage line, directly downstream of the eastern tunnel portal, associated with Oaky Creek.

Water collected inside the tunnel (groundwater, washdown, firefighting etc) will be collected via drainage pits throughout the tunnel and connected longitudinally by a drainage pipe. Collected water will be conveyed via gravity to the tunnel collection sump(s) located at the eastern tunnel portal. This water will likely be processed through a WTP at the eastern tunnel portal.

ARTC will confirm the design of the WTP during detailed design, including whether the water can be directly discharged into the surrounding environment or whether water should be collected at the western tunnel portal and mixed with the water from the tunnel (i.e. dilution) or a combination of all three options. Any separated pollutants will be held for collection by a licensed waste contractor.

The extent to which water from the tunnel is treated will depend largely on the quality of the groundwater ingress. Groundwater modelling indicates that the majority of the groundwater inflow into the tunnel, predicted to be up to 15 ML/annum, will be from the Koukandowie Formation, where salinity levels are generally higher than the MRV. Baseline monitoring of groundwater bores established along the tunnel alignment will confirm the quality of groundwater resources intersected by the tunnel.

It is noted that the volume and quality of inflow will vary spatially and temporarily, with detailed design to further consider measures to manage groundwater inflow, together with the requirement to obtain authorisations under the Water Act. Further discussion on groundwater resources is provided in EIS Appendix N: Groundwater technical report.

During operation, stormwater will be diverted away from the tunnel portals and the ventilation building and any water that falls within the tunnel portals will be captured by purpose-built sumps and directed to the surrounding environment and not directed through the tunnel. The collection sump will also likely include a 'first flush' tank that will collect the first quantity of water which is expected to contain the majority of pollutants. Any separated pollutants will be held for collection by a licensed waste contractor.

Water quality will be monitored and if water quality objectives cannot be achieved for waters to be released, alternate treatment/disposal options will be implemented in accordance with any relevant conditions of approval or legislation.

1.14.3.4 Operational water supply and management

The Project's operational water requirements are anticipated to be minor relative to the construction phase requirements. Water may be required to support localised maintenance activities, along with fire-fighting activities at the tunnel. A water pipeline will be constructed along Ganzer Morris Road, road reserve, running south under the Toowoomba Bypass to Hermitage Road, enabling the Project to connect into the TRC water network. This new connection will ensure that the fire management system has the required pressure (e.g. 30 L/s). ARTC may also be able to reuse water collected from the tunnel portals and the tunnel itself to support operations.

1.14.3.5 Operational maintenance

Standard ARTC maintenance activities will be undertaken during operations. Typically, these activities include minor maintenance works, such as bridge and culvert inspections, sleeper replacement, rail welding, rail grinding, ballast dropping and track tamping, through to major periodic maintenance, such as ballast cleaning and reconditioning of track.

These activities will occur on a scheduled basis, in addition to being in response to unplanned requirements, e.g. maintenance following adverse weather events.

1.15 Decommissioning

The Project is expected to be operational for in excess of 100 years. The design life of structures is 100 years to support this operational objective. The decommissioning of the project cannot be foreseen at this point in time.

If the Project, or elements of it, were subject to plans for decommissioning it is envisaged that the works would be undertaken in accordance with a decommissioning plan, which would be developed in consultation with relevant stakeholders and regulatory authorities.

1.16 Social and economic benefits

The Project is expected to represent an investment of up to $1.35 billion — this includes both direct and indirect costs. Indirect costs include items such as design services, contractor overhead and margin, contingency and escalation, together with ARTC Program costs such as management, train control systems, property requirements, insurances and utilities. The total investment figure makes provision for expected Project contingency and risk.

The total capital expenditure for the five Inland Rail projects in QLD is estimated to be between $5 and $6 billion. This includes both direct and indirect costs.

1.16.1 Social benefits

Development of the Project would result in social and economic benefits, primarily in relation to employment, training and business supply opportunities. Local benefits as a result of the Project include:

- **Employment** - the construction workforce is expected to be drawn primarily from communities within the Project region and nearby Local Government Areas, and therefore employment and training benefits would extend to construction industry workers across the region. The availability of long periods of employment in Project construction is likely to be a strong positive opportunity for those personnel and their families. At the peak of construction, the Project is estimated to require a workforce of 596 full-time equivalent personnel, with an approximate average of 264 full-time equivalents required over the life of construction.

  Employment opportunities in the Project region during the construction stage will have positive mental health benefits for the individuals employed, particularly if they are exiting a period of unemployment or commencing their career. This would be particularly important in communities with high levels of unemployment, and for particular population groups where unemployment rates are high (such as Indigenous people and young people).

- **Business opportunities** - local and regional businesses will benefit from the construction phase. Opportunities to supply the Project may include supply of fuels, equipment, borrow and quarried material, and services including fencing, electrical installation, rehabilitation, landscaping, maintenance and trades services.

  Local transport or logistics businesses may also have significant opportunities to service the construction phase.

  The Project's local supply arrangements will provide an opportunity to develop and grow local businesses, with some possible benefits in nearby communities, but with regional benefits of greater significance.

  The expansion in construction activity in the vicinity of the Project will support additional flow-on demand and additional spending by the construction workforce, and therefore business trading levels in the region.

  The Project will improve the connection between local produce such as bulk grain, containerised cotton and other agricultural products, and markets; through to both domestic markets in cities and international markets via the Port of Brisbane.

- **Crash reduction** - Crash cost savings represent the reduced costs associated with fatal and serious injuries resulting from both road and rail incidents.

- **Environmental externalities** - Reduced environmental externality costs represent reductions in air pollution and greenhouse gas emissions due to the Project. The majority of these benefits can be attributed to the mode shift from road freight to rail freight.

- **Road decongestion benefits** - As the Project encourages greater movement of freight by rail, the reduced truck movements that are projected upon completion of the Project result in reduced congestion in urban areas.

More information social benefits is provided in EIS Appendix Q: Social Impact Assessment.

1.16.2 Economics benefits

An economic impact assessment has been undertaken, focusing on the specific economic impacts resulting from the construction and operation of the Project. However, the assessment acknowledges the role of the Project, and the remaining project segments, in collectively delivering the benefits of the Inland Rail Program. In its entirety, Inland Rail will enhance Australia's existing national rail network and serve the interstate freight market.

At a local level, the Project will support regional economic development through opportunities for local and regional employment, businesses and industries:

- The Project offers opportunities to encourage, develop and grow Indigenous, local, and regional businesses through the supply of resources and materials for the construction and operation of the Project (e.g. fencing, electrical installation (excluding rail systems) and instrumentation, rehabilitation and landscaping, cleaning and maintenance of construction and accommodation facilities). ARTC has developed a Sustainable Procurement Policy which will ensure that local, regional and Indigenous businesses will have opportunities to supply the Project.
- The Project offers opportunities in secondary service and supply industries (such as retail, hospitality and other support services) for businesses in close proximity to the Project. The expansion in construction activity is also likely to support additional temporary flow-on demand and additional spending by the construction workforce in the local community.
- The Project offers opportunities to unlock the construction of ancillary and complementary infrastructure, industrial development and logistics operations within the local area. Key activities will likely relate to rail dependent industries and support industries associated with transport, freight handling, warehousing and logistics. Specifically, the Project (alongside the adjacent B2G and H2C projects) may act as a significant catalyst for development in the planned and existing industrial areas at the Toowoomba Enterprise Hub and Gatton West Industrial Zone.
- As a predominantly greenfield development, the Project comprises new dual gauge track to create a more efficient and direct rail freight corridor for freight operators (current and future) through the Toowoomba Range. As part of the broader Inland Rail Program, the Project offers opportunities to support the local agricultural industry, by driving savings in freight costs, improving market access, and reducing the volume of freight vehicles on the region's road network.

The economic benefits assessment estimate that the Project is expected to provide a total of $81.54 million ($2019 present value terms) in incremental benefits (at a 7 per cent discount rate). These benefits result from improvements in freight productivity, reliability and availability, and benefits to the community from crash reductions, reduced environmental externalities and road decongestion benefits.

The Project will promote regional economic growth across the Toowoomba labour market region. Using recent labour market trends and projected construction sector activity to inform workforce capacity and capability within the local region, it has been concluded that it is likely that the labour market conditions that will prevail during the construction phase of the Project will most likely be closer to those characterised by a slack labour market scenario. Under this scenario, over the construction phase, real GRP is projected to be $595 million higher than the baseline level.

Under a slack labour market scenario, the Project is also expected to deliver an additional 1,027 jobs (direct and indirect) per year over the construction period.

The possibility of some tightness in the labour market cannot be completely dismissed. If the government's health and economic policy responses to the pandemic are highly effective, the economy may grow much faster than is expected resulting in significantly more activity in the construction sector than anticipated. For example, the government may seek to bring forward projects to stimulate the economy. If this transpires then labour market conditions may tend towards somewhere between the "slack" and "tight" scenarios.

1.16.2.1 Cumulative regional impact analysis

A quantitative assessment of the cumulative macroeconomic impact of the Inland Rail Program on the economy, resulting from the construction of the Queensland sections of the Inland Rail Program was undertaken. In addition to the Project, there are four other segments of the Inland Rail Program which fall in Queensland, including B2G, H2C, C2K and K2ARB.

Under the assumption of slack labour markets, the incremental economic impacts of the QLD sections include an increase in real GSP of $1.75 billion (measured in 2019 dollars) and an increase in the average number of jobs over the construction period of 2,059 jobs per year. If labour markets are tight then the incremental benefits are smaller with real GSP increasing by $0.83 billion and the average number of jobs increasing by 485 per year.

The results of the regional economic impact assessment indicate that it is reasonable to assume that the regional labour market will have the capacity to supply a portion of the workforce requirements of the Project, without major disruption. However, these conditions may change in the context of cumulative labour market demand. Prior to the COVID-19 shock, the major infrastructure projects in the adjacent and surrounding areas, including those associated with Inland Rail, had the potential to put some pressure on labour markets if inopportune scheduling resulted in cumulative and competing demand for trades and construction labour. However, the overall labour demands of the various infrastructure projects expected to be constructed were modest and that scheduling could be optimised to minimise market impact. The prevailing trends in the Toowoomba labour market, and the ability of workers to mobilise to project locations, suggested that the risks of labour market disruption were limited. In the current environment, this risk has now been further reduced.

The expansion in construction activity and regional employment is also likely to increase demand for a range of local infrastructure and services, including in the construction supply chain and for local retail and hospitality businesses.

More information economic benefits is provided in EIS Appendix R: Economic Impact Assessment.

1.17 Stakeholder engagement

1.17.1 Identification of stakeholders

During the development of the EIS, ARTC has engaged with a wide range of stakeholders across local, regional and national levels as identified in Table 1.6. Noting that the Project has also considered outcomes from stakeholder engagement activities on the other Queensland Inland Rail projects, where applicable.

Table 1.6 Identified stakeholders associated with the project

Stakeholder type	Stakeholders
Commonwealth Government	▪ Department of Agriculture, Water and the Environment ▪ Department of Infrastructure, Transport, Cities and Regional Development ▪ Regional Development Area ▪ Member for Groom John McVeigh
Queensland Government	▪ Member for Condamine, Pat Weir ▪ Member for Lockyer, Jim McDonald ▪ Member for Toowoomba North, Trevor Watts ▪ Member for Toowoomba South, David Janetzki ▪ The Hon Minister Mark Bailey MP Office of Coordinator-General ▪ Department of Seniors, Disability Services and Torres Strait Islander Partnerships (formerly the Department of Aboriginal and Torres Strait Islander Partnerships) ▪ Department of Agriculture and Fisheries ▪ Department of Communities, Housing and Digital Economy (formerly the Department of Communities, Disability Services and Seniors) ▪ Department of Education

Stakeholder type	Stakeholders
	■ Department of Employment, Small Business and Training ■ Department of Environment and Science ■ Department of Energy and Public works (formerly the Department of Housing and Public Works now) ■ Department of Innovation, Tourism Industry Development and the Commonwealth Games ■ Department of State Development, Infrastructure, Local Government and Planning (formerly the Department of Local Government, Racing and Multicultural Affairs and the Department of State Development, Manufacturing, Infrastructure and Planning) ■ Department of Resources (formerly the Department of Natural Resources, Mines and Energy) ■ Queensland Fire and Emergency Services ■ Queensland Health ■ Department of Transport and Main Roads ■ Economic Development Queensland ■ Queensland Rail
Local government	■ Toowoomba Regional Council (TRC) Mayor, Cr Paul Antonio ■ Lockyer Valley Regional Council (LVRC) Mayor, Cr Tanya Milligan ■ TRC Councilors ■ LVRC Councilors Regional Development Australia – Ipswich and West Moreton ■ Regional Development Australia – Ipswich and West Moreton Inc and Darling Downs and South West Inc
Local communities	■ Directly affected landholders ■ Indirectly affected landholders ■ Interested individual community members
Business and industry	■ InterLinkSQ ■ New Hope Group ■ Gowrie One Stop Convenience Centre ■ Gowrie Landscape Supplies ■ Birdsong Market Garden ■ Sanbeg Pty Ltd (Harlaxton Quarry) ■ Withcott Town Centre (Business owners) ■ Withcott Quarry ■ Withcott Seedlings ■ Toll- Mitchell Helidon ■ Dyno ■ Combat Simulation Systems ■ Klucks Investment ■ Teen Challenge Toowoomba ■ Gehrke Grains and Transport ■ Lockyer Better Business ■ Lockyer Valley Growers ■ Lockyer Valley Water Users Forum ■ Nolans Transport ■ Regional Development Authority – Ipswich and West Moreton ■ SEQ Catchments Limited ■ Chamber of Commerce and Industry Queensland ■ Toowoomba Go Kart ■ Southern Queensland Country Tourism ■ Toowoomba Chamber of Commerce ■ Lockyer Valley Chamber of Commerce and Industry ■ Laidley Better Business ■ Lockyer Better Business

Stakeholder type	Stakeholders
Health, emergency and social infrastructure services	▪ Queensland Police Service (QPS) ▪ Queensland Ambulance Service (QAS) ▪ Queensland Fire and Emergency Services (QFES) ▪ Queensland Rural Fire Services ▪ Toowoomba Police Station ▪ Helidon Police Station ▪ Gatton Police Station
Quarries and resource interest holders	▪ Sanbeg Pty Ltd ▪ Withcott
Utility service providers	▪ APA ▪ Energy Qld ▪ Ergon ▪ Powerlink ▪ Santos ▪ TPG ▪ Telstra ▪ Nextgen ▪ NBN ▪ QUU ▪ Optus
Community groups	▪ Gowrie Junction Progress Association ▪ Murphy's Creek Progress Association ▪ Helidon and District Progress Association ▪ Toowoomba Community Housing Service ▪ Toowoomba Community Health Centre ▪ Toowoomba and South West Housing Service Centre ▪ Lockyer Community Centre ▪ Lockyer Valley Community Activities Shed ▪ Toowoomba Hospital (Darling Downs HHS) ▪ Inner Darling Downs Community Consultative Committee (CCC) ▪ Lockyer Valley CCC
Special interest groups	▪ Brisbane Region Environment Council ▪ Condamine Alliance ▪ Drayton & Toowoomba Agricultural & Horticultural Society, QLD ▪ Australia Koala Foundation ▪ Australian Wildlife Conservancy ▪ SQ Landscapes ▪ Darling Downs Regional Organisation of Councils ▪ Friends of the Escarpment Parks Toowoomba Inc. ▪ Healthy Catchments & Waterways ▪ Highfields and District Business Connection Incorporated ▪ Hope Australia (links to Condamine Catchments) ▪ Inglewood and Texas Landcare Association Inc ▪ Macintyre Valley Cotton Growers Association Inc. ▪ Murray Darling Association ▪ Murray-Darling Basin Authority ▪ Queensland Conservation Council ▪ RSPCA Queensland The Wilderness Society ▪ Toowoomba Bird Observers ▪ Landcare Group ▪ Wildlife Preservation Society of Queensland ▪ Wildlife's Welfare Carers Inc.

Stakeholder type	Stakeholders
	▪ Wilsonton Agricultural Environmental Education Centre ▪ Transport Main Roads Heritage Centre ▪ Cobb+Co Museum ▪ Toowoomba Historical Society ▪ The Toowoomba & Darling Downs Family History Society ▪ Royal Agricultural Society of Queensland
Indigenous interests	▪ Western Wakka ▪ Yuggera Ugrarapul
Education and training	▪ Helidon State School ▪ TAFE South West ▪ TAFE Queensland ▪ University of Queensland, Gatton Campus ▪ University of Southern Queensland ▪ Toowoomba East ▪ Holy Name Primary ▪ Toowoomba North State ▪ Mater Dei Primary, Newtown State ▪ Harlaxton State ▪ St Saviours Primary ▪ Our Lady of Lourdes Primary ▪ Harristown State, ▪ Toowoomba West Special ▪ Toowoomba South State ▪ Toowoomba Grammar ▪ The Glennie School (K-12) ▪ Toowoomba State High ▪ Fairholme College ▪ Toowoomba Anglican College (P-12), ▪ St Mary's College (P-12), ▪ Charlton State ▪ Highfields State School ▪ Mary MacKillop Catholic School ▪ Highfields State Secondary College ▪ Gowrie State School ▪ Lockyer District High School
Media	▪ ABC Southern Queensland ▪ Toowoomba Chronicle ▪ Gatton Star ▪ The Courier Mail ▪ Highfields Herald ▪ The Brisbane Times ▪ The Courier Mail ▪ Queensland Times ▪ Queensland Country Life ▪ ABC Radio ▪ The Australian ▪ WIN ▪ Channel 7

Table note:
Department names current as of 2021 at the time this report was written.

1.17.2 Stakeholder engagement activities

Consultation activities have been structured to provide multiple opportunities for both targeted stakeholders and the wider community to participate in the Project. Stakeholders have been engaged using a range of communication channels, including presentations and briefings, newsletters, drop in sessions, web-based material and face-to-face discussions. These were supported by feedback mechanisms, including comment forms, interactive mapping, workshops and project specific contact channels (1800 phone number, email, interactive 'Frequently Asked Questions').

1.17.3 Consultation themes

Table 1.7 provides the key themes of community concern that were identified over the course of consultation activities for the Project's key stakeholders.

Table 1.7 Key themes raised during Project consultation activities

Stakeholder	Key themes raised
Department of Transport and Main Roads	▪ Impacts on road corridor widths ▪ Impacts to their tenants ▪ Maintain connection to existing lots
Toowoomba Regional Council	▪ Potential impacts on Gowrie Junction area ▪ Changes to current flooding patterns ▪ General traffic and transport access concerns ▪ Impacts on Morris Road ▪ The provision of information on the road/rail interface and optimisation ▪ The need to avoid creating new roads and providing additional property management for council ▪ The impact on hydrology through areas such as Gatton and Helidon ▪ The desire for early planning around offsets ▪ The need for the project to consider stock movements on private property ▪ Property acquisition and the requirement for constituents to have assurance of Inland Rail being delivered
Lockyer Valley Regional Council	▪ Noise impacts of freight trains due to topography ▪ Noise amelioration ▪ Freight train scheduling ▪ Flood mitigation ▪ Protected species and offsets requirements ▪ Coal dust impacts and costs to agriculturalists ▪ Uncertainty for property owners in proximity to the G2G corridor
Landholders	▪ Exceedances and mitigation of noise ▪ Landscape and visual amenity, particularly in the Helidon (Lockyer Valley) area ▪ Traffic concerns, including proposed overpass at Gowrie Junction and closure of Morris Road, Gowrie Junction ▪ Stock routes ▪ Impacts to koala habitat ▪ Fauna crossings ▪ Changes to current flooding patterns, including increased debris during flooding events
Office of Coordinator-General	▪ EIS' compliance with required guidelines ▪ SIA methodology – integration of environmental matters, nature of scale of project, identification of impacts and benefits, consideration of vulnerable communities ▪ Potential impacts of housing supply and affordability ▪ Assessment of impacts and opportunities for local industry to participate in potential procurement and supply opportunities

Stakeholder	Key themes raised
Queensland Fire and Emergency Services	▪ Access to 6.24 km tunnel in case of emergency
Queensland Rail	▪ Impacts to existing QR operations (current traffic for freight, coal and passengers) and access for maintenance and operation of QR infrastructure.
Inner Darling Downs Community Consultative Committee	▪ Increased noise and air quality impacts as a result of increased train traffic and the location of tunnel vents, which will extract fumes and emissions ▪ A grade separation is proposed for Gowrie Junction Road. This reduces waiting times, but creates noise and amenity impacts for neighbours where the road is raised ▪ Road closures ▪ Property impacts and access ▪ Location of tunnel infrastructure. The use of a tunnel-boring machine 24/7 will create noise and dust, especially on service vehicle routes and near laydown areas ▪ Visual amenity, however area already has existing trains ▪ Cumulative impact from TSRC, Inland Rail, InterLinkSQ terminal, and a planned sports complex in the area. How will this be addressed? ▪ Operation of freight – what will be transported and what happens if there is an accident with dangerous materials? ▪ Timeframe to comment on the EIS and the time needed to digest and get assistance on the detail. ▪ Political predetermined outcomes and things changing without community input ▪ Social impacts and how it ranks against economic ratings. Short-term cuts impact long-term lives.
Lockyer Valley Community Consultative Committee	▪ Noise impacts on Squires Road and Ashlands Drive residents ▪ Visual amenity at Murphy's Creek Road ▪ Concept of operations – number of trains predicted to operate and what it means for the community ▪ Local road connectivity ▪ Timeframes to comment on EIS process ▪ Property impacts and access ▪ Business opportunities
Traditional Owners	▪ Provisions for managing accidental discovery of cultural material; contingency planning for finds ▪ Clear documentation process and dispute resolution process ▪ Development of appropriate cultural heritage awareness training and inductions
Utility companies	▪ Clashes with existing utilities and easements

1.17.4 Consultation outcomes

Consultation with individuals and groups at workshops, community consultation sessions, via the interactive online map, community committee meetings and face to face meetings have assisted in highlighting issues and identifying potential impacts and benefits to inform the EIS. These interactions have also helped to shape the project design and inform proposed mitigation measures for implementation in future stages of design, construction, commissioning and operation. In summary, the key issued raised were:

- Property access after construction, particularly around Gowrie Junction overpass and Morris Road
- Visual amenity (Gowrie Junction overpass and changes to natural landscape in Helidon)
- Impacts to fauna, in particular koalas
- Stress and anxiety potentially caused by property acquisition
- Impacts on property values.

Stakeholder engagement activities have resulted in the following information being considered in the development of the Project design and mitigation measures included during the development of the EIS as identified in Table 1.8.

Table 1.8 Key consultation outcomes

EIS component	Consultation outcome
Flooding and hydrology	Landholder consultation was undertaken to obtain specific photographic records and anecdotal evidence of existing flooding impacts and extents through a series of workshops. Based off primary feedback this information was validated and shared again with landholders to verify the modelling outcomes and findings of the Project's hydrology and flooding assessment.
Traffic and transport	Consultation is ongoing with local councils, DTMR and QR about the road network, construction traffic management and expectations with regards to temporary and permanent road network changes. Concerns regarding property access and road surfacing at Gowrie Junction, have been raised by landholders and TRC. The Project has undertaken additional works to explore this road rail interface and will continue consultation through the next phase of the Project.
Land use and tenure	Consultation activities undertaken with directly affected landholders, local businesses, utility and service providers, councils and State Government departments and agencies has confirmed the preference for the Project to minimise land acquisition requirements and other property impacts (such as creation of small lots, services interruption, severance, fragmentation, sterilisation and accessibility) by following the previously identified Gowrie to Grandchester corridor. Consultation also highlighted concerns regarding land acquisition and compensation processes, property values and ongoing land use viability. Given the amount of time that had passed since the investigation , assessment and approval of the Gowrie to Grandchester corridor, consultation was also necessary to inform residents of the Project objectives and proposed timeline, to request access to land for field studies, and to also understand their concerns and issues around their land potentially being acquired for the construction and operation of the Project.
Cultural heritage – Native title claimants	As part of the development of cultural heritage management plans, ARTC engaged with Aboriginal representative groups Western Wakka and Yuggera Ugrarapul.
Landscape and visual amenity	In October 2019 and November 2019, several community information sessions were held with stakeholders, including directly affected and nearby residents, to understand their landscape and visual amenity concerns. Through this consultation, specific visual amenity was identified within the Gowrie Junction and Helidon areas due to the proposed infrastructure. Providing access to 'before and after' landscape illustrations of the proposed project area, available on the Project's website page helped address landowners concerns and promote understanding to the changes to landscape and visual amenity due to the proposed infrastructure. Concerns about the visual amenity have been captured and addressed via the online interactive map, community consultation sessions and CCC meetings.
Waste and spoil management	Consultation with Toowoomba and Lockyer Valley councils was undertaken to identify current and forecast landfill capacities and waste transport service providers and appreciate operational capacities and industry processes. The Project Team also consulted with the DTMR about managing spoil transport, acknowledging the key issues of safety for road users, traffic management and pavement life.
Flora and fauna	Consultation with individuals and groups such as Wildcare and Lockyer Upland Catchments took place to understand key concerns, present project findings, provide face to face access to EIS technical specialists and provide an opportunity for stakeholder input into mitigation and design. Environmental groups requested the Project team source a technical specialist to meet with and show them how to use the WildNet database. ARTC sourced an independent facilitator to run WildNet database training in recognition of environmental concerns regarding protected species. This resulted in new records being included in the WildNet database that were not previously available. Based on the new records, ARTC was able to update Project reporting to better reflect the magnitude of impact on flora and fauna species. The feedback provided by stakeholders and the community to the Project Team has continuously reinforced the importance of ecological values to the community and driven the Project Team to seek opportunities to avoid, minimise and manage impacts to species and their habitats wherever feasible in this stage of the Project's development.

EIS component	Consultation outcome
Social	Consultation to inform the EIS Social Impact Assessment (SIA) was undertaken to provide the opportunity for directly affected stakeholders and other community members to provide informed input to the social baseline, impact assessment and mitigations. Consultation for the SIA involved meetings and workshops with: ■ Directly affected and nearby landholders ■ Community members (including landowners) and groups ■ Council representatives ■ Representatives of the traditional owners and other indigenous community members ■ Community and government agencies ■ Businesses, including tourism businesses, and business organisations. These interactions provided the Project with insight on community concerns, vulnerabilities, potential social impacts and benefits and advanced discussions on social infrastructure access, community concerns about the Project and opportunities to collaborate on training and employment programs.
Air quality and noise	Landowners shared concerns about their perceived air quality and noise impacts near the western portal in Gowrie Junction, and in the rural area of Helidon Spa. Operational noise for landowners and businesses is another concern along the Project alignment due to the current rural quietness of the area. During October 2019 and November 2019, the Project team held four community information sessions and consulted with the community about air quality and noise. In February 2020, the Project team also held workshops with potentially affected landowners where modelling showed property noise exceedances.

For a detailed discussion of consultation activities and outcomes refer to EIS Appendix D: Community Consultation.

1.18 Principles of ecologically sustainable development

Ecologically sustainable development refers to using, conserving and enhancing the community's resources so that ecological processes are maintained and the total quality of life, both now and in the future, can be increased. There are four principles of ecologically sustainable development:

- Precautionary principle
- Principle of inter-generational equity
- Conservation of biological diversity and ecological integrity
- Improved valuation and pricing of environmental resources.

It is impossible to construct major transport infrastructure, such as this Project, without causing environmental, social and/or economic impacts (positive and negative). During Project development, the four principles of ecologically sustainable development were used as a guide to identify potential impacts and develop mitigation measures that afford equal weighting to environmental, social, economic and engineering opportunities and constraints.

1.18.1 Precautionary principle

The precautionary principle stipulates that 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. In applying the precautionary principle, decisions should be guided by:

- Careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment
- An assessment of the risk-weighted consequences of various options.

The Project is aligned with the precautionary principle in the following ways:

- The assessment of potential impacts is based on best practice, using the best available information. The assessment has involved key stakeholders and the relevant government agencies.

- The impact assessment considered the maximum potential area of disturbance
- The Project alignment was first investigated in 2005. Since 2005, the Project alignment has been the subject of numerous desktop and field investigations, as well as wide-reaching stakeholder consultation. Knowledge gained over this period will ensure that the Project is designed, constructed and operated in a way that minimises potential impacts.
- The EIS draws attention to aspects of the Project that may cause serious and/or irreversible environmental damage, especially if the nature and extent of the damage is uncertain. Where environmental damage cannot be avoided, mitigation and management measures to protect the receiving environment are proposed. This includes securing offsets for impacts to biodiversity values.
- Lack of full scientific certainty has not been used as a reason for postponing measures to prevent environmental damage. For example, threatened species that could potentially occur but were not observed within the MNES study area during field surveys are still assumed present (rather than absent). Measures to avoid and/or mitigate impacts on threatened species are proposed, on the basis that these threatened species could be present within the MNES study area.
- The detailed design will aim to further minimise impacts and site and species-specific mitigation measures will then be applied to ensure that the significance ratings of any potential impacts are classified as low as reasonably practicable and the significant residual impacts are offset.
- During development of the Project, the alignment has been refined to:
  - Avoid sensitive vegetation, areas with known threatened flora and fauna communities, and key habitat areas
  - Avoid known items/areas of cultural heritage significance
  - Minimise flooding impacts
  - Minimise impacts on existing agricultural land and infrastructure, while also considering potential future land uses.

1.18.2 Intergenerational equity

The principle of intergenerational equity is that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.

The Project is aligned with the principle of intergenerational equity in the following ways:

- When developing the proposed alignment, minimising potential environmental impacts was a key consideration. This will ensure that environmental values (hydrological regimes, water quality, habitat connectivity, cultural heritage sites, etc.) are conserved for existing and future generations.
- Climate change projections were factored into flood modelling for the Project, and climate change-specific mitigation measures are proposed
- A Sustainability Management Plan will be developed prior to commencement of construction and sustainability initiatives will be incorporated the draft Outline Environmental Management Plan (draft Outline EMP) for the Project which will include engaging meaningfully with stakeholders, promoting long-term economic benefits and training and development opportunities for locals.

The need for Inland Rail is well documented. As part of the wider Inland Rail Program, the Project would benefit existing and future generations by providing a safer, more efficient, means of transporting freight between Melbourne and Brisbane.

Conversely, should the Project (and therefore Inland Rail) not proceed, the principle of intergenerational equity may be compromised. Future generations would experience increasingly worse safety and environmental impacts due to continued growth in road transport between Melbourne and Brisbane, particularly along the Newell Highway.

1.18.3 Conservation of biological diversity and ecological integrity

A broad range of sustainability initiatives were identified and incorporated into the Project during the development of the design which included protecting the environment by minimising the environmental footprint.

Impacts on biological diversity and ecological integrity have been avoided to the greatest extent possible. For example, investigations to verify the presence of threatened species and ecological communities within the MNES study area were completed. The results were used to inform the design and location of fauna crossings, fauna exclusion fencing, and landscaping, revegetation and rehabilitation works.

Other ways in which the Project contributes to the conversation of biological diversity and ecological integrity include:

- A crossing structure hierarchy was adopted during design development. Preference was given to bridges over culverts as, on the whole, bridges result in less severe impacts to fauna passage.
- Close attention was paid to the Department of Agriculture and Fisheries' (DAF) Accepted development requirements for operational work that is constructing or raising waterway barrier works when designing bridges and culverts across mapped QLD Waterways for Waterway Barriers Works
- A Rehabilitation and Reinstatement Plan will be developed to guide the approach to rehabilitating disturbed areas. Rehabilitation will occur progressively throughout the construction phase.
- Other plans that will be developed to minimise potential impacts on biodiversity during the construction phase include: Soil Management Plan; Biosecurity Management Plan; Flora and Fauna Sub-plan; and Land Resources Sub-plan.

Where impacts cannot be avoided (e.g. clearing of Regional Ecosystems (RE) and essential habitat), mitigation and management measures will be implemented. Where required, biodiversity offsets will be secured. An Environmental Offset Delivery Strategy for the Project has been prepared in consultation with the QLD and Commonwealth Governments and is included as Appendix I.

1.18.4 Improved valuation, pricing and incentive mechanisms

The principle of improved valuation, pricing and inventive mechanisms requires that environmental factors should be included in the valuation of assets and services, such as:

- Polluter pays, that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement
- The users of goods and services should pay prices based on the full life cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste
- Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

It is difficult to place a monetary value on the Project's environmental impacts. However, the value placed on environmental resources within and surrounding the alignment is apparent in the breadth and depth of environmental investigations undertaken to inform the Project design and mitigation measures.

The costs associated with environmental design and mitigation measures have been built into the overall Project cost. For example:

- Where required, offsets will be secured to ensure a neutral or net beneficial biodiversity outcome for the region is achieved

- A range of mitigation measures will be implemented to ensure that, during construction and operation, waste is avoided, reused or recycled wherever possible. Waste mitigation measures will be documented in a Waste and Resource Management Sub-plan to the Construction Environmental Management Plan (CEMP), including:
  - The management of waste activities associated with the Project will be underpinned by the 2018 National Waste Policy and *Waste Reduction and Recycling Act 2011* (Qld) waste and resource management hierarchy, as listed below in the preferred order to be considered:
    - Avoid or reduce
    - Reuse
    - Recycle
    - Recover energy
    - Treat
    - Dispose.
- Increased economic growth and reduced freight transport costs as a result of Inland Rail have been recognised. As stated in EIS Chapter 17: Economics, Inland Rail is expected to increase Australia's Gross Domestic Product by $16 billion during construction and the first 50 years of operation, while decreasing freight transport costs by an estimated $10 per tonne.

2 Legislation and policy

This section describes the legislative, policy and management framework for the Project to describe the legislative framework which applies to the assessment of MNES applicable to the Project at the Commonwealth level and to provide the statutory context in which the MNES assessment has been undertaken.

An overview of Commonwealth legislation that is relevant to MNES aspects of the Project, outlining the intent of the legislation and applicability to the Project, is presented in Table 2.1. Post primary approval requirements are outlined in Section 8.1.

In addition, the threatened species survey guidelines for bats, birds, fish, mammals and reptiles were considered during planning for the field assessment. This included survey effort, timing and techniques along with ecological information relevant to a species (refer Section 3.3).

Table 2.1 Commonwealth legislation and policies relevant to the Project

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Commonwealth			
Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act)	Australia and its Territories. Specifically, projects that involve or have the potential to impact upon nationally and internationally important flora, fauna, ecological communities and heritage places – defined under the Act as MNES.	The EPBC Act is the Australian Government's central piece of environmental legislation and provides the legal basis for the management and protection of nationally and internationally important flora, fauna, ecological communities and heritage places. Under Section 45 of the EPBC Act, the Australian Government and QLD Government have implemented a bilateral agreement relating to environmental assessment. This agreement allows the Commonwealth Minister for the Environment and DAWE to rely on specified environmental impact assessment processes of QLD in assessing actions under the EPBC Act. The bilateral agreement specifically aims to achieve the following objectives: ■ Protect the environment in accordance with the requirements of the EPBC Act ■ Promote the conservation and sustainable use of natural resources ■ Ensure an efficient, timely and effective process for environmental assessment and approval of actions.	ARTC submitted an EPBC Act referral for the Project to the DotEE in February 2017 (EPBC 2017/7882). The Minister for the Environment determined the Project to be a 'controlled action' on 17 March 2017. The controlling provisions for the Project controlled action are: ■ Listed threatened species and communities. The EPBC Act controlled action will be assessed under the bilateral agreement with the QLD Governments. As required by the ToR, this EIS addresses the relevant sections of Schedule 4 of the Environment Protection and Biodiversity Conservation Regulations 2000.
EPBC Act Environmental Offsets Policy (2012) (EPBC Act Offsets Policy)	Areas subject to the EPBC Act	Developed to support the management and protection of MNES under the EPBC Act and outlines the Australian Government's approach to the use of environmental offsets for impacts to MNES. Eight principles for the use of environmental offset under the EPBC Act have been developed by DAWE. These principles are used to assess any proposed environmental offset for MNES to ensure consistency, transparency and equity under the Act. The Australian Government's position is that environmental offsets must: ■ *Deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action* ■ *Be built around direct offsets but may include other compensatory measures* ■ *Be in proportion to the level of statutory protection that applies to the protected matter* ■ *Be of a size and scale proportionate to the residual impacts on the protected matter* ■ *Effectively account for and manage the risks of the offset not succeeding*	The Project will implement avoidance and mitigation measures to minimise the significant adverse residual impacts on the MNES. implementing mitigation measures including offsets will be consistent across Inland Rail. Offsets provided for under the policy include direct offsets, and other compensatory methods (or indirect offsets). It is likely that a combination of methods will be applicable to the Project, based on the extent of the significant adverse residual impacts on MNES. The Project will comply with the EPBC Act Offsets Policy for any significant adverse residual impacts to MNES. A detailed Environmental Offset Delivery Plan and Offset Area Management Plans will be developed and implemented by ARTC prior to construction commencement subject to the approval under the EPBC Act.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		▪ *Be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of State or territory offsets that may be suitable as offsets under the Act for the same action)* ▪ *Be efficient, effective, timely, transparent, scientifically robust and reasonable* ▪ *Have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced* (DSEWPAC 2012a). The Australian Government defines offsets as measures that compensate for the significant adverse residual impacts of an action on the environment (DSEWPAC 2012a).	
Significant impact guidelines 1.1 – Matters of National Environmental Significance: *Environment Protection and Biodiversity Conservation Act 1999* (DotE 2013a)	MNES	The purpose of the guideline is to assist any person who proposes to take an action to decide whether or not they should submit a referral to the DAWE for a decision by the Australian Government Environment Minister (the minister) on whether assessment and approval is required under the EPBC Act. These guidelines outline a 'self-assessment' process, including detailed criteria, to assist persons in deciding whether or not referral may be required. Important terms and phrases are explained.	Assessment of MNES against the MNES Guidelines will facilitate the determination of a significant residual impact to MNES. This has been undertaken in Sections 5.3.3, 5.3.4 and 5.3.5).
EPBC Act Referral Guidelines for the vulnerable koala (combined populations of QLD, NSW and the Australian Capital Territory) (DotE 2014a)	MNES	The purpose of the guideline is to assist any person who proposes to take an action to decide whether or not they should submit a referral to the DAWE for a decision by the Australian Government Environment Minister (the minister) on whether assessment and approval is required under the EPBC Act in relation to the Koala. These guidelines outline a 'self-assessment' process, including detailed criteria, to assist persons in deciding whether or not referral may be required. Important terms and phrases are explained.	Assessment of MNES against the guidelines will facilitate the determination of a significant residual impact to Koala. This has been undertaken in Section 5.3.5).
Draft *Guide to nationally protected species significantly impacted by paddock tree removal* (DotEE 2020)	MNES	National environmental law applies to the removal of paddock trees when a 'significant impact' on a nationally protected ecosystem or species is likely to occur. Nationally protected ecosystems include Ramsar wetlands and ecological communities listed in the critically endangered, endangered or vulnerable categories under the EPBC Act. In very rare circumstances, these ecosystems may be significantly impacted by paddock tree removal. Only a very small subset of nationally protected species may be significantly impacted by removing paddock trees. In some cases, undertaking mitigation activities may mean that the removal of paddock trees is lawful and does not require referral under national environmental law.	Assessment of MNES against the guideline will facilitate the determination of a significant residual impact to applicable threatened species (such as Koala). This has been undertaken where necessary in Section5.3. The following species are relevant to the Project and included within the draft guide. The species-specific approval requirements noted in the draft Guideline are identified here with their relevance to the Project. ▪ Regent honeyeater (*Anthochaera phrygia*): *Removing Ironbark paddock trees within known breeding areas or frequented visitation sites.* The

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		The purpose of the guideline is to assist any person who proposes to clear paddock trees to decide whether or not the action may impact threatened species listed under the EPBC Act and if submission of a referral to the DAWE for a decision by the Australian Government Environment Minister on whether assessment and approval is required under the EPBC Act. These guidelines outline species-specific actions, to assist persons in deciding whether or not referral may be required.	nearest breeding site is over 75 km south of the Project. The species occurs sporadically in the Toowoomba region (at best) and does not 'frequent' the MNES study area or surrounds. The approval requirements within the Guideline are not relevant to this species regarding the Project. ■ Painted honeyeater (*Grantiella picta*): *Removing old growth eucalyptus paddock trees containing mistletoe within known breeding areas.* The species is not known to breed in the Toowoomba area which is on the eastern edge of the Great Dividing Range and only sporadically occurs in the region. The approval requirements within the Guideline are not relevant to this species regarding the Project. ■ Coxens fig parrot (*Cyclopsitta diophthalma coxeni*): *Any removal of old growth fig paddock trees in areas of known visitation by this species*. There are no records of the species within 50 km of the Project. There are no records in the region from the year 2000 onwards. As such there are no areas of known visitation associated with the Project. The approval requirements within the Guideline are not relevant to this species regarding the Project. ■ Swift parrot (*Lathamus discolor*) – *Removing Tasmanian Blue Gum and Black Gum paddock trees in known breeding areas. These parrots only breed in Tasmania.* The Project is located in SEQ. The approval requirements within the Guideline are not relevant to this species regarding the Project. ■ Koala (*Phascolarctos cinereus*): *Removing paddock trees where they are habitat critical to the species survival or provide the only movement opportunity / refuge to or between areas of habitat critical to the species survival.* There is *potential habitat* within the Project disturbance footprint and surrounds which is analogous to this description. Addressed further in Section 5.3.5.3 under the significant residual impact assessment for the species.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Species recovery plans	MNES	Recovery plans for listed threatened species and ecological communities have been made or adopted under the EPBC Act. These plans remain in force until and unless the species is removed from the threatened list. A recovery plan is a document stating the research and management actions necessary to stop the decline, support the recovery and enhance the chance of long-term survival in the wild, of a protected community, animal or plant species.	Species recovery plans for the following MNES relevant to this Project have been considered as part of this assessment: ■ Brush-tailed rock-wallaby (*Petrogale penicillata*) ■ Spotted-tail quoll (*Dasyurus maculatus maculatus*) ■ Black-breasted button-quail (*Turnix melanogaster*) ■ Red goshawk (*Erythrotriorchis radiatus*) ■ Regent honeyeater (*Anthochaera phrygia*) ■ Swift parrot (*Lathamus discolor*) ■ Murray cod (*Maccullochella peelii*) ■ Condamine earless dragon (*Tympanocryptis condaminensis*). Draft recovery plans awaiting adoption under the EPBC Act and utilised for this report include the following species: ■ Australian painted snipe (*Rostratula australis*) ■ Australasian bittern (*Botaurus poiciloptilus*) ■ Grey-headed flying-fox (*Pteropus poliocephalus*). Species recovery plans adopted by DAWE are accessible at the at the following internet location: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowallrps.pl

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Threat abatement plans	MNES	Threat abatement plans provide for the research, management, and any other actions necessary to reduce the impact of a listed key threatening process on native species and ecological communities. Implementing the plan should assist the long-term survival in the wild of affected native species or ecological communities	Threat abatement plans relevant to MNES associated with the Project include: ■ Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* ■ Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads (*Rhinella marina*) ■ Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) ■ Threats identified in the Threat abatement plan for competition and land degradation by rabbits ■ Threat abatement plan for predation by feral cats ■ Threat abatement plan for predation by the European red fox ■ Threat abatement plan for competition and land degradation by unmanaged goats. Threat abatement plans approved by DAWE are accessible at the at the following location: https://www.environment.gov.au/biodiversity/threatened/threat-abatement-plans/approved

3 Assessment methodology

3.1 Overview

An overview of the stages involved in the assessment of MNES controlling provision of the Project is provided in Figure 3.1. Further information regarding the development of predictive habitat mapping to support the assessment process is provided in Appendix A.

The initial step of the assessment was to identify the MNES (e.g. EPBC Act listed species and threatened ecological communities (TECs)) relevant to the Project. This was undertaken using a combination of desktop-based datasets and validation of predictive, species specific mapping, which was supplemented by targeted field surveys at defined locations (refer Section 3.3.1). Ecological site investigations associated with pre-clearance work for geotechnical investigations (EPBC Referral 2017/7882) were also incorporated into the findings where relevant (refer Section 3.2.2).

Predictive habitat modelling for each of the MNES (refer Section 3.2.4, as well as Appendix A) was developed based on the desktop and field survey results. It is noted the survey guidelines for EPBC Act threatened fauna species state:

"… Alternatives to a dedicated survey may also be appropriate. For example, a desktop analysis of historic data may indicate that a significant impact is not likely. Similarly, a regional habitat analysis may be used to determine the importance of a site to the listed birds. Proponents should also consider the proposals impact in the context of the species' national, regional, district and site importance to establish the most effective survey technique(s)…" (e.g. DEWHA 2010a; DSEWPAC 2011a)

It should be noted from the outset that detailed onsite surveys for threatened fauna have not necessarily been carried out as per the relevant Commonwealth survey guidelines for each species (where applicable). There are no Commonwealth guidelines regarding threatened flora and surveys for protected flora have been carried out following State guidelines such as the Protected Plant Survey Guidelines (Department of Environment and Science (DES) formerly the Department of Environment and Heritage Protection (DEHP) 2020). Nevertheless, a range of survey methods carried out over a number of years and seasons are considered applicable to detecting the potential presence of MNES fauna that may occur in the area. Section 3.3.2.2 outlines the methods used during Project-associated surveys as they apply to MNES fauna species.

The threatened species habitat modelling has been based on a conservative approach to mapping habitat. In the absence of sufficient and robust scientific information to support a species being excluded from the area, the species has been assumed to be present if habitat for the species is present, or there are local records to this species. The approach is even more conservative as the quality of habitat or the carrying capacity of the habitat has been excluded from the assessment although this information may be used to determine whether a significant impact is likely when assessed against the MNES Guidelines (refer Sections 5.3.3, 5.3.4 and 5.3.5).

The predictive habitat modelling along with relevant scientific information was used to inform the significant impact assessment (direct and indirect) and where applicable the measures to avoid, minimise and mitigate impacts. This assessment has determined the maximum potential area of disturbance for each MNES using the predictive habitat modelling to provide the total maximum extent of habitat to be cleared irrespective of habitat category (e.g. *Potential habitat*, *Important habitat* or *Habitat critical to the survival of the species*; refer Section 3.2.4) or quality.

A key outcome of the significant impact assessment is the determination as to whether the Project will have a significant residual impact on each of the MNES under the MNES Guidelines (refer Sections 5.3.3, 5.3.4 and 5.3.5).

The interaction of each stage of the assessment process is represented schematically in Figure 3.1.

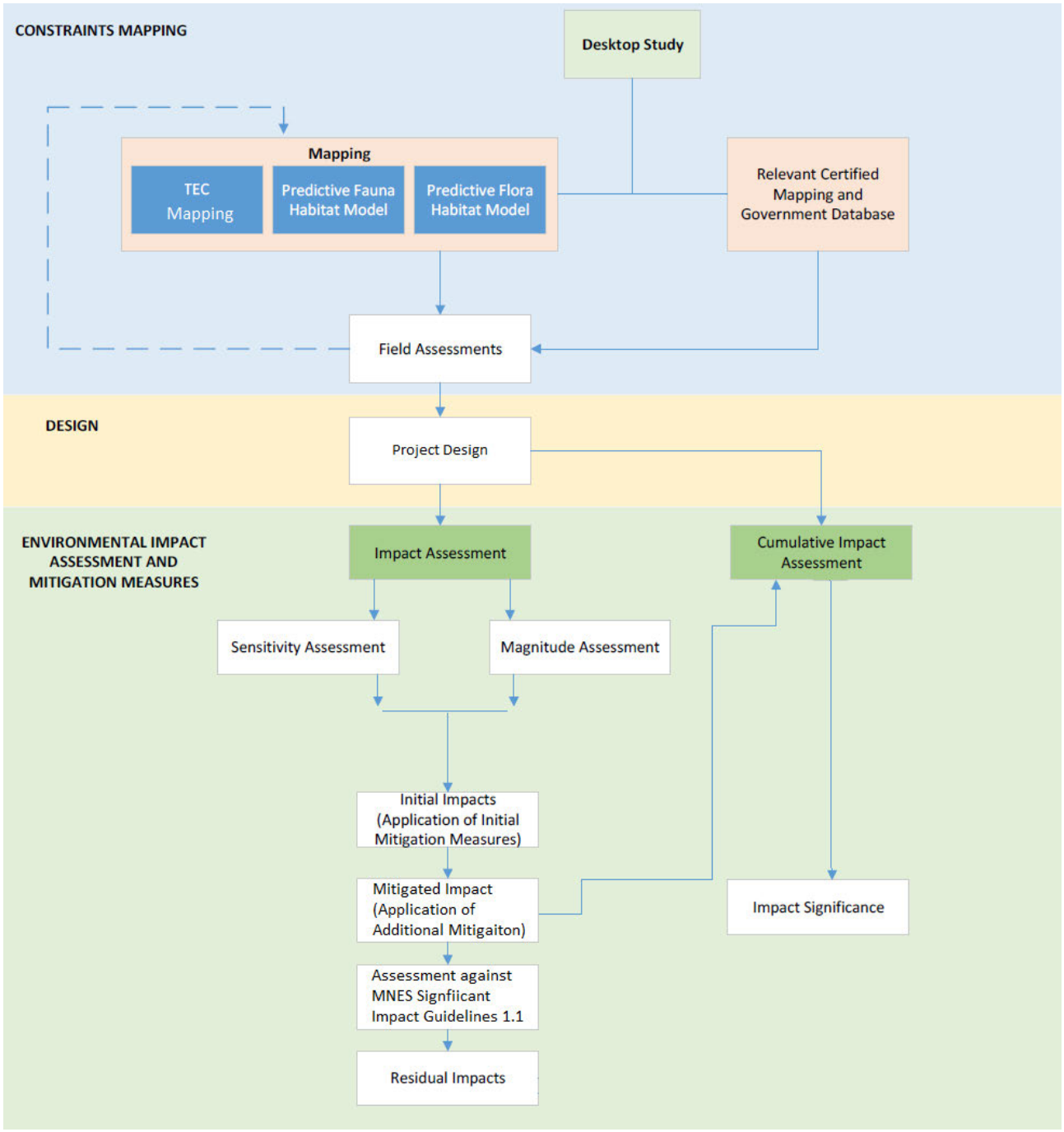


Figure 3.1 Assessment methodology

The approach outlined in Figure 3.1 and documented in this report, is the initial step in the determination of the extent of impacts associated with the Project upon MNES. During the detailed design, the design and construction methodology will be refined, which will result in refinements to the Project disturbance footprint. The detailed design process will have regard to measures to minimise the Project's impacts and implementation of mitigation measures, approval conditions and additional information on the ecological values of the Project, including the results of additional ecological surveys. It is expected that through the detailed design process, the significance of the impacts on MNES from the Project will reduce, in comparison to the conservative assessment that has been presented in this EIS

The approach adopted for this assessment is designed to be dynamic and will evolve in response to changes to the design and footprint, along with additional ecological information gained from Project activities (e.g. pre-clearing surveys or protected plant surveys in accordance with the relevant flora survey guidelines (e.g. DES 2020c) and changes to species status. This flexibility also has benefits such that during the construction stage, it allows management and monitoring of compliance with disturbance limits and environmental offset requirements. That is, the predictive mapping models along with other Project inputs (e.g. fauna 'breeding places' identified during pre-clearing surveys) can be used to identify temporary and permanent no-go zones and track clearing extents against relevant disturbance limits and where applicable inform additional specific mitigation measures.

3.2 Desktop study

This section details the desktop analysis undertaken to identify MNES located within the MNES study area, and existing gaps in datasets. This analysis included a review of existing field data collected prior to the commencement of the Project EIS and field data collected during the field component of the Project EIS data collection phase. In addition, this section provides details related to the creation of predictive GIS models which specifically identify areas of habitat capable of supporting species listed under the EPBC Act and communities within the MNES study area.

3.2.1 Database review

A database review was initially undertaken prior to field investigations to identify MNES that were known or likely to be present within the MNES study area. However, to ensure that the most recent data was obtained, searches were re-run to ensure that any relevant updates, or additional species observations were incorporated into the assessment. Details of the relevant database sources, the most recent search dates, search area parameters and type of information considered for the desktop study are summarised in Table 3.1. Desktop searches can be found in Appendix D.

Table 3.1 Database review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia (AoLA) (2020)	25/02/2020	MNES study area	Ongoing inspection of records of flora and fauna, including threatened species listed under the EPBC Act.
Flying Fox Monitoring Program (DES 2020a)	24/04/2020	MNES study area	Show the location of flying-fox roosts in QLD recorded by the department and include monitoring data of continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Flying-fox roost monitoring and locations	24/04/2020	MNES study area	Show the general location of flying-fox roosts in Queensland recorded by the department and include continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Birdlife Australia (2019)	29/03/2019	MNES study area	Records of avian fauna, including threatened and migratory species listed under the EPBC Act.
EPBC Act Protected Matters Search Tool (PMST) (Australian Government 2019)	26/02/2020	MNES study area	Provides a "predictive" account of MNES identified within a specific area. Includes MNES such as world heritage properties, national heritage places or wetlands of international importance and threatened/migratory species.

Database/data source name	Database search date	Database search areas	Data type
Regulated Vegetation Management Map (QLD Government 2020c)	25/02/2020	MNES study area	Mapping of REs and High Value Regrowth that provide habitat for TECs and threatened species under the EPBC Act.
Wetland Info database (QLD Government 2020b)	25/02/2020	MNES study area	Provides interactive maps, species records, case studies and legislation associated with QLD wetlands.
Wildlife Habitat Map (DES 2020b)	25/02/2020	MNES study area	Modelled habitat for threatened species listed under the EPBC Act.
Wildlife Online database (DES 2020d) incorporating WildNet and Herbrecs datasets	25/02/2020	MNES study area	Records of flora and vertebrate fauna including threatened species listed under the EPBC Act.
QLD Springs Database (QLD Government 2020a)	25/02/2020	Regional extent	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression GDEs.

Specifically, data from the sources identified above were used to identify the following MNES contained or predicted to be contained within the MNES study area. For the purposes of this assessment, MNES are identified as the following:

- EPBC Act listed threatened species and ecological communities (controlling provision)
- EPBC Act listed migratory species
- World Heritage Properties
- National Heritage Places
- Wetlands of International Importance (i.e. Ramsar)
- Great Barrier Reef Marine Park
- Commonwealth Marine environment.

3.2.2 Review of existing literature and previous studies

Ecological assessments have been by undertaken various parties to inform the preferred corridor and approval process. The assessments describe the ecological values contained within the MNES study area, including habitat, species diversity, abundance and seasonal distribution (refer Table 3.2).

Seasonal variation was also captured in the modelling approach (refer Section 3.2.4) which utilised government datasets and historic records that were developed across multiple seasons/years. The results of the modelling and subsequent mapping output provide a measure of the amount of suitable habitat that is present regardless of season as it collates essential 'habitat components' required by the species (e.g. vegetation structure, geological features (i.e. surface rocks, cliff faces or boulder piles), and presence of specific hydrological regimes).

In addition to the material identified in Table 3.2, site specific database queries as identified in Table 3.1 have been accessed to produce the predictive habitat mapping related to MNES flora, fauna and TECs (refer Sections 3.2.4 and 3.2.5). Whilst it is acknowledged that each of the previous investigations were undertaken over a single season, the analysis of existing database records, additional survey work (refer Section 3.3) and the formulation of the predictive habitat models which are considered to adequately account for seasonal variation and detectability related to threatened species.

The Project EIS ecology team has experience and knowledge in the assessment of MNES including Austral toadflax (*Thesium australe*), Hawkweed (*Picris evae*), Koala (*Phascolarctos cinereus*), and the Collared delma (*Delma torquata*) which has been utilised during the desktop component of the Project. The team also has local experience and knowledge having worked on the Toowoomba Second Range Crossing project

As such, there is a high level of confidence in the assessments of MNES undertaken within the MNES study area, including their adequacy for providing a baseline of the terrestrial and aquatic ecology area.

The findings of each of the existing background studies were used to inform this MNES assessment, particularly the likely extent of ecological communities and habitat for threatened species listed under the EPBC Act in the MNES study area. The reports reviewed, in which the survey areas match that of the Project, include those listed in Table 3.2. Information contained within these documents was incorporated into the predictive habitat mapping and relevant results sections of this report. This information was used to assess Project related impacts in relation to threatened species and TECs, and where applicable any other MNES.

Table 3.2 Assessments and reports providing ecological information for areas associated with the Project

Document title	Reference	Summary of significant findings related to MNES
Gowrie to Grandchester Corridor Study Part (2) Gowrie to Helidon	Queensland Transport (2003)	■ Two clear divisions are apparent in the vegetation – limited areas of vine forests on the scree slopes of the Toowoomba Range escarpment and a range of eucalypt communities dominating the slopes, crests and alluvial/colluvial plains of the study ■ Detailed field inspections that apart from *Floydia praealta*^ which is listed as vulnerable under the NC Act, noted that no other threatened flora species or their habitat are expected to occur in areas likely to be affected by the preferred route. Though further surveys works were recommended for *Cyperus clarus* in the Gowrie Creek floodplain, along with *Floydia praealta* and *Sarcochilus weinthalii* (refer Section 4.4.1.2). ■ No targeted fauna surveys were undertaken, though the report identified the potential for 16 threatened species to occur.
Australian Rail Track Corporation/Transport - Land/Gowrie to Helidon/Queensland/Inland Rail Gowrie to Helidon Project, QLD (EPBC Referral number 2017/7882)	ARTC (2017a)	■ Provides initial details on how the project is likely to impact upon MNES. This includes identification of potential impacts to threatened flora and fauna species and TECs. ■ Observations of Koala (*Phascolarctos cinereus*) presence (scats) – 16 distinct locations along the project alignment (high activity noted in some areas) (refer Section 4.4.2.2)
Initial Advice Statement: Inland Rail – Gowrie to Helidon – 15 February 2017.[#]	ARTC (2017b)	■ Potential impacts on threatened flora, fauna and ecological communities identified for the project. ■ Confirmation of the presence of Austral Toadflax (*Thesium australe*) as part of the nearby Toowoomba Second Range Crossing (TSRC) investigations (refer Section 4.4.1.2) ■ The project will likely impact Koala (*Phascolarctos cinereus*) habitat ■ The need for further detailed targeted surveys for three fauna species was identified; specifically for Koala (*Phascolarctos cinereus*), Collared delma (Delma torquata) and Black-breasted button quail (*Turnix melanogaster*)
Inland Rail – Gowrie to Kagaru Geotechnical investigations. MNES assessment report – 23 July 2018	EMM (2018a)	■ Identified habitat for Austral toadflax (*Thesium australe*), Hawkweed (*Picris evae*) and Austral cornflower (*Rhaponticum australe*) within the Project disturbance footprint (refer Section 4.4.1.2) ■ Evidence of Koala (*Phascolarctos cinereus*) presence (scratches/scats) within Project disturbance footprint (refer Section 4.4.2.2) ■ Known populations of Collared delma (*Delma torquata*) within Project disturbance footprint associated with findings of the TSRC project (refer Section 4.4.2.2)
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey report – Toowoomba Range (July 2019)	EMM (2019a)	■ Confirmation of the presence of Brush sophora (*Sophora fraseri*) (two individuals) in the Toowoomba Range area (refer Section 4.4.1.2)

Document title	Reference	Summary of significant findings related to MNES
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey reports (2019) Preclearance survey reports (2018 and 2019)	EMM (2018b, 2018c; 2019a, 2019b, 2019c)	▪ No MNES observed
Inland Rail – Gowrie to Helidon Geotechnical investigations. Protected plant survey report – 29 May 2019 Preclearance survey report (30 July 2019)	Eco logical Australia (2019a, 2019b)	▪ Koalas (*Phascolarctos cinereus*) observed as well as evidence of presence (scatches/scats) within MNES study area (refer Section 4.4.2.2) ▪ Collared delma recorded as well as evidence of presence (skins) within MNES study area ▪ Lowland Rainforest of subtropical Australia TEC confirmed within MNES study area (refer Section 4.4.1.3)

Table notes:

Based on the Gowrie to Grandchester future State transport corridor alignment

^ There are no records of *Floydia praealta* within the region and the record could not be verified (i.e. the surveys data is not available) and as such the species is not considered further

3.2.3 Assessment of the likelihood of occurrence of threatened MNES species

The likelihood of threatened species listed under the EPBC Act to occur within the MNES study area was determined based on the results of the desktop study and review of existing literature (refer Appendix B), which was later supplemented with data derived from field assessments (refer Section 4.4, Appendix E, Appendix F and Appendix H) and used to refine the predictive habitat mapping (refer Figure 3.1 and Appendix A). The likelihood of occurrence assessment is central to determining which threatened MNES species were identified as receptors for the Project and were subject to predictive habitat modelling (refer Section 3.2.4 and Appendix A).

Threatened species considered **possibly** or **likely** to occur, or which were identified in the MNES study area during the field assessment, were applicable to this assessment. Threatened species which were considered **unlikely** to occur within the MNES study area were not considered further as part of this MNES assessment.

This process allowed for the identification of species that are most likely to be at risk from the Project impacts.

The likelihood of occurrence assessment was based on records collected during the Project EIS field assessments, historic datasets and consideration of a species current (known) distribution range and the presence and condition of suitable habitat in the MNES study area.

Species considered **unlikely** to occur include species that fit one or more of the following criteria:

- The MNES study area is beyond the current distributional limits for the species
- Use specific habitat types or resources that are not known to be present in the MNES study area (e.g. intertidal saltmarshes and estuarine wetlands for the Eastern curlew (*Numenius madagascariensis*))
- The species are considered locally extinct based on expert knowledge and/or literature (e.g. Southern black-throated finch (*Poephila cincta cincta*) and Northern quoll/digul (*Dasyurus hallucatus*).

Species considered to **possibly** occur include species that fit one or more of the following criteria:

- Have infrequently been recorded previously in the MNES study area (i.e. sporadic records with no recent sightings within the past 10 years within 20 km of the MNES study area)
- Use habitat types or resources that are present in the MNES study area, although habitat types may be in a poor or modified condition (with condition based on based desktop works, literature review and, where available and possible, supplementary field assessments)

- Are unlikely to maintain sedentary populations, however, may seasonally utilise resources within the MNES study area opportunistically during variable seasons or migration (e.g. Swift parrot (*Lathamus discolor*)). Note that species that can be identified as sporadically utilising areas of the MNES study area (e.g. Grey-headed flying-fox (*Pteropus poliocephalus*)) are assigned to the "likely" category.

Species considered **likely** to occur include species that fit one or more of the following criteria:

- Have been recently recorded in the MNES study area (i.e. sightings within the past 10 years within 20 km of the MNES study area)
- Use habitat types or resources that are present in the MNES study area, which are in good condition (with condition based on desktop works, literature review and, where available and possible, supplementary field assessments)
- Are likely to maintain sedentary populations within the MNES study.

Information related to ecology, habitat requirements and distribution for each of the threatened species and communities identified from the desktop component is provided in Sections 5.3.4 and 5.3.5 and Appendix B.

3.2.4 Predictive habitat modelling for threatened flora and fauna species

3.2.4.1 Overview

Predictive habitat modelling was undertaken to identify and map areas that were determined as having the potential to provide habitat for threatened species listed under the EPBC Act in accordance with the ToR.

Whist this technical report deals with MNES, State-based GIS layer datasets are used as habitat delineators and were incorporated into the predictive habitat model where applicable for each species. For example, regional ecosystems associated with remnant and high value regrowth vegetation, geological datasets, drainage feature mapping and cadastral boundaries were used to identify road reserves (where grazing pressures would be excluded) that may provide important habitat for species such as Austral toadflax (*Thesium australe*).

In addition, to adequately capture known records of threatened species (e.g. historic records and those identified during field assessment), all areas (regardless of existing vegetation communities) within a 1 km radius of the record were "automatically" assigned as providing habitat for the specific species to which the record belonged. This distance adequately accounts for the potential movement and dispersal for the relevant species and would also mitigate potential issues associated with record precision. If the record occurred on the outside edge of the MNES study area, the 1 km buffer area for the record would still be integrated into the predictive habitat mapping where it intersected the MNES study area.

In some instances, the mapped '*potential habitat*' contained areas of agricultural land, grassland and open forest/woodland habitat, as well as scattered trees. With reference to Koala (*Phascolarctos cinereus*) this may provide habitat connectivity to larger forest patches or refuge opportunities between habitat patches considered critical to the survival of the species and such may be koala habitat under the EPBC Act Referral Guidelines for the vulnerable koala (combined populations of QLD, NSW and the Australian Capital Territory) (DotE 2014a).

The model was designed to recognise specific requirements of each threatened species, which were identified through the broader desktop analysis. Where available this information was derived from species/community recovery plans, DAWE-approved conservation advice for a species/community, and relevant scientific studies. This approach to habitat mapping represents a highly conservative methodology and applies the precautionary principle so that where doubt exists, habitat is included rather than excluded in addition to the inclusion of some areas of habitat that are not considered essential to the survival of the species.

Databases and other information that were used to feed into the predictive GIS based model are identified in Table 3.1, Appendix A and Appendix C. Because of the general paucity of information on the distribution of biota over much of the MNES study area, much of the predictive habitat modelling has been undertaken utilising the State-based vegetation mapping (REs) database to delineate potential habitats. Regional ecosystems are an integrated entity derived from landscape pattern, geology and landform, and vegetation. As such, they provide a robust classification for biodiversity planning that incorporates ecological processes at the landscape scale. Regional ecosystems have also been used to define threatened ecological communities within Queensland (refer Section 3.2.5). Aerial imagery was also used to delineate areas of potential habitat located outside of mapped REs which are not captured under the State-based mapping (e.g. vegetated drainage lines).

In addition to database information (e.g. previous ecological survey data and historic records), flora and fauna species data collected during Project-associated field-based assessments (such as species records) (refer Section 3.3) was used to verify and "fine-tune" model outputs (refer Figure 3.1).

The habitat in the predictive threatened species habitat model was categorised as *Habitat critical to the survival of the species, Important habitat*, essential and *Potential habitat* using current scientific knowledge and pre-existing data derived from historic surveys, State based mapping and scientific publications and industry recognised experts (eg, Dr C. Schell and J Stark in relation to the *Delma torquata*, Greg ford in relation to Microchiropterian bats and R. Hobson in relation to the Condamine earless dragon). The specific habitat assumptions for each species are provided in Appendix A.

The predictive habitat modelling provides greater conservatism in predicting the likelihood of a threatened flora and fauna species (EPBC Act) occurring within the MNES study area, when compared to limited and or sporadic field investigations.

The species specific assumptions allowed the following areas to be identified for each threatened species:

- Unlikely habitat
- *Potential habitat*
- *Important habitat* (where applicable – refer Section 3.2.4.4)
- *Habitat critical to the survival of the species* (where applicable)

The use of these habitat categories aligns with DAWE's habitat definitions for species protected under the EPBC Act where they are defined under relevant recovery plans and/or referral guidelines.

An overview of each of these categories is provided in the sections below.

3.2.4.2 Unlikely habitat

Unlikely habitat consists of areas that do not contain specimen backed records of the particular species (i.e. no point data derived from the positive identification/confirmation of a species in the field) and contain no evidence of habitat values to support the presence or existence of resident individuals or populations of the species. However, it is acknowledged that these areas may provide temporary habitat for species during exceptional circumstances. It is considered that occurrences of the subject species within these areas is an anomaly as these areas are not likely to support the species in the long-term.

3.2.4.3 Potential habitat

Potential habitat consists of areas or locations used by transient individuals or where species may have been recorded but where there is insufficient information to assess the area as *Important habitat* or *Habitat critical to the survival of the species* , that is records of the species are considered anomalies as general microhabitat features are not considered to be present. *Potential habitat* also includes habitat that is considered to potentially support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records and where this does not completely address the relevant criteria to be mapped as *Important habitat* or *Habitat critical to the survival of the species*. *Potential habitat* may include areas of suboptimal habitat for a species. Species specific assumptions that define the *Potential habitat* category are identified in Appendix A. Impacts to *Potential habitat* are not considered to contribute to significant impacts on a threatened species as the loss of these areas is not deemed to be significant in accordance with the Commonwealth significant impact criteria. However, impact to *Potential habitat* have been considered in relation to movement of species and the potential to contribute towards fragmentation and barrier effects, rather than the loss of habitat *per se.*

3.2.4.4 Important habitat

In line with DAWE's guidelines, areas of Important habitat are regarded as a surrogate for important populations of Brigalow belt reptiles. Relevant to the current investigations, the following species are classified as Brigalow Belt reptiles and where relevant, Important habitat for these species has been mapped as defined in Section 5 of the *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b):

- Dunmall's snake (*Furina dunmalli*)
- Collared delma (*Delma torquata*)
- Five-clawed worm-skink (*Anomalopus mackayi*)

In addition to the species identified above, the Important habitat has been used to capture "Priority habitat areas" for the Swift parrot (*Lathamus discolor*) as identified in the *National Recovery Plan for the Swift Parrot (Lathamus discolor)* (Saunders and Tzaros 2011).

Species specific assumptions that define the Important habitat category for the abovementioned species are provided in Appendix A. Impacts to *Important habitat* are considered to contribute towards significant residual impacts to a threatened species.

3.2.4.5 Habitat critical to the survival of the species

Habitat critical to the survival of the species represents habitat with the greatest value for the relevant threatened species and aligns with habitat identified in the conservation listing advice for a relevant threatened species. This habitat category identifies areas that align with 'Habitat critical to the survival' of a listed threatened species identified in an approved Recovery Plan for the relevant MNES. However, in instances where there are no Recovery Plans for a specific species, and in line with a precautionary assessment approach, the presence of a specimen backed record (i.e. derived from field investigations or previous database records with low location error information and from within the last 30 years) is considered to align with this category where breeding and foraging habitat is potentially present. For these species, elevation of habitat to this level adequately accounts for the significance of such areas regardless of the absence of a Recovery Plan. Species specific assumptions associated with the mapping of Habitat critical to the survival of the species are detailed in Appendix A.

Impacts to *Habitat critical to the survival of the species* are considered to contribute towards significant residual impacts to an MNES.

3.2.5 Mapping of threatened ecological communities

Threatened ecological communities (TECs) relevant to the Project are outlined in Table 1.1. For each of these REs the DAWE's SPRAT database, approved conservation advices, listing advices and other relevant document was reviewed

- Extent of the communities, noting that the area of occurrence of some of these TEC is a single polygon (e.g. Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions and Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD) , while for other TECs (e.g. Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregion and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland) the mapping is at a finer scale and includes smaller polygons showing areas where the community may or is likely to (Generally aligning with the Queensland Government vegetation mapping)
- Analogous regional ecosystems noting that all six TEC have analogous RE mapping under the SPRAT database, approved conservation advice and/or listing advice. Regional ecosystem mapping (i.e. remnant and regrowth regional ecosystems as provided within the Vegetation management regional ecosystem mapping dataset, this mapping can be seen in Figure 4.15 in the EIS Appendix I: Terrestrial and aquatic ecology technical report)) was therefore used to identify and map out the extent of each of the identified TECs within the MNES study area map each of the TECs. (DAWE 2020a),
- Diagnostic characteristics of the TEC, including minimum patch size, where applicable condition thresholds and survey requirements

The identified TECs and the relevant information used to map out the extent of TECs within the MNES study area (prior to ground-truthing) is presented in Table 3.3. Following ground-truthing was TEC mapping was updated to include any new TECs encountered, any new patches not already identified form the RE mapping (or historic surveys) or refinement the existing patch size.

It is acknowledged that the State-based RE mapping may not accurately delineate the extent of a TEC within the MNES study area, as the threshold size for some TECs are less than 0.5 ha (refer Table 3.3), while remnant patches from the State-based RE mapping (i.e. 1:50,000 mapping) is 2 ha and/or 75 m width limit for linear features. Therefore, the use of RE mapping may not identify the true extent of potential TECs within the Project disturbance footprint (e.g. smaller patches of potential TEC vegetation may not be mapped as remnant or high-value regrowth communities under State-based mapping). In addition, not all patches of analogous RE (remnant or regrowth) may meet the relevant condition thresholds resulting in an overestimation of area until the patches are verified and delineated in the field. Analysis of aerial imagery was used to supplement the mapping, along with targeted field investigations (refer Section 3.3.1 for survey locations). This information was incorporated into the final TEC mapping for the MNES study area (refer Section 4.4.1.3).

Table 3.3 EPBC Act listed threatened ecological community assumptions used to map areas of occurrence within the matters of national environmental significance study area

TEC name	EPBC Act status	Habitat requirements or analogous REs[1]
Lowland Rainforest of Subtropical Australia	Critically Endangered	The following REs (remnant vegetation and high value regrowth vegetation) are analogous to this TEC: 12.3.1, 12.3.1a, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.3, 12.8.4, 12.11.1, 12.11.10, 12.12.1 and 12.12.16 where they meet the following criteria: ■ Is located at or below 300 m above sea level ■ Is located at least 2 km from the coastline. Note that for remnant patches (which meet the key diagnostic characteristics) the threshold is 0.1 ha or 1 ha for where some residual trees are present, while for non-remnant areas the threshold is 2 ha.

TEC name	EPBC Act status	Habitat requirements or analogous REs[1]
Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	The following REs (remnant vegetation and high value regrowth vegetation) are analogous to this TEC: 11.3.3, 11.3.3a, 11.3.3b, 11.3.3x1, 11.3.3c, 11.3.15a, 11.3.15, 11.3.16, 11.3.28, 11.3.37 Note the minimum the minimum patch size is 5 ha. This may include areas of native vegetation that may be naturally open or contain regrowth.
Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD	Critically Endangered	The following REs (remnant vegetation and high value regrowth vegetation) are analogous to this TEC: 11.3.21, 11.3.24 The minimum patch size is dependent on the quality of the TEC Minimum patch size of at least 0.5 ha for a best quality community (At least 4 native perennial grass species from the indicator species list, at least 200 native perennial grass tussocks, canopy cover of less than 30% and less than 5% of non-woody introduced species). Minimum patch size of at least 2 ha for a good quality community (At least 3 native perennial grass species from the indicator species list, at least 200 native perennial grass tussocks, canopy cover of less than 50% and less than 30% of non-woody introduced species).
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	The following semi-evergreen vine thicket (SEVT) REs (remnant vegetation and high value regrowth vegetation) may be analogous to this TEC: 11.2.3, 11.3.11, 11.4.1, 11.5.15, 11.8.3, 11.8.6, 11.8.13, 11.9.4, 11.9.8, 11.11.18, 11.3.11x1, 11.9.4a, 11.9.4c, 11.10.8, 11.11.5, 11.11.21, 11.12.4 Seven SEVT REs (12.8.21, 12.8.22, 12.9/10.15, 12.11.4, 12.11.13, 12.12.17 and 12.12.18) occur in western and northern areas of the South East Queensland Bioregion, but all have been excluded from the EPBC Act listing. It is noted that additional REs contained within the Bioregion 11 have been included to assist in identification of SEVT more broadly, and may not necessarily meet the TEC definition of this TEC.
Weeping Myall Woodlands	Endangered	The following REs (remnant vegetation and high value regrowth vegetation) are analogous to this TEC: 11.3.2, 11.3.28, 11.3.2a, 11.3.2b, 11.3.2c For this community the patch of woodland must be at least 0.5 ha (5,000 m²) in size and the minimum plot size for determining the presence of TEC should be 0.04 ha (i.e. 20 m x 20 m). It is noted that the RE11.3.2 is also analogous with the endangered Poplar Box Grassy Woodland on Alluvial Plains TEC.
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	The following REs (remnant vegetation and high value regrowth vegetation) are analogous to this TEC: 11.8.2a, 11.8.8, 11.9.9a, 13.3.1, 13.11.8, 13.12.8, 13.12.9, 11.3.23, 12.8.16 (west of bioregion) For this community a patch (which meets the key diagnostic characteristics) must be an area that contains five or more trees in which no tree is greater than 75 m from another tree, or the area over which the understorey is predominantly native. Patches must be assessed at a scale of 0.1 ha (1,000 m^2) or greater.

Table note:

1 As regulated under the Queensland VM Act. Obtained from conservation listing advice contained within SPRAT unless otherwise stipulated

3.3 Field assessments

This section outlines the field assessment methodologies adopted in recognition of relevant departmental guidelines or policies (i.e. survey guidelines, species recovery plans and the EPBC Act Significant Impact Guidelines). Survey were undertaken in accordance with the following:

- Commonwealth published guidelines for threatened species where applicable (refer: http://www.environment.gov.au/epbc/policy-statements).
- *Methodology for survey and mapping of Regional Ecosystems (RE) and vegetation communities in Queensland* (Neldner et al 2012; 2017)
- *Terrestrial vertebrate fauna guidelines for Queensland* (Eyre et al 2014)
- *Flora Survey Guidelines - Protected Plants, Nature Conservation Act 1992* (DEHP 2016a).

There are no Commonwealth guidelines regarding surveys for MNES flora and State guidelines (DEHP 2016a) are considered suitable for surveying flora species. For the TECs, there are also no specific Commonwealth survey guidelines. Therefore, Neldner et al 2012 (and subsequent revisions) is considered suitable to verify and delineate the extent of a TEC. This is based on the relevant diagnostic criteria and condition thresholds (where available) in the relevant Approved conservation advice for the TEC.

The information within this document is based on desktop information and targeted field-based information from survey activities carried out over a number of years (refer Section 3.3.1). The approach to assessing threatened species presence and habitat modelling for threatened species has adopted a conservative approach in order to avoid underestimating the available habitat potentially present within the Project disturbance footprint. For some fauna species the presence of suitable habitat features may be sufficient to consider the species as present (e.g. dry rainforest understorey with well-developed leaf litter layer for Black-breasted button-quail (*Turnix melanogaster*)). As such, it is considered this maintains the intent of the various guidelines.

The extent of fieldwork and predictive flora and fauna modelling undertaken for the Project, when used in conjunction with existing information (refer Table 3.4), are considered sufficient to provide confidence in predictions of potential impacts to threatened species and where applicable TECs. Specific methodologies utilised in assessing threatened species and where applicable TECs are set out below.

The location of terrestrial and aquatic survey sites was dictated by land access agreements with landholders which was provided on a voluntary basis. This reduced the areas that were accessible to ecological investigations. However, where access agreements existed, these locations were surveyed in addition to publicly accessible areas. Publicly accessible areas were selected as they were contiguous and/or representative of habitat present in the Project disturbance footprint

Where access is not possible or where surveys were not required the assessment is based on habitat mapping (e.g. remnant and regrowth vegetation, regional ecosystem descriptions, watercourse mapping etc) and interrogation of current and historic aerial imagery, supported by surveys from representative and/or contiguous habitat to that present in the Project disturbance footprint. Using this information the ecologists were able to predicted the likely values of the area for a range of MNES.

ARTC is committed to undertaking additional surveys in accordance with relevant guidelines to verify the assumptions used to inform the mapping and address any constraints/limitations.

Ecological surveys are ongoing, including targeted threatened fauna in accordance with relevant Commonwealth survey guidelines which aim to address gaps in the current dataset (e.g. where land access was not available or where the alignment has been amended.

Results of previous field work conducted by Arup (2016) and findings associated with ecological investigations to support approval processes for the Gowrie to Helidon geotechnical program (i.e. undertaken by EMM and Eco Logical Australia (ELA)) which occurred concurrently with the EIS investigations reported in this document, have been incorporated within the EIS reporting (refer Figure 3.2 for the locations of areas undertaken as part of these surveys). Surveys undertaken to support the geotechnical program were undertaken in accordance with the Flora survey guidelines - protected plants, *Nature Conservation Act 1992* (DEHP 2016a) and in addition, habitat assessments (including breeding and foraging habitat for threatened species), focussing on those listed as threatened (e.g. Koala). This data has been used to assist in the predictive habitat mapping and refinement of TECs located within the MNES study area. Where data from these surveys is considered relevant it has been incorporated throughout this document but specifically in the significant impact assessments associated with TECs (refer Section 5.3.3), threatened flora (refer Section 5.3.4), and threatened fauna (refer Section 5.3.5).

3.3.1 Field assessment locations and timing

A representative sampling approach was employed as part of the field sampling methodology. Seasonal sampling (i.e. Spring (mid-September to mid-December) and Autumn (late February to April)) are recommended for the SEQ bioregion (Eyre et al. 2014). Targeted surveys were undertaken by the Future Freight Joint Venture (FFJV) EIS team during Spring 2017. Additionally, the use of publicly available datasets and surveys undertaken by Arup in Autumn 2016 and various surveys undertaken by ELA and EMM as part of geotechnical works fulfil the seasonal survey requirements (refer Table 3.4). The survey timings are considered adequate to measure taxa diversity and their repetition throughout the MNES study area. In addition, when combined with the predictive habitat modelling (refer Section 3.2.4) which has been supplemented with field based datasets, a highly conservative approach has been adopted to the assessment of threatened species.

3.3.1.1 Previous and concurrent ecological surveys for Project

Table 3.4 presents the survey timing and survey activities associated with previous Project associated ecological investigations, including the Arup works in 2016, and geotechnical field investigations undertaken by ELA and EMM (2018 and 2019). Figure 3.2a-e present the survey location points. Note, there is substantial overlap in the location of surveys undertaken during programs presented in Figure 3.2a-c with those undertaken as part of targeted surveys associated with the EIS in 2017 (refer Figure 3.3a-c), allowing for seasonal assessments of the same areas. The targeted surveys for the EIS have also captured areas within the alignment not subject to assessment elsewhere such that the majority of the Project disturbance footprint has been subject to ecological assessment.

Table 3.4 Timing of field investigations undertaken associated with the Project used to supplement results of the current study

Study/investigation	Consultant /year	Timing of investigations	Season	Methodologies and notes
Habitat assessment surveys to support the EPBC referral for the Project - 2017/7882	Arup 2016	March 2016	Autumn (2016)	Targeted Koala habitat searches – 17 sites Fauna habitat assessments - 21 sites
Protected plant surveys associated with geotechnical investigations to inform the Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan	EMM (2019a, 2019b, 2019c)	16 May – 19 June 2019 13 May – 24 May 2019 3 June – 16 July 2019	Autumn, Winter (2018)	Protected plant surveys within/adjacent to alignment (meander surveys – minimum 30 minutes) at 30 sites and access tracks throughout G2H alignment

Study/investigation	Consultant /year	Timing of investigations	Season	Methodologies and notes
Pre-clearing surveys associated with geotechnical investigations to inform the Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan	EMM (2018b, 2018c, 2019d)	4-14 September 2018 26-28 November 2018 14-29 May 2019	Spring (2018) Autumn (2019)	Threatened fauna habitat assessments within/adjacent to alignment Searches for fauna breeding places TEC confirmation Fauna observations Carried out at 57 sites throughout the MNES study area
Pre-clearing surveys associated with geotechnical investigations for G2H alignment	Eco Logical Australia (2019a)	Various from 18 December 2018 – 16 April 2019	Summer 2018/2019 –	Threatened fauna habitat surveys within/adjacent to alignment Koala habitat assessment Searches for fauna breeding places Fauna observations TEC confirmation Carried out at 214 sites and additional access tracks throughout the MNES study area
Protected plant surveys associated with geotechnical investigations for G2H alignment	Eco Logical Australia (2019b)	Various from 18 December 2018 – 16 April 2019	Summer 2018/2019 – Autumn 2019	Protected plant surveys within/adjacent to alignment (meander surveys – minimum 30 minutes) at 23 sites throughout alignment (covering 46.93 ha)

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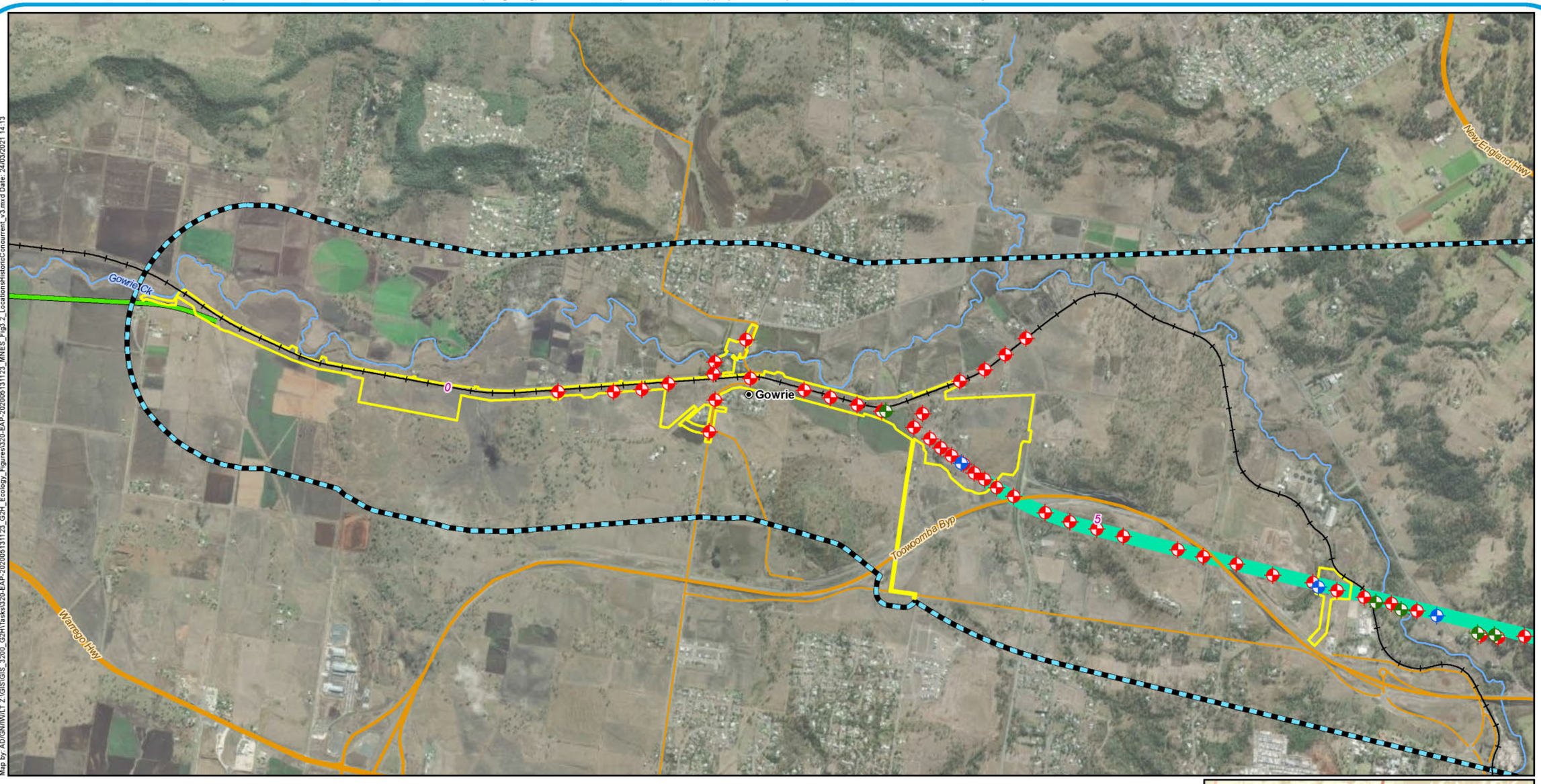
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Map by: AD/GN/RWILT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig3.2_LocationsHistoricConcurrent_v3.mxd Date: 24/03/2021 14:13

Legend

- 5 Chainage (km)
- Localities
- Supplementary flora survey point (EMM 2019)
- Supplementary fauna survey points (ELA 2019)
- Supplementary terrestrial ecological surveys (Arup 2016)
- B2G project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas



A3 scale: 1:30,000
0 0.5 1 1.5km

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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.2a: Location of areas sampled as part of historic and concurrent works

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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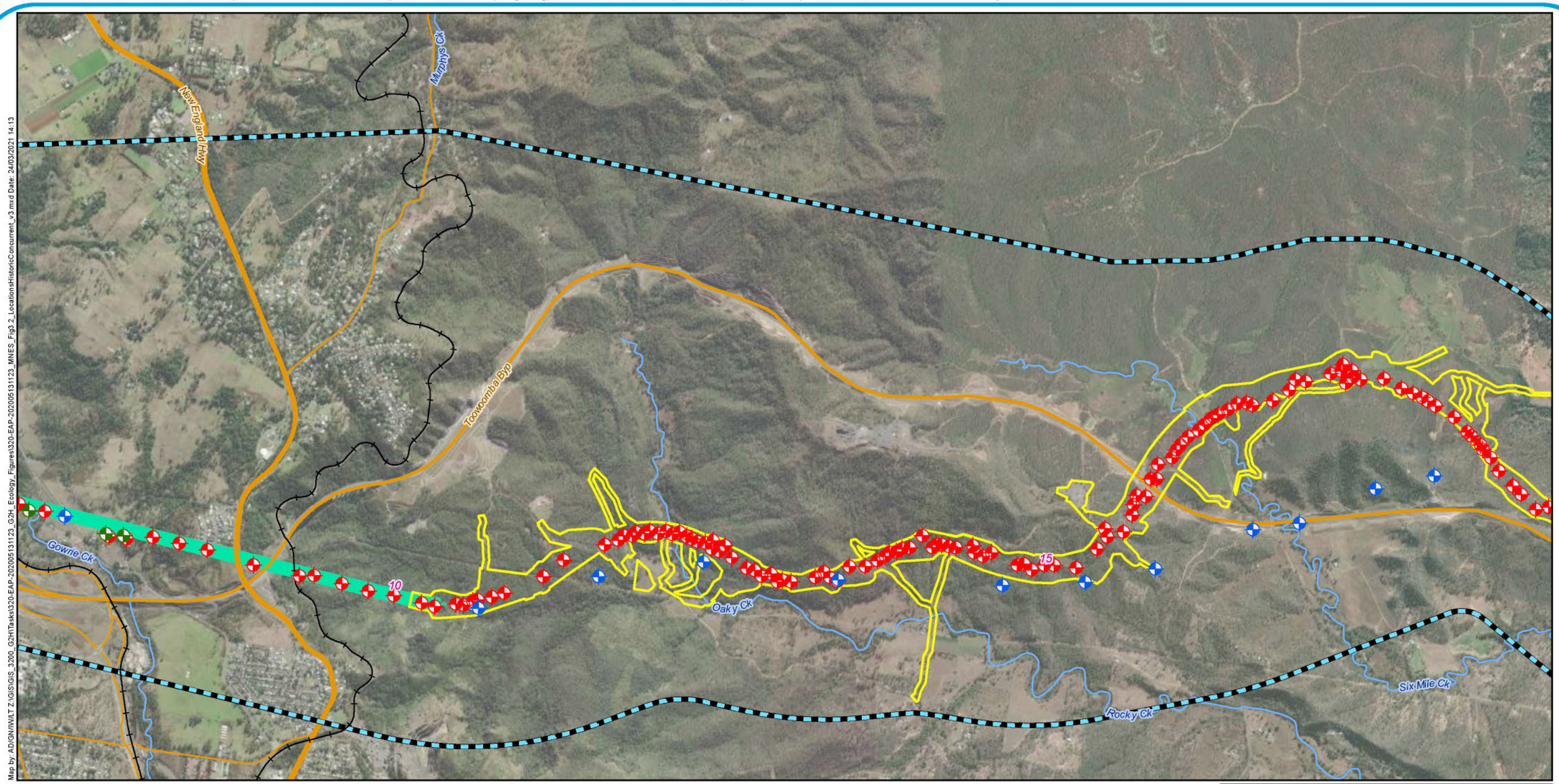
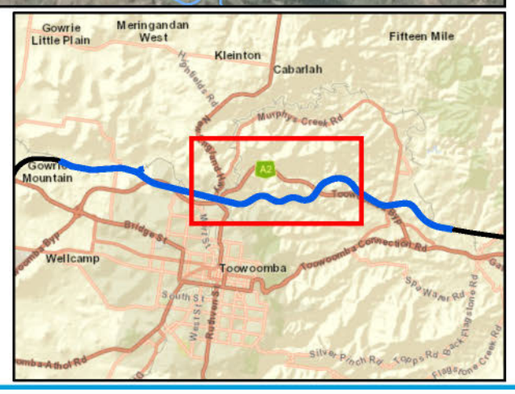


Map by: AD/GN/MVLT Z:\GIS\GIS_3200_G2HTasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig3.2_LocationsHistoricConcurrent_v3.mxd Date: 24/03/2021 14:13

Legend

- 5 Chainage (km)
- Localities
- Supplementary flora survey point (EMM 2019)
- Supplementary fauna survey points (ELA 2019)
- Supplementary terrestrial ecological surveys (Arup 2016)
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas



A3 scale: 1:30,000
0 0.5 1 1.5km

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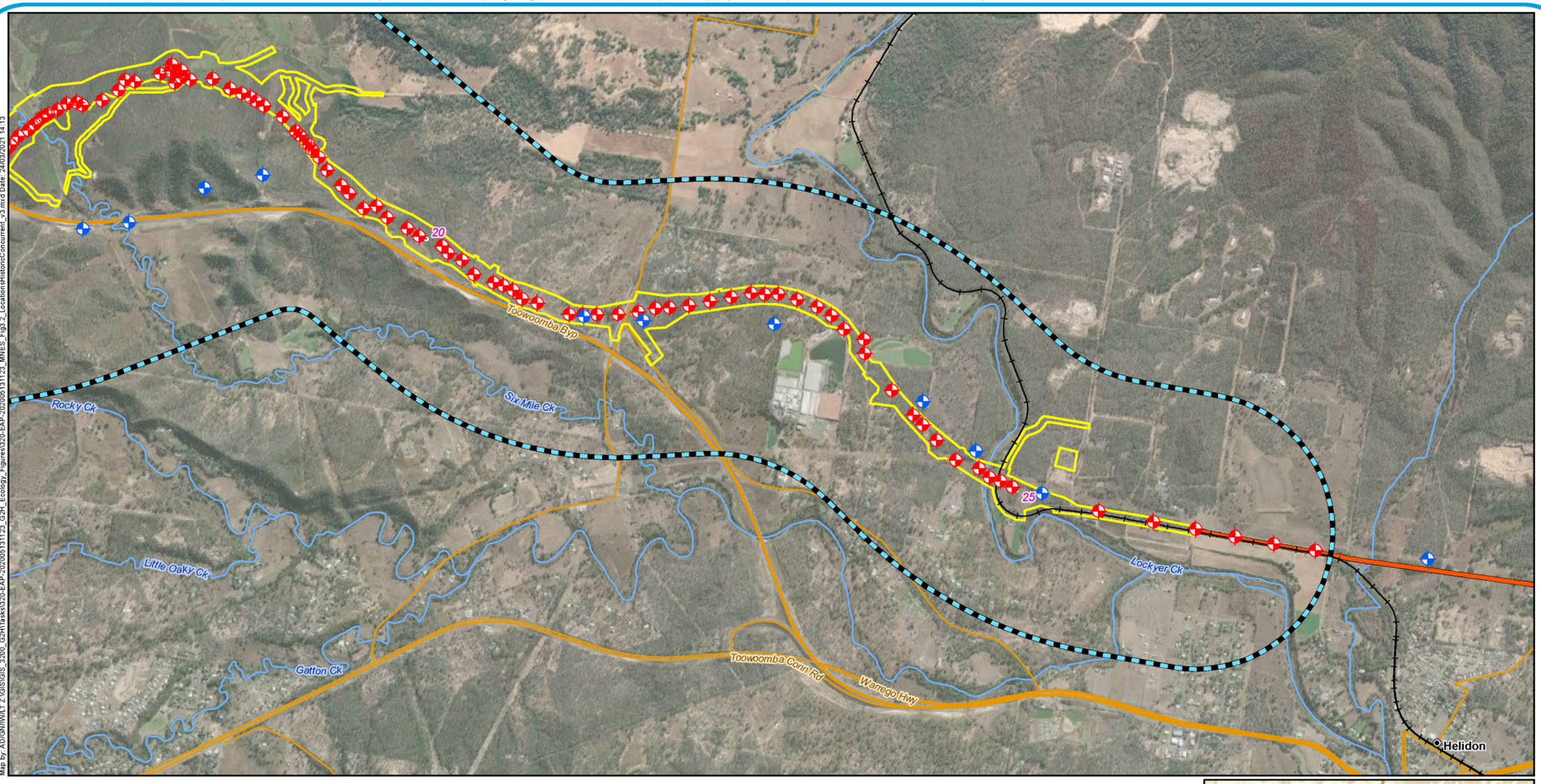
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.2b: Location of areas sampled as part of historic and concurrent works

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Supplementary fauna survey points (ELA 2019)
- Supplementary terrestrial ecological surveys (Arup 2016)
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas



A3 scale: 1:30,000

0 0.5 1 1.5km

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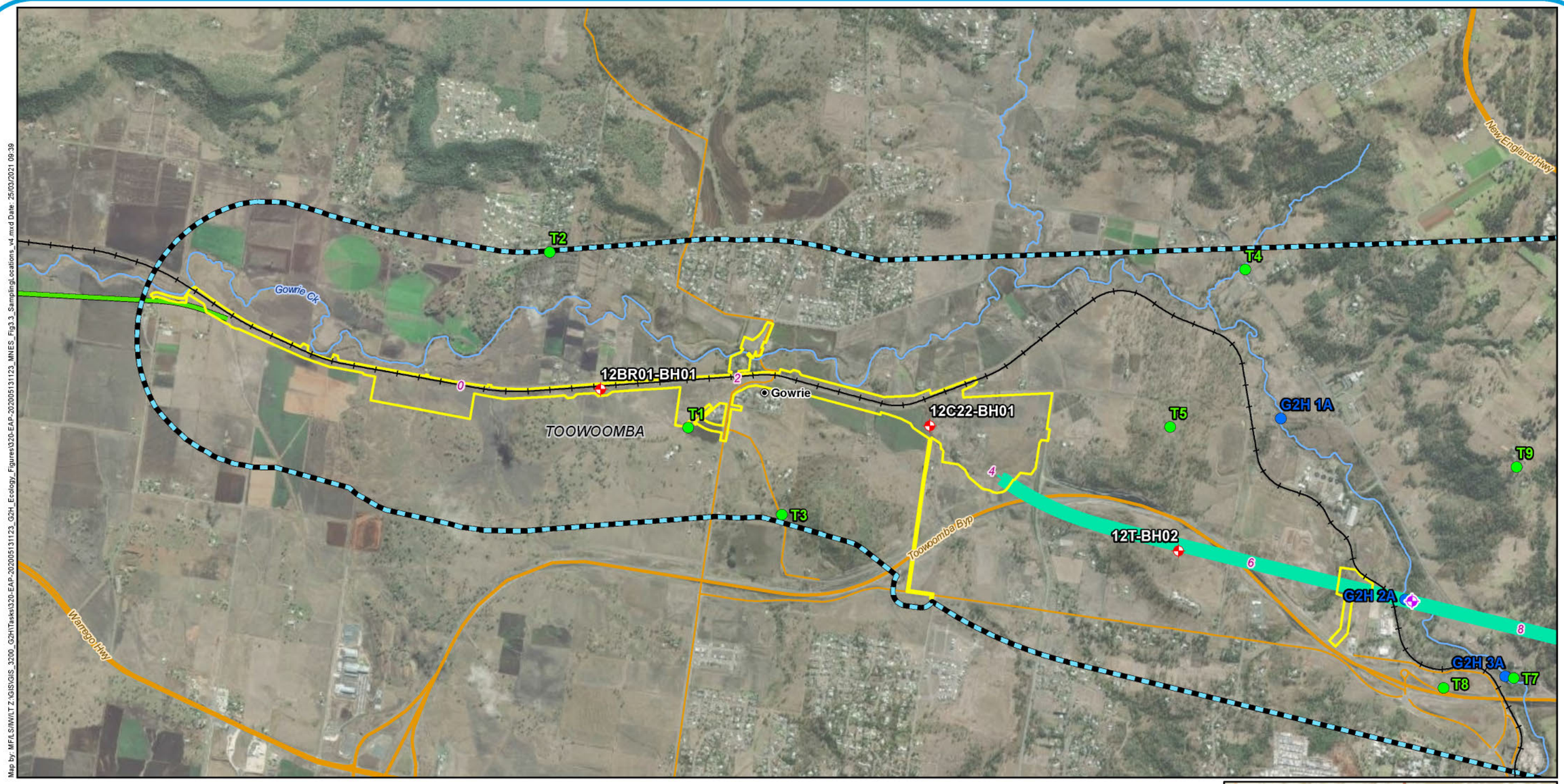
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.2c: Location of areas sampled as part of historic and concurrent works

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



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Legend

- 5 Chainage (km)
- Localities
- Terrestrial survey site
- Aquatic survey site
- Anabat sites
- Opportunistic survey sites
- B2G project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas



A3 scale: 1:30,000

0 0.5 1 1.5 2 2.5 km

Future Freight
Integrating Community, Environment and Engineering

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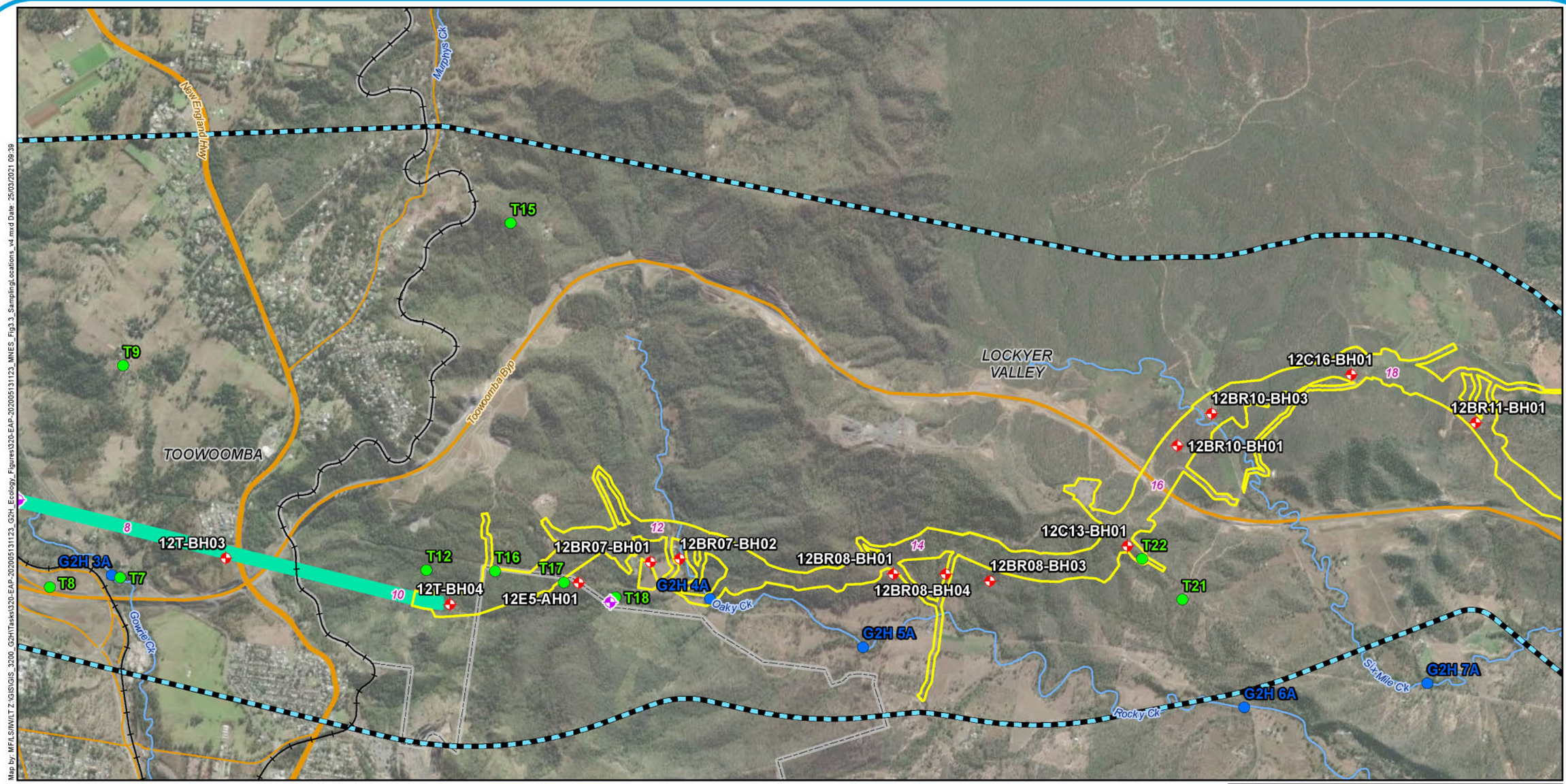
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.3a: Location of sampling locations within MNES study area

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- Terrestrial survey site
- Aquatic survey site
- Anabat sites
- Opportunistic survey sites
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas



A3 scale: 1:30,000

0 0.5 1 1.5 2 2.5 km

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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.3b: Location of sampling locations within MNES study area

Map by: MFILS/INV/LTZ:\GIS\GIS_3200_G2HTasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig3.3_SamplingLocations_v4.mxd Date: 25/03/2021 09:39

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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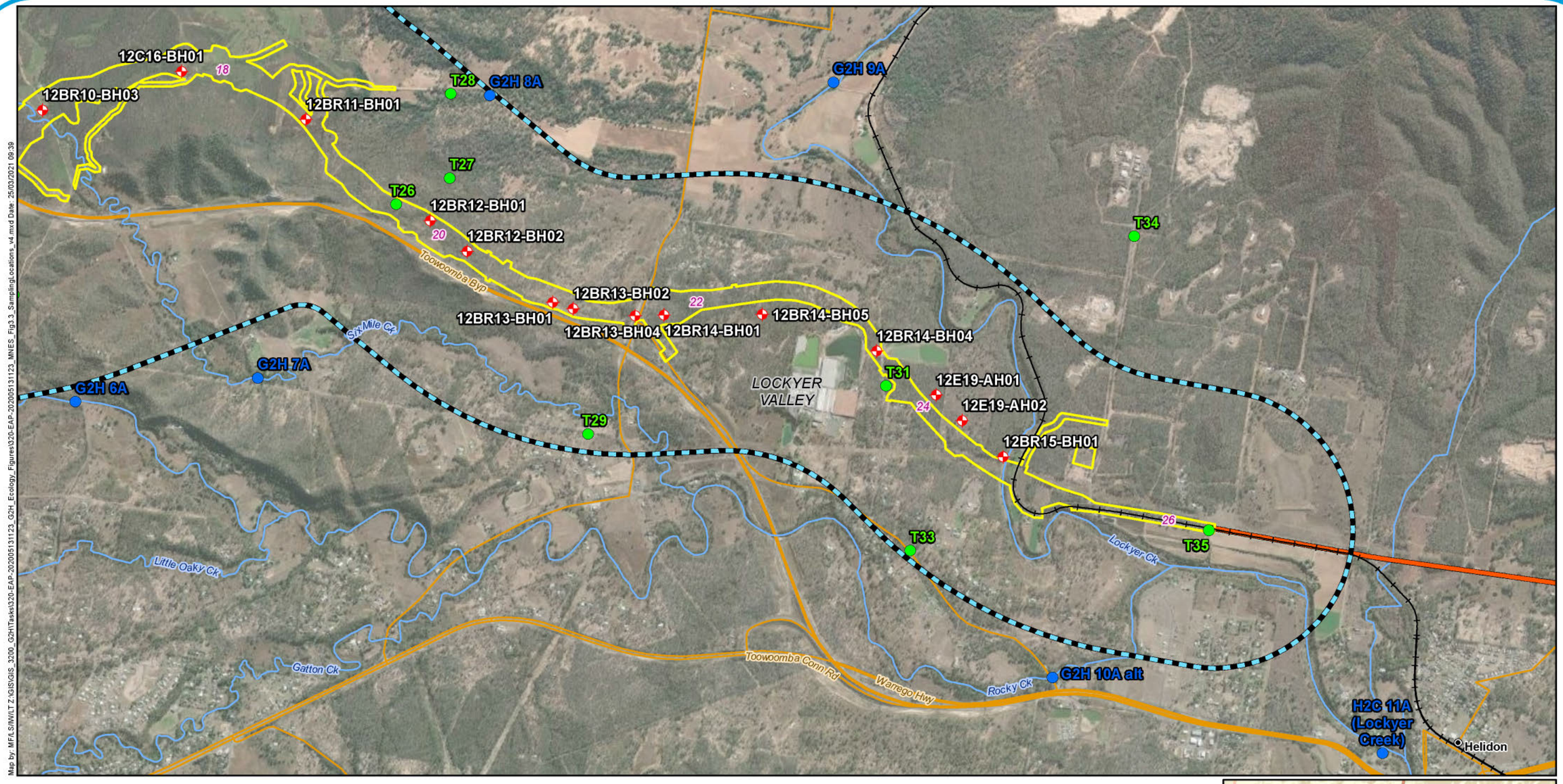

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Legend

- Chainage (km)
- Localities
- Terrestrial survey site
- Aquatic survey site
- Anabat sites
- Opportunistic survey sites
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas



A3 scale: 1:30,000

0 0.5 1 1.5 2 2.5 km

Future Freight
Integrating Community, Environment and Engineering

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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.3c: Location of sampling locations within MNES study area

3.3.1.2 Project ecological studies

Following the desktop study, field survey sites were selected which were specifically identified as containing features of interest. Terrestrial ecology surveys were carried out at 23 sites and aquatic ecology surveys were carried out at 11 sites. Specifically, the following features were used to target areas:

- Containing a representative example of a distinct vegetation community (i.e. areas contained within mapped remnant vegetation, regrowth vegetation, and non-remnant vegetation areas)
- Containing landscape features that were considered likely to support threatened species when viewed from aerial photography (e.g. gilgai areas, wetlands and rocky areas)
- Known or predicted to support threatened species
- Identified as containing or potentially containing EPBC Act listed TECs
- That have not been subject to previous ecological investigations.

At each terrestrial sampling location, a vegetation survey, a fauna habitat assessment, active searches for cryptic fauna and opportunistic observations were undertaken as a minimum (refer Sections 3.3.2.1 and 3.3.2.2 or datasheets in Appendix H). Wetland assessments were carried out in instances where wetland indicators were present (e.g. macrophytes, topography consistent with wetlands or areas mapped as a wetland), the location of survey sites within the MNES study area, and the date of assessment, are presented in Table 3.5 and shown in Figure 3.2. In addition, opportunistic fauna sampling locations are provided in Figure 3.2.

Table 3.5 Field survey sites and date of assessment

Site ID	Site location (GDA94)					Assessment date
	Zone	Easting	Northing	Latitude	Longitude	
Terrestrial ecology survey sites						
T1	56J	389724	6957491	-27.501 770°	151.883 560°	27 September 2017
T2	56J	388726	6958758	-27.490 252°	151.873 574°	27 September 2017
T3	56J	390399	6956865	-27.507 475°	151.890 336°	27 September 2017
T4	56J	393738	6958632	-27.491 791°	151.924 292°	24 September 2017
T5	56J	393197	6957496	-27.502 002°	151.918 716°	24 September 2017
T7	56J	395674	6955690	-27.518 496°	151.943 634°	27 September 2017
T8	56J	395168	6955620	-27.519 089°	151.938 505°	24 September 2017
T9	56J	395694	6957208	-27.504 796°	151.943 967°	26 September 2017
T12	56J	397872	6955741	-27.518 203°	151.965 891°	23 September 2017
T15	56J	398477	6958231	-27.495 773°	151.972 225°	19 September 2017
T16	56J	398366	6955733	-27.518 313°	151.970 892°	21 September 2017
T17	56J	398860	6955654	-27.519 063°	151.975 887°	21 September 2017
T18	56J	399233	6955548	-27.520 047°	151.979 654°	21 September 2017
T21	56J	403302	6955531	-27.520 497°	152.020 850°	20 September 2017
T22	56J	403012	6955820	-27.517 867°	152.017 937°	18 September 2017
T26	56J	406062	6956182	-27.514 814°	152.048 845°	20 September 2017
T27	56J	406447	6956372	-27.513 126°	152.052 757°	20 September 2017
T28	56J	406454	6956980	-27.507 638°	152.052 875°	22 September 2017
T29	56J	407446	6954525	-27.529 867°	152.062 730°	22 September 2017
T31	56J	409591	6954872	-27.526 879°	152.084 475°	18 September 2017
T33	56J	409766	6953686	-27.537 597°	152.086 159°	19 September 2017
T34	56J	411382	6955951	-27.517 257°	152.102 689°	21 September 2017
T35	56J	411920	6953830	-27.536 438°	152.107 982°	19 September 2017

Site ID	Site location (GDA94)					Assessment date
	Zone	Easting	Northing	Latitude	Longitude	
Aquatic ecology survey sites						
G2H 1A	56J	393993.99	6957558.86	-27.501 505°	151.926 779°	19 September 2017
G2H 2A	56J	394891.77	6956258.39	-27.513 309°	151.935 756°	19 September 2017
G2H 3A	56J	395612.92	6955703.24	-27.518 374°	151.943 007°	19 September 2017
G2H 4A	56J	399911.15	6955536.33	-27.520 206°	151.986 518°	21 September 2017
G2H 5A	56J	401008.04	6955189.14	-27.523 418°	151.997 596°	21 September 2017
G2H 6A	56J	403746.79	6954757.21	-27.527 515°	152.025 284°	20 September 2017
G2H 7A	56J	405062.55	6954929.58	-27.526 055°	152.038 622°	22 September 2017
G2H 8A	56J	406736.14	6956968.84	-27.507 766°	152.055 729°	21 September 2017
G2H 9A	56J	409213.69	6957063.15	-27.507 076°	152.080 812°	20 September 2017
G2H 10A alt	56J	410793.06	6952770.89	-27.545 933°	152.096 491°	22 September 2017
H2C 11A (Lockyer Creek)	56J	413174.29	6952225.32	-27.5507779°	152.120564°	9 October 2017

3.3.2 Matters of national environmental significance

3.3.2.1 Flora, community and wetland field assessment

At each survey site targeted for the FFJV EIS studies, a list of all flora species and TECs encountered were recorded and documented. In addition, any wetlands or other notable features relevant to MNES were identified and documented. In addition to specific target areas, opportunistic observations across the MNES study area were used to supplement site specific datasets. Significant flora species that were not previously encountered, or species that were unidentifiable in the field (when sampling occurred), were collected and lodged at the QLD Herbarium for formal identification (refer Appendix D). As per current Scientific Purposes Permit requirements, no more than two samples per species were taken at each survey location when sampling was required for identification purposes.

Verification via ecological assessment of a representation of distinctly different vegetation communities (including remnant, regrowth and non-remnant communities) and wetlands, or any other features relevant to MNES identified during the desktop component, was undertaken in the field (refer Appendix H). The following approach to sampling was applied:

- Within a representative of each different type of vegetation or feature identified from aerial imagery, an intensive survey occurred, which included an assessment of the relative species density and diversity within the emergent (E), canopy (T1, T2, T3), shrub (S1, S2, S3) and ground (G) strata layers when they were present. Methodologies used were consistent with the Tertiary level as described by Neldner et al. (2012; 2017). Survey transects approximated 100 m in length and 20 m in width. Where applicable (e.g. wetland or spring features were present) spring and wetland verification was undertaken by assessing the presence of wetland features related to floristic communities, wetland indicators, signs of flooding and topography.
- Once a full vegetation survey was complete for each representative of the specific vegetation community, verification of the remaining map units of the same type was undertaken at the Quaternary level as described by Neldner et al. (2012; 2017) (refer Appendix H for site flora datasheets).

A representation of the predictive flora habitat modelling for MNES listed species (i.e. flora) (refer Section 3.2.4) was verified where applicable during site field investigations throughout the MNES study area. In addition, where present wetlands and springs were verified, this information fed back into the GIS system and was used to refine the predictive habitat modelling, wetlands and springs mapping as appropriate (refer Figure 3.1) and noting where wetlands and water courses were dry during the surveys.

Where a threatened species was observed, these areas were elevated in status to either *potential habitat* (for areas that were not currently mapped as *potential habitat* for the species), or *Habitat critical to the survival of the species* (for locations that were already included within the *potential habitat* mapping layer) (refer Section 3.2.4 for further detailed information).

Protected plant surveys

In addition to the methodologies presented above, a random meander survey was undertaken at each target/opportunistic site (regardless of their inclusion/exclusion from "High Risk" areas identified in the QLD Government Protected Plants flora survey trigger map) to specifically target threatened species. At each site, the random meander survey was undertaken (as per the QLD Protected plants survey guidelines (DEHP 2016a)) until no new flora species were identified for 30 minutes following the recording of the last identified flora species. As such, surveys were carried out for a minimum of 30 minutes at each site but may have extended well beyond this search timeframe where new species were encountered. Samples of all EPBC Act listed flora species encountered, were submitted with the QLD Herbarium for incorporation into the HERBRECS database, and all flora survey records were submitted to DES as part of FFJV's scientific purposes licencing commitments.

The random meander survey method was also employed at sites within and adjacent to the Project footprint associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) (EMM 2018a, 2019a, 2019b, 2019c; ELA 2019a). As per the QLD protected plant survey guidelines (DEHP 2016a), surveys were carried out within the targeted clearing area with an additional 100 m buffer area applied (providing a substantial survey area at each site).

Survey effort

In addition to the targeted EIS study survey locations identified in Table 3.5 (34 sites within the MNES study area), flora surveys were carried out by EMM and ELA between September 2018 and July 2019. Surveys associated with geotechnical investigations were also undertaken by FFJV personnel, specifically targeting areas within the disturbance footprint. These surveys consisted of pre-clearance ecology survey reports and protected plant survey reports. The location of opportunistic surveys is shown in Figure 3.2a-c.

Protected plant surveys carried out throughout 2018 and 2019 (refer Table 3.2) by EMM (2018a, 2019a, 2019b, 2019c) and ELA (2019a) includes surveys at 159 sites within and adjacent to the Project disturbance footprint. Surveys carries out by EMM in 2019 (2019a, 2019b, 2019c) included 30 sites and ELA (2019a) included 23 sites within the MNES study area). The methods employed are considered to provide an acceptable level of survey effort to sufficiently inform an assessment against the MNES Guidelines for MNES flora species.

3.3.2.2 Fauna field assessments

Assessments for EPBC Act listed species were conducted for the EIS studies (FFJV) with the following objectives:

- Validation of the predictive habitat mapping where applicable
- Use of specific techniques to identify EPBC Act listed species and their habitat where present.

In addition to the techniques identified above, the use of existing datasets, historic records and the formulation of the predictive habitat models for EPBC Act listed species provided a comprehensive assessment of the MNES fauna habitat contained within the MNES study area, that is considered to incorporate seasonal (i.e. temporal) variation and takes a precautionary approach to EPBC Act listed species contained within the MNES study area.

Field based methodologies are further described in the sections below. A list of species encountered at each site was recorded.

Fauna habitat assessments

At each vegetation assessment location (refer 'terrestrial sampling sites' in Figure 3.3a-c), an assessment of fauna habitat features, and a record of all fauna species encountered was undertaken (a total of 23 sites). Fauna habitat assessments were also undertaken within the MNES study area by Arup (2016) (a total of 21 sites). Fauna habitat features recorded included, but was not limited to:

- Level of disturbance (scale of 0 – nil and 3 – severe) relating to the following:
  - Fire
  - Grazing
  - Clearing
  - Erosion
- List of threatened fauna species that are likely to utilise the area based on available habitat types (based on database search results and predictive habitat mapping)
- Abundance of tree hollows present in the following categories:
  - > 30 centimetre (cm) diameter
  - > 15 cm but < 30 cm diameter
  - > 10 cm but < 15 cm diameter
  - > 5 cm but < 10 cm diameter
  - < 5 cm diameter
- Abundance of fallen logs (>10 cm diameter)
- Abundance of coarse woody debris (<10 cm diameter)
- Abundance of trees with decorticating bark
- Percentage of groundcover containing the following:
  - Leaf litter
  - Bare ground
  - Grasses
  - Soil cracks
  - Surface rocks
  - Non-native flora species (e.g. weeds)
- Presence of:
  - Soil banks (e.g. river beds, road cuttings)
  - Boulders
  - Wetlands/drainage features
- Abundance of the following:
  - Flowers
  - Fruit.

All species of fauna observed at each site were identified to the species level where possible (refer Appendix H for site fauna habitat assessment datasheets).

Targeted fauna survey methods

When areas were identified as containing habitat considered likely to support threatened species (i.e. both within vegetation assessment areas and at opportunistic locations), specific techniques were employed to increase the likelihood of detecting these species. Remote sensing techniques were used to ensure maximum chances of detecting threatened species, without increasing the species risk of harm or placing stress upon the animal (i.e. animals sampled ethically and humanely).

In addition, where appropriate, the following techniques were adopted where applicable:

- Anabat devices (Microchiropteran bats) were deployed at two sites (for two and three nights) for a total survey effort of five detector nights (refer Figure 3.3a-c for locations)
- Area searches for nests including for Red goshawk (*Erythrotriorchis radiatus*) in suitable riparian areas during the EIS studies and by EMM (2018b, 2018c, 2019d) and ELA (2019a) during targeted pre-clearance surveys (2018 and 2019)
- Active searches for feeding platelets of the Black-breasted button-quail (*Turnix melanogaster*) within suitable habitat for the EIS studies, Arup (2016) and by ELA (2019a)
- Standardised surveys for all birds which is suitable for all MNES species including the Swift parrot (*Lathamus discolor*), Painted honeyeater (*Grantiella picta*) and Australian painted snipe (*Rostratula australis*) at all EIS assessment sites comprising recording birds by observation or calls for 20 minutes over a 2 ha survey area. These used the Birds Australia census technique described by Loyn (1986) for the EIS studies (refer Figure 3.3a-c for locations).
- Active searches for Koala (*Phascolarctos cinereus*) at all EIS assessment sites (refer 'fauna ecology survey site in Figure 3.3a-c for locations), their pellets and scratches were undertaken for the EIS studies and across Project-associated studies by Arup (2016) and ELA (2019a) (refer Figure 3.2a-c for locations)
- Active search for latrine sites and dens for the Spotted-tail quoll (*Dasyurus maculatus*) within suitable rocky habitat or the EIS studies and ELA (2019a)
- Active searches for Brush-tailed rock wallaby (*Petrogale penicillata*) and their pellets which were validated by experts at QLD Museum for confirmation. Searches for signs and habitat resources are considered an adequate form of survey method for detecting this species, as long as all suitable rocky habitat including mid-level ledges and holes are inspected for signs of activity (DSEWPaC 2011a). Carried out for the EIS studies, Arup (2016) and ELA (2019a).
- Active searches for reptiles at all EIS assessment sites including the Collared delma (*Delma torquata*). This involved 20 minutes of searching by two people over 1 ha within suitable microhabitats. This involved searching within suitable microhabitats, particularly beneath rocks and fallen logs and amongst leaf litter and woody debris. Carried out for the EIS studies, Arup 2016 and ELA (2019a)
- Spotlighting and night driving for amphibians, reptiles, birds and mammals - outside of formalised survey locations. Carried out for the EIS studies

It is noted that in consideration of survey effort (refer Sections 3.3.1.1 and 3.3.1.2), the full extent of survey activities may not be fully known.

Other species encountered during these works were recorded, along with opportunistic observations (all fauna species) (refer Appendix F for species list and the EIS Appendix I: Terrestrial and aquatic ecology technical report for more details).

Preclearance habitat surveys

In addition to the fauna survey methods employed for the EIS studies identified above (i.e. surveys carried out by FFJV and Arup in 2016) a large number of 'preclearance surveys' associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) have been carried out during 2018 and 2019. These surveys were carried out to further inform the Project EIS studies and as part of requirements under QLD legislation. Surveys were carried out at 57 locations (EMM 2018b, 2018c, 2019d) and 214 borehole locations (with additional assessment for access tracks) (ELA 2019a) throughout the Project disturbance footprint and immediate surrounds.

The surveys included the following methods:

- Searches for potential breeding habitat for threatened species such as:
  - Recording of all burrows/dens, logs, rocks, caves and suitable leaf litter that may contain breeding habitat for threatened species
  - Recording of hollow bearing trees noting hollow attributes such as size, angle, height in the tree and orientation it was facing
  - Recording of bird nests and potential for active nesting
- Habitat suitability assessments for threatened species with key habitat types recorded
- Assessment of Koala microhabitat incorporating evidence of Koalas in the area (e.g. sightings, scratches and scats), food tree abundance, tree species and habitat context (ELA survey locations only)
- Incidental fauna observations recorded.

3.3.2.3 Aquatic surveys

Aquatic habitat assessments

A total of 11 sites were selected for aquatic habitat assessments based on wetland and watercourse mapping and land access (refer Table 3.5). The aquatic habitat assessments described the environmental values of targeted watercourses (to assess existing environmental condition proximal to, and where the Project alignment intersects watercourses) within the MNES study area. The AUSRIVAS Physical Assessment Protocol (Parsons et al. 2002) was used in the field assessment of the drainage systems.

The key geomorphological, physical habitat and riparian data which was collected at each assessment site included:

- Valley characteristics, including valley shape and channel slope
- Land use, including catchment land use and local land use
- Physical morphology and bedform of the watercourse, including channel shape and extent and type of bars
- Cross sectional dimensions of the watercourse, including bankfull channel width and depth, bank width and height and baseflow stream width and depth
- Substrate characteristics, including bed compaction, sediment angularity, bed stability rating, sediment matrix and substrate composition
- Floodplain characteristics, including floodplain width and features
- Bank characteristics, including bank shape and slope, bank material, bedrock outcrops, factors affecting bank stability and artificial bank protection measures
- Instream vegetation and organic matter, including extent of large woody debris, macrophyte cover and species composition
- Physical condition indicators and habitat assessment

- Riparian vegetation characteristics, including shading of channel, extent of trailing bank vegetation, species compositions, riparian zone width and extent of disturbance
- Water quality visual observations, including turbidity, water and sediment oils, water and sediment odours, algae and moss cover. Qualitative water quality observations were supported by collection of water samples for quantitative assessments as part of the Project surface water quality investigations.

In addition, surface water quality sampling was conducted at aquatic habitat assessment sites. Three discrete water sampling events were carried out: one spring (September 2017); and two autumn assessments (March 2018 and 2019). Watercourse flow was limited; however, this was consistent with the highly seasonal, and sporadic flow regimes throughout the water quality study area. Noting the seasonal flow regimes of the watercourses, timing of the assessments was chosen in order to capture dry or wet condition water quality samples.

In-situ water quality field data was collected during each monitoring round in addition to samples collected for laboratory analysis. Sampling could not be undertaken at all habitat assessment sites due to a lack of adequate water (i.e. dry conditions) at the time of the water quality assessments. As such, it was not possible to collect water samples at all 11 locations (refer Table 3.5) during each of the three sample events due to the sites being dry and/or inaccessible at the time of the site visit. The results of the water quality sampling assessments are provided in detail in EIS Chapter 13: Surface water and hydrology.

Aquatic fauna surveys

Recordings of incidental fauna species observed during the aquatic field survey were taken at each aquatic ecology assessment site. A sample of aquatic fauna species present at the time of the aquatic sampling was undertaken using two baited traps and dip netting, specifically targeting vertebrate species such as fish and turtles where adequate water was present. Capture and release trapping and netting works associated with fish and turtle assessments was conducted to collect incidental species occurrence data and supplement existing data sets. These works did not exceed two hours at any site to reduce risk of harm to species, whilst dip netting was completed on an incidental basis to address size-specific constraints associated with baited traps.

3.3.3 Permits to conduct works

The ecological field surveys reported in this document were conducted under the provisions of the relevant FFJV Permits: Aurecon's Scientific Purposes Permit (WISP14453114), General fisheries permit (182654) and Animal ethics approval for General Fish Surveys (CA 2015/01/833) and General Terrestrial Surveys (CA 2015/03/846) and AECOM's Scientific Purposes Permit (WISP16615015) and Animal ethics approval for fauna surveys in QLD (CA 2015/01/834).

3.3.4 Quality assurance/quality control

Quality assurance/quality control in relation to field results occurred through the following processes:

- At least one suitably qualified person in accordance with Section 4.2.1 of the Flora Survey Guidelines (DEHP 2016a) was present within each survey team
- All flora samples to be submitted to the QLD Herbarium were stored in a field press to ensure their integrity. Samples were stored in a cool/dry environment and were submitted to the QLD Herbarium within 9 days of collection.
- A portion of any potential MNES flora species encountered, or species that could not be confidently identified during field recognisance, was submitted to the QLD Herbarium for verification/identification
- Scats that were collected in the field were taken to the QLD Museum for species confirmation
- Any threatened fauna species had to be sighted/confirmed by both member of the field team to produce a confirmed record. Where applicable/possible, proof (e.g. photograph, scat or other evidence) was collected.

- Surface water quality sampling was conducted in accordance with industry-accepted standards and quality assured procedures. Field quality control included rigorous sample collection, decontamination procedures (where appropriate), and sample documentation. As each sample was collected it was labelled with a unique sample identifier, the initials of the sampler, the date and the Project number. All sample jars were filled leaving no headspace and placed immediately into ice-filled cooler boxes. All samples were transported in ice-filled coolers to prevent degradation of organic compounds. Chain of Custody (CoC) documentation was completed, with data including sample identification, date sampled, matrix type, preservation method, analyses required and name of sampler. Field data monitoring equipment was fully serviced and calibrated prior to use.

3.3.5 Nomenclature

3.3.5.1 Flora

The source of nomenclature for the flora sections of this report is the Census of the QLD Flora (DES 2016a). The botanical names comply with the rules of the current International Code of Botanical Nomenclature (McNeill et al. 2006) and the International Code of Nomenclature for Cultivated Plants (Brickell et al. 2016). Author abbreviations follow Brummitt and Powell (1992).

3.3.5.2 Fauna

The sources of nomenclature for the fauna sections of this report are as follows:

- Ingram, McDonald and Nattrass (2002) for frogs
- Wilson and Swan (2017) for reptiles
- Pizzey and Knight (2001) for birds
- Menkhorst and Knight (2011) for mammals
- Duncan et al's Action Plan for Australian Bats (1999) for microbats
- Pusey, Kennard and Arthington (2004) for freshwater fish.

3.4 Impact assessment methodology

The MNES assessment of the Project uses a significance-based impact assessment framework to identify and assess potential Project related impacts in relation to MNES. Initial impact assessment was undertaken to identify MNES where they may be subject to significant impacts (refer Section 3.4.3). Where impacts were identified as significant, these were subject to assessment against the *EPBC Act MNES significant impact assessment guidelines 1.1* (DotE 2013a) (refer Sections 5.3.3, 5.3.4 and 5.3.5).

The MNES assessment was undertaken both quantitatively (e.g. measurable assessment of vegetation community (RE) attributes) and qualitatively (e.g. visual evaluation of fauna habitat values). The significant impact depends upon the sensitivity of the MNES, the quality of the environment which is impacted, and upon the magnitude of the potential impact. Determination of the sensitivity or vulnerability of the MNES and the magnitude of the potential impacts facilitate the assessment of the significance of total potential project impacts.

The sections below discuss and define impact magnitudes, MNES sensitivity and impact significance.

3.4.1 Magnitude of impacts

The magnitude of a potential impact is essential to the determination of its level of significance on sensitive receptors. For the purposes of this assessment, impact magnitude is defined as being comprised of the nature and extent of the potential impacts, including direct and indirect impacts. The impact magnitude is divided into five categories (refer Table 3.6). The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the **extent**, **duration** (refer Table 3.7) and **frequency** of the impacts.

Table 3.6 Criteria for magnitude

Magnitude	Description
Major	An impact that is widespread, permanent and results in substantial irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of environmental management controls are required to address the impact. (e.g. greater than 50% of the habitat within the greater area disturbed*).
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the environmental value. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact. (e.g. between 13-50% of the habitat within the greater area disturbed).
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the Project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls. (e.g. between 2-13% of the habitat within the greater area disturbed).
Low	A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls. (e.g. between 1-2% of the habitat within the greater area disturbed).
Negligible	An extremely localised impact that is barely discernible and is effectively mitigated through standard environmental management controls. (e.g. less than 1% of the habitat within the greater area disturbed).

Table note:

* 'Greater area disturbed' refers to the wider area within which the proposed impact is situated and compared against (e.g. the MNES study area).

The timeframes used to predict the duration of potential impacts on MNES (refer Table 3.7) has been derived using the approach described in the Environmental Assessment and Management (EAM) Risk Management Framework as employed by the Great Barrier Reef Marine Park Authority (GBRMPA 2009). The Framework is designed to manage risk and help inform decisions regarding the construction and operational risks associated with Project activities on environmental values (in this case MNES).

Table 3.7 Timeframes for duration terms

Duration term	Timeframe – to be defined for each activity type
Temporary	Days to months (e.g. 1 to 2 seasons; 3 to 6 months)
Short term	Up to 2 years (i.e. 6 to 24 months)
Medium term	From 2 to 11 years[1]
Long term/long lasting	From 11 to 21 years[2]
Permanent or irreversible	More than 21 years[3]

Table notes:

1 Derived from the term 'moderate' EAM Risk Management Framework 2009 (Great Barrier Reef Marine Park Authority 2009)
2 Derived from the term 'major' EAM Risk Management Framework 2009 (Great Barrier Reef Marine Park Authority 2009)
3 Derived from the term 'catastrophic' EAM Risk Management Framework 2009 (Great Barrier Reef Marine Park Authority 2009)

3.4.2 Sensitivity

To assess the significance of potential impacts on sensitive receptors, sensitivity categories are applied to each of the features. The sensitivity categories are split into five discrete groups as described in Table 3.8. These groupings are based on qualitative assessments utilising information related to the sensitivity of the receptor, in addition to the potential of a sensitive receptor's occurrence within the receiving environment.

Through the determination of sensitivity categories for each of the MNES, the features are then able to be assessed through a matrix against the magnitude of the potential Project impact type to indicate the level of significance for each of the impact types on the MNES.

Each particular environmental value assessed (MNES in this case) is treated individually (i.e. MNES are not treated collectively). In the case where there are conflicting classes, the "worst-case" is taken.

Table 3.8 Sensitivity criteria for sensitive values/receptors within the study area

Sensitivity	Description
Major	▪ The sensitive receptor is listed on a recognised or statutory state, national or international register as being of conservation significance ▪ The sensitive receptor is **entirely** intact and **wholly** retains its intrinsic value ▪ The sensitive receptor is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region, state, country or the world ▪ It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the environmental value. ▪ Project activities would have an adverse effect on the value.
High	▪ The sensitive receptor is listed on a recognised or statutory state, national or international register as being of conservation significance ▪ The sensitive receptor is **relatively** intact and **largely** retains its intrinsic value ▪ The sensitive receptor is unique to the environment in which it occurs. It is isolated to the affected system/area, which is poorly represented in the region ▪ The sensitive receptor has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the sensitive value. ▪ Project activities would have an adverse effect on the sensitive value.
Moderate	▪ The sensitive receptor is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers ▪ The sensitive receptor is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements ▪ The sensitive receptor is relatively well represented in the systems/areas in which it occurs, but its abundance and distribution are exposed to threatening processes ▪ Threatening processes have reduced the sensitive receptor‘s resilience to change. Consequently, changes resulting from Project activities may lead to degradation of the prescribed value ▪ Replacement of unavoidable losses is possible due to its abundance and distribution.

Table note:

Low and negligible sensitivity criteria shown in Table 3.9: Significance assessment matrix are not included in this table as they are not considered applicable to the MNES assessment.

3.4.3 Initial assessment of the significance of total impact

The significance of a potential impact is a function of an impacted receptor’s **sensitivity** and the **magnitude** of the potential impact. Although the sensitivity of the receptor will not change (i.e. is generally determined qualitatively by the interaction of the receptor’s condition, adaptive capacity and resilience), the **magnitude** of the potential impact is variable and may be categorised quantitatively to facilitate the prediction of the significance of the potential impact.

Once the sensitive value/receptor has been identified, and the **sensitivity** of the receptor and the **magnitude** of the potential impact have been determined, this will facilitate the assessment of the significance of the potential impact through use of a five by three matrix (refer Table 3.9).

Table 3.9 Significance assessment matrix

Magnitude of impact	Sensitivity				
	Major	**High**	**Moderate**	**Low**	**Negligible**
Major	Major	Major	High	Moderate	Low
High	Major	Major	High	Moderate	Low
Moderate	High	High	Moderate	Low	Low
Low	Moderate	Moderate	Low	Negligible	Negligible
Negligible	Moderate	Low	Low	Negligible	Negligible

Table 3.10 Significance classifications

Significance rating	Description
Major	Arises when an impact will potentially cause irreversible or widespread harm to an MNES that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
High	Occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the MNES. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
Moderate	Results in degradation of the MNES due to the scale of the impact or its susceptibility to further change even though it may be reasonably resilient to change. The abundance of the environmental value ensures it is adequately represented in the region, and that replacement, if required, is achievable.
Low	Occurs where an MNES is of local importance and temporary or transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
Negligible	Does not result in any noticeable change and hence the proposed activities will have negligible effect on environmental values. This typically occurs where the activities are located in already disturbed areas.

Significance ratings of Low, Moderate, High and Major constitute a potential significant residual impact to a threatened species or TEC and are assessed against the *MNES Significant impact guidelines 1.1* (DotE 2013a) Guidelines to confirm the initial impact assessment results (refer Sections 5.3.3, 5.3.4 and 5.3.5).

Following the identification of the level of significance using initial impact mitigation measures, Project mitigation measures were then applied to the potential impacts to identify the residual (mitigated) impacts in a tabular form.

Initial assessment of the significance of impacts was undertaken for the following Project phases:

- Construction
- Commissioning and reinstatement
- Operation.

Given the uncertainty associated with timeframe for decommissioning, this phase was not considered in the initial impact assessment.

3.4.4 Assessment of the significance of impact against matters of national environmental significance significant impact guidelines

Following the initial assessment of significance (refer Section3.4.3), assessment of impacts to MNES that returned a mitigated initial significance rating of Major, High, Moderate or Low was undertaken. MNES that returned a rating of Negligible, or those MNES for which habitat had not been identified within the MNES study area, were omitted from assessment against the MNES Guidelines. Relevant MNES were assessed against the following guidelines as applicable:

- Significant impact guidelines 1.1 – Matters of National Environmental Significance: *Environmental Protection and Biodiversity Conservation Act 1999* (DotE 2013a)
- EPBC Act Referral Guidelines for the vulnerable koala (combined populations of QLD, NSW and the Australian Capital Territory) (DotE 2014a).

Assessment of MNES against the relevant criteria in the MNES Guidelines is presented in the following sections:

- TECs – Section 5.3.3
- Threatened flora species – Section 5.3.4
- Threatened fauna species – Section 5.3.5.

3.5 Cumulative impact assessment methodology

When numerous projects occur in a region they result in cumulative impacts, which differ from those of an individual project when considered in isolation. Cumulative impacts may be positive or negative, and their severity and duration will depend on the project size and timing overlap.

The sections below outline the selected projects to be used in the cumulative impact assessment and the methodology to be applied in order to undertake the assessment.

3.5.1 Project selection

Projects for inclusion in the cumulative impact assessment are all those within the Project regions, as shown in Figure 1.2, including the projects that:

- Have been declared a ‘coordinated project’ by the Coordinator-General under the SDPWO Act and an EIS is currently being prepared or is complete, or an Initial Advice Statement is available on the QLD Department of State Development, Infrastructure, Local Government and Planning (DSDILGP) website.
- Are currently being assessed under Part 1 of the Chapter 3 of the EP Act as per DES website.
- May use resources located within the region (including materials, groundwater, road networks or workforces) that are the same as those to be used by the Project
- Could potentially compound residual impacts that the Project may have on environmental or social values.

Table 3.11 indicates the projects that have been included in the cumulative impact assessment, and their associated selection criteria. The approximate location of these projects in relation to the Project is shown in Figure 3.4. The projects listed in Table 3.11 include infrastructure development projects located in proximity to the Project.

It is important to note that projects that fall into the following categories have been excluded from the cumulative impact assessment:

- Existing or historic projects within the Project cumulative impact area that are considered to constitute part of the baseline environment
- Projects that have not been developed to the point that their environmental assessment process has been made public.

Table 3.11 Projects to be included in cumulative assessment

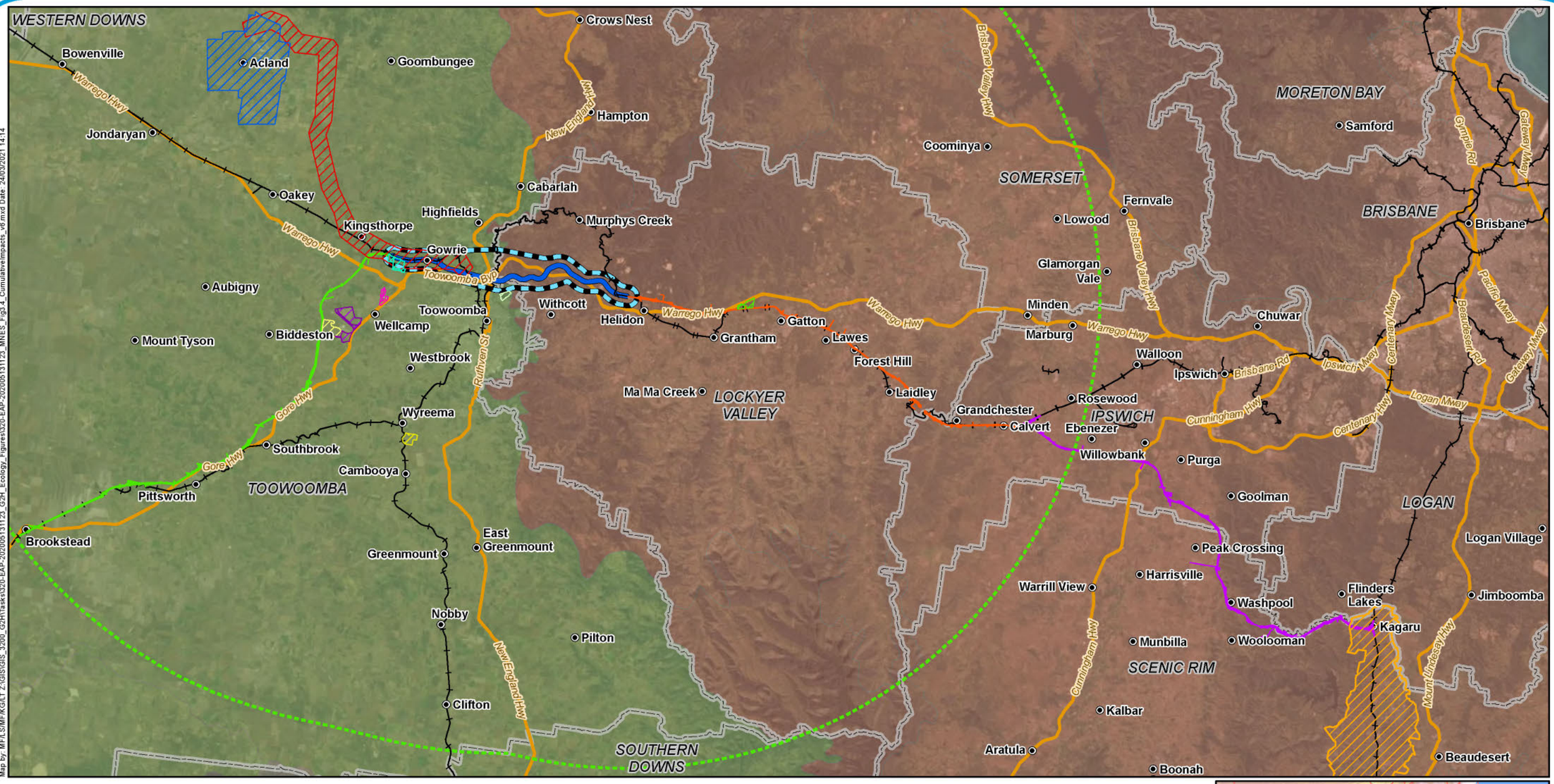
Project and proponent	Location	Description	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria	Relationship to the proposal
Kagaru to Acacia Ridge and Bromelton Inland Rail project (K2ARB) (ARTC)	Rail corridor from Kagaru to Acacia Ridge and Bromelton	Enhancing and connecting the existing rail corridor (approximately 49 km) from north-east of Kagaru to Acacia Ridge and from south of Kagaru to Bromelton	Application for coordinated project status currently under consideration by the Coordinator-General. Proponent awaiting coordinated project decision by the Coordinator-General.	2023 to 2025 Jobs: information not publicly available	> 50 years Jobs: information not publicly available	b)	Potential overlap of construction for G2H and commencement for K2ARB
B2G (ARTC)	Rail alignment from NSW/QLD Border to Gowrie	Approximately 146 km of new dual gauge track and 78 km of upgraded track from the NSW/QLD border, near Yelarbon, to Gowrie Junction, north-west of Toowoomba in QLD.	Draft EIS being prepared by ARTC	2021 – 2026 Jobs: Peak 950 FTE	>50 years Jobs: Average 10-15 FTE	a) and b)	Overlap of construction with G2H and B2G resulting in conflict in demand for construction resources and additional traffic on arterial roads. Operational impacts associated with the road network from the operation of the Inland Rail Program.
H2C (ARTC)	Rail alignment from Helidon to Calvert	The H2C project will include 47 km single-track dual-gauge freight rail line to accommodate double stack freight trains up to 1,800 m long and a tunnel through the Little Liverpool Range.	Draft EIS being prepared by ARTC	20201 – 2026 Jobs: Peak 410 FTE	>50 years Jobs: Average 15-20 FTE	a) and b)	Overlap of construction with G2H and H2C resulting in conflict in demand for construction resources and additional traffic on arterial roads. Operational impacts associated with the road network from the operation of the Inland Rail Program.
Calvert to Kagaru Inland Rail project (C2K) (ARTC)	Rail alignment from Calvert to Kagaru	The C2K project will include 53 km dual gauge track and a 1.1 km tunnel through the Teviot Range	Draft EIS being prepared by ARTC	2021-2026	>50 years Jobs: Average 15-20 FTE	a) and b)	Overlap of construction with G2H and H2C resulting in conflict in demand for construction resources and additional traffic on arterial roads. Operational impacts associated with the road network from the operation of the Inland Rail Program.

Project and proponent	Location	Description	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria	Relationship to the proposal
InterLinkSQ – Global Logistics Centre (InterLinkSQ)	13 km west of Toowoomba	200 ha of new transport, logistics and business hubs. Located on the narrow-gauge regional rail network and interstate network. Located at the junction of the Gore, Warrego and New England Highways.	N/A	2017 – 2037	- Jobs: 1,500	b)	Ongoing development could result in competition for construction resources and workforce. There may also be an increase in heavy vehicles using the surrounding highways.
Wellcamp Business Park (Wagner)	Wellcamp QLD	The Wellcamp Business Park is a 500 ha industrial and commercial park that forms part of the Toowoomba Enterprise Hub. The Business Park is located in close proximity to the Toowoomba Wellcamp Airport and other major transportation infrastructure.	Operational – subject to continuing construction and expansion	Ongoing	Ongoing	b)	Located approximately 7 km south-west of the Project alignment.
Witmack Industry Park and Charlton Logistics Park (FKG Group)	Wellcamp QLD	The Witmack Industry Park is a large industrial land development that offers large size industrial land parcels. Businesses situated within the Witmack Industrial Park include the Toowoomba Pulse Data Centre. The Charlton Logistics Park is part of the Toowoomba Enterprise Hub and provides fully serviced 2 ha sites and is well situated for potential transport and logistics operators due to its proximity to transport infrastructure.	Operational – subject to continuing construction and expansion	Ongoing	Ongoing	b)	Located approximately 4 km south-west of the Project alignment.

Project and proponent	Location	Description	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria	Relationship to the proposal
Asterion Medicinal Cannabis Facility	Wellcamp, QLD	A high-tech medicinal cannabis cultivation, research and manufacturing facility. The project involves construction of a 40 ha glasshouse to produce 20,000 plants per day at full capacity. Medicinal grade cannabis grown at the facility will be manufactured into a range of medicinal products, including single patient packs, cannabis oils, gels, salts and related products, destined solely for the medicinal market. This facility is anticipated to be the largest facility of its kind in the world.	Under construction	2020 to 2021	Unknown	a) and c)	Adjoins the Project footprint 1 km south of Toowoomba-Cecil Plains Road
Gatton West Industrial Zone (GWIZ) (Lockyer Valley Regional Council)	3 km north-west Gatton	Industrial development including a transport and logistics hub on the Warrego Highway	N/A	2019-2024 Jobs: 13.5FTE	Unknown Jobs: 36.3FTE	b)	May increase road traffic and increase need for rail resources during both construction and operation
Defence Housing Authority Mount Lofty Development (DHA)	Toowoomba, suburb of Mount Lofty	Former rifle range redeveloped into a master-planned residential community comprising of 342 lots. Some lots will be retained by DHA on which homes will be built for Defence members and their families with remaining lots available for public purchase.	Development application lodged in June 2018. Development on hold following rejection of the development application(s) by TRC	Unknown	Unknown	b)	Located approximately 1.7 km to the south of the Project
New Acland Coal Mine Stage 3 expansion (New Hope)	35 km north-west of Toowoomba	Expansion of the existing New Acland open-cut coal mine to up to 7.5 Million tonnes per annum.	Operational with ongoing expansion projects	Ongoing	Sequential development of resource areas expected to extend coal production until 2042	b)	Ongoing development could result in competition for construction resources and workforce. There may also be an increase of heavy vehicles using the surrounding highways.

Project and proponent	Location	Description	Project status	Construction dates and jobs	Operation years and jobs	Selection criteria	Relationship to the proposal
Wetalla Water Pipeline (New Acland Coal Pty Ltd)	From the Wetalla Wastewater Reclamation Facility in Toowoomba to the New Acland Mine, 35 km north-west of Toowoomba	A 45 km underground water pipeline to supply up to 5,500 megalitres of treated wastewater to the New Acland coal mine	EIS approved with conditions in 2008. The Wetalla Water Pipeline has been completed	-	To support water requirements for the extension of coal production at the New Acland Mine (until 2042)	b)	Associated with the New Acland Mine expansion (New Hope).
Toowoomba Regional Council/ Waste Management Facility (TRC)	Wyreema, QLD	A new waste transfer facility that caters for the Toowoomba Region's Northern and Southern Growth Corridors. Will replace the existing Greenmount landfill and was previously a sewage treatment plant.	Design is currently underway with development assessment application lodged in July/August 2019	Expected to be completed in 2022	Unknown	b)	Potential for cumulative traffic and social impacts to the region.

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: MFALS\MFK\GIS\LT Z:\GIS\GIS_3200_G2H\Tasks\3320-EAP-20200513123_G2H_Ecology_Figures\3320-EAP-20200513123_MNES_Fig3-4_CumulativeImpacts_v6.mxd Date: 24/03/2021 14:14

Legend

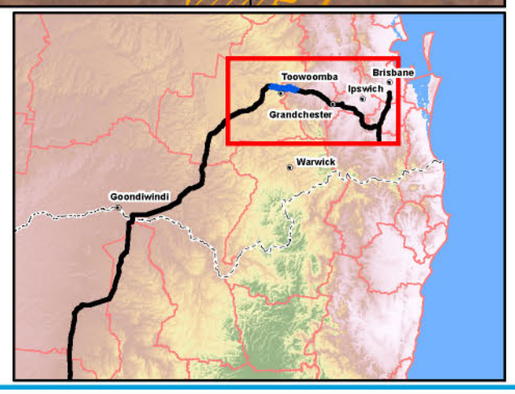
- Localities
- G2H project alignment
- Existing rail
- Major roads
- MNES study area
- Local Government Areas
- Cumulative project area

Projects

- Border to Gowrie
- Calvert to Kagaru
- Helidon to Calvert
- Asterion Medicinal Cannabis Facility
- Bromelton State Development Area
- DHA Mount Lofty Development
- Gatton West Industrial Zone
- Interlink SQ - Global Logistics Centre
- New Acland Coal Mine Stage 3
- TRC/Waste Management Queensland
- Wellcamp Business Park
- Wetalla Water Pipeline
- Witmack Industry Park

Bioregions

- South Eastern Queensland
- Brigalow Belt South



A3 scale: 1:450,000

0 5 10 15 20 25 km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 24/03/2021 Version: 6
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 3.4: Locations of projects that have been included in the cumulative impacts assessment area

3.5.2 Approach

The approach used to identify and assess potential cumulative impacts of this Project in this technical report is summarised below.

- A review of the potential impacts identified within the EIS assessments:
  - The environment at the time of the EIS ToR is the baseline, prior impacts from past land use has not be considered
- A register of assessable projects has been collated with timelines to demonstrate the temporal relationship between projects. This has included:
  - The Inland Rail projects immediately adjacent to the project within the assessment
  - Identification of projects outside of Inland Rail, including 'Coordinated Projects' under *State Development and Public Works Act 1971* (Qld) Where additional projects have arisen after the finalisation of the EIS ToR, the Coordinator-General has been consulted to determine if assessment is required.
  - For this Project, the adjoining B2G and H2C Inland Rail Projects have been considered
- Identification and mapping of the assessable projects and the areas of influence of the aspect being considered:
  - Current operational projects and commercial or agricultural operations that are in the areas of influence around the Project are accounted for in the corresponding technical baseline studies (e.g. air, noise, social, economic, etc.).
- Where there is a potential overlap in impacts (either spatially or temporally), a cumulative impact assessment has been undertaken to determine the nature of the cumulative impact. This includes:
  - Where possible the assessment method has been quantitative in nature (e.g. calculation of impact areas which inform magnitudes) but qualitative assessment has also been undertaken
  - Where quantitative assessment is possible, the significance of impact should be assessed in comparison to the same criteria or guidelines as adopted by the relevant technical impact assessments
  - Where the impacts are expressed qualitatively, the probability, duration, and magnitude/intensity of the impacts should be considered as well as the sensitivity and value of the receiving environmental conditions
- An assessment matrix method (further detailed within Section 3.5.3) has been used to determine the significance of cumulative impacts with respect to detrimental effects
- Where cumulative impacts are determined to be of 'medium' or 'high' significance, additional mitigation measures are proposed, beyond those already proposed by the relevant technical impact assessments.

3.5.3 Assessment matrix

Following the identification of each potential cumulative impact, a relevance factor score of Low, Medium and High has been determined in consideration of the impacts, in accordance with the assessment matrix given in Table 3.12.

The significance of the impact has been determined by using professional judgement to select the most appropriate relevance factor for each aspect in Table 3.12 and summing the relevance factors. The sum of the relevance factors determines the impact significance and consequence which are summarised in Table 3.13. For example, if an environmental value such as groundwater was considered to have a probability of impact of 2, duration of impact of 3, magnitude/intensity of impact of 1 and a sensitivity of receiving environment of 1 the significance of impact would be (2+3+1+1 = 7) = Medium.

Table 3.12 Assessment matrix

Aspect	Relevance factor		
	Low	Medium	High
Probability of impact	1	2	3
Duration of impact	1	2	3
Magnitude/Intensity of impact	1	2	3
Sensitivity of receiving environment	1	2	3

Table 3.13 Impact significance

Impact significance	Sum of relevant factors	Consequence
Low	1 to 6	Negative impacts need to be managed by standard environmental management practices. Monitoring to be part of general project monitoring program.
Medium	7 to 9	Mitigation measures likely to be necessary and specific management practices to be applied. Targeted monitoring program required, where appropriate.
High	10 to 12	Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Targeted monitoring program necessary, where appropriate.

4 Description of environmental values

4.1 Content of this section

This section describes the ecological values of the MNES study area, including the results of the desktop analysis, field surveys results and predictive habitat mapping. This section then defines the ecological values and receptors of the MNES study area which will be the scope of the impact assessment presented in Section 5.

4.2 Regional and local context

The Project is located in both the Brigalow Belt South Bioregion (west from the top of the Toowoomba Range) and SEQ Bioregion (remainder of the MNES study area). The most notable landscape features within the MNES study area are the mountainous regions of the Great Dividing Range and the dramatic vertical face of the Great Escarpment. Both geological features are evident along the east coast of Australia, however Toowoomba is one of the few exceptions where both features are coincident (Queensland Roads 2008).

The Great Dividing Range divides the watershed between coastal flowing rivers and inland flowing rivers, while the Great Escarpment separates tablelands. The Great Escarpment, while lesser known is a much more identifiable landscape feature due to its steep gorge-like valleys and abrupt elevation changes, which within the MNES study area are up to approximately 400 m high (Queensland Roads 2008). The escarpment separates two areas of differing elevation and underlying geology, the Darling Downs to the west and the Lockyer Valley (part of the Brisbane Valley Basin) to the east. Accordingly, landform across the MNES study area varies greatly.

The MNES study area is characterised by non-remnant vegetation comprised of cleared pastures and cropping in the west and larger, contiguous extents of remnant vegetation in the east. The ecological value of this habitat varies depending on extant land use and its intensity.

The MNES study area is located within the Toowoomba and Lockyer Valley LGAs in SEQ, which have experienced a long history of human disturbance as a result of agricultural practices, urban development and resource development. At a regional level, large tracts of remnant vegetation as defined under the VM Act are typically fragmented, occurring on the areas that are less attractive to development (i.e. rocky ranges, sloping topography) and roadside vegetation, or as relatively small isolated patches subject to edge related impacts. Open agricultural fields are a dominant feature in views across the landscape, with areas of both pastoral and arable farming. Mature vegetation frequently lines local roads with scattered trees across open pastoral fields. Local pockets of residential properties and farmsteads scatter the landscape with the larger residential areas including Gowrie Junction, Cranley, Mount Kynoch and Helidon (refer Photograph 4.1).

Whilst highly fragmented areas of regrowth native vegetation occur within the eastern portion of the Project disturbance footprint, mature eucalypt open forest and woodland is the dominant forest/woodland habitat type in the MNES study area. Although fragmented, relatively large continuous areas of remnant forest/woodland are concentrated in the central portion of the Project disturbance footprint, on the eastern face of the Toowoomba Range (refer Photograph 4.2), although the Toowoomba Bypass alignment represents an existing barrier to wildlife movement in a north/south direction. Areas of remnant forest/woodland range in size from small fragments less than 1 ha in size, which are often degraded as a result of weed invasion and structural simplification, to larger areas of forest/woodland greater than 130 ha in size. In addition, non-remnant linear vegetation along roadsides and drainage lines, regrowth vegetation and isolated paddock trees form a variegated landscape mosaic in an otherwise fragmented environment.

The escarpment and foothills of the Toowoomba Range are generally heavily vegetated and are mapped as a State-wide ecological corridor of State significance, providing north-south connectivity for a range of terrestrial fauna species. The range encompasses eucalypt woodlands and substantial tracts of vine forest/semi-evergreen vine thicket communities. Some significant infestations of *Lantana camara* are present on the escarpment slopes, which may impact reducing fauna habitat values for some species. The Lockyer Creek corridor is also a State and regionally significant ecological corridor. At the local scale, waterways and remnant vegetation across the MNES study area provide for habitat connectivity.

Vegetation in the MNES study area, particularly within the Toowoomba Range, provides habitat for a variety of conservation significant flora and fauna species, including MNES (Brush sophora (*Sophora fraseri*), Koala (*Phascolarctos cinereus*) and Collared delma (*Delma torquata*)). Records of additional MNES threatened species are also known to occur within the MNES study area, based on studies associated with the TSRC project. This includes Austral toadflax (*Thesium australe*), Austral corn flower (*Rhaponticum australe*), and Hawkweed (*Picris evae*).

There are a number of protected areas to the north and northeast of the MNES study area, including Geham State Forest (approximately 13 km to the north), Lockyer National Park (approximately 2 km north), Lockyer Regional Park and Lockyer State Forest (both 3-4 km north-east of the eastern extent of the Project).



Photograph 4.1 Fragmented landscapes retaining pockets of mature vegetation within the vicinity of Mount Kynoch within MNES study area



Photograph 4.2 Intact mature forest associated with the Toowoomba Range within the MNES study area

4.2.1 Topography and geology

The land resources study area traverses through the rugged topography of the Toowoomba Range (Dudgeon 1982). The shape of the terrain, hills and valleys, are a result of Mount Kynoch and Mount Lofty as well as the alignment straddling escarpments of the Great Dividing Range (GDR). The landscape, from Gowrie, approaching the GDR consists of a gentle incline before reaching peak elevation of approximately 644.5 m Australian Height Datum (AHD), as the alignment traverses under (depth of ~200m) the New England Highway and Toowoomba Bypass at Mount Kynoch.

A steep drop in elevation occurs after the alignment passes the GDR to the east with periodic and isolated peaks featuring with reducing elevation as the alignment reaches Helidon. The lowest elevation for the rail alignment occurs at Lockyer Creek, 1 km to the west of Helidon, with an approximate elevation of 148.5 m AHD.

The topography intersected by tunnel ranges from approximately 450 m AHD, at the eastern tunnel portal, to approximately 643 m AHD, where the tunnel intersects the New England and Warrego Highways (refer Figure 4.1).

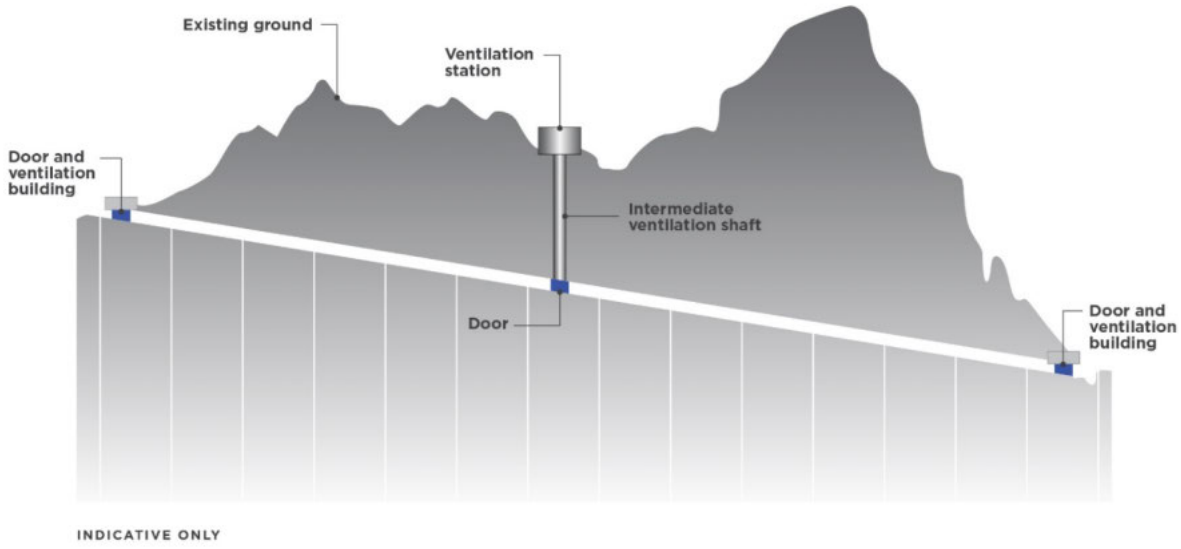


Figure 4.1 Topographical cross-section of G2H tunnel from eastern to western portal

The Toowoomba region and Darling Downs are situated on top of basalts of the MRV and are characterised by isolated basaltic peaks (Gowrie Mountain, Storey Mountain, Mount Mt Davidson (Sugarloaf), McGregor Mountain and Glenvale Mountain), dryland cropping and large open grazing properties.

The Lockyer Valley is largely volcanic in origin with large areas of sedimentary deposits and falls within the Lockyer Creek drainage sub-basin, a sub-basin of the Brisbane River Basin. Much of the catchment is underlain by sandstone formations, and the area is characterised by cultivated alluvial plains surrounded by flat to gently undulating lowlands that give way to densely vegetated hilly to sub-mountainous basaltic uplands ranges on igneous, metamorphic, and sedimentary rocks (DEHP 2016a). Within Lockyer National Park there are small areas of impermeable rocks and isolated patches of basalt, providing sandstone ridges and sandy soils. Elevated areas of Lockyer National Park are steep and rugged with gorges, exposed cliff lines and waterfalls in the foothills of the Great Dividing Range (Department of National Parks, Recreation, Sport and Racing 2013). Other local peaks include Mt Tabletop, Mt Davidson, Katoomba Point, Mt Kynoch, Ben Lomond Mountain, Wards Hill, Stringybark Mountain and Evans Hill.

The geology of the MNES study area includes three broad geological divisions; Tertiary MRV, Jurassic Marburg Formation (Koukandowie Formation and Gatton Sandstone) and Quaternary Alluvium and Colluvium (refer EIS Appendix W: Geotechnical factual report).

The geology and hydrogeological regime are influenced by the Great Dividing Range (GDR), where the GDR is a regional groundwater divide. West of the GDR is associated with the MRV and east of the GDR transitions to the Koukandowie Formation, which is outcropped by Gatton Sandstone. The tunnel intersects the MRV from Ch 4.10 km to Ch 4.53 km and Ch 8.45 km to Ch 9.05 km and intersects the Koukandowie Formation from Ch 4.53 km to Ch 8.45 km and Ch 9.05 km to Ch 10.00 km. The tunnel intersects crater rim and colluvium units at the eastern portal (refer EIS Appendix W: Geotechnical Factual Report).

4.2.2 Surface water catchment values

The Project traverses the catchments of the Condamine River and Lockyer Creek, with the boundary between these two catchments along the crest of the Toowoomba Range. The Condamine River drains west toward the Balonne-Condamine drainage basin and is part of the Drainage Division for the Murray Darling Basin. Lockyer Creek drains northeast toward the Brisbane River and is part of the Drainage Division for the North East Coast (refer EIS Appendix L: Surface water quality technical report).

The Project crosses Gowrie Creek, Rocky Creek, Six Mile Creek, and Lockyer Creek. Gowrie Creek runs parallel to the existing railway, with agricultural uses extending up to the high banks of the creek. This creek is the subject of an existing rehabilitation project, with a focus on bringing the creek back to a more natural state while also reducing the flood risk within the Toowoomba CBD. The TSRC project EPBC Act Referral describes Rocky Creek as a 'perennial stream with a series of semi-permanent waterholes' and Six Mile Creek as 'ephemeral, extremely sinuous, and characterised by deeply incised meanders.' The western catchments of Lockyer Creek are generally in poor condition due to a legacy of long-term riparian vegetation clearing (as documented in the SEQ Healthy Waterways Ecosystem Health Monitoring Program).

The aquatic conservation assessment using AquaBAMM assesses the conservation and ecological value of wetland systems based on a series of national and international criteria, including naturalness (aquatic and catchment), diversity and richness, threatened species/ecosystems, priority species/ecosystems, special features, connectivity and representativeness (DEHP 2015).

4.2.3 Groundwater values

The water table generally follows topography as it gently decreases to the west of the divide and decreases steeply east of the GDR, down the escarpment, towards Helidon. Groundwater flow direction of the alluvial aquifers may be represented by the surface water catchment boundaries, which correlates well with the groundwater divide observed. Local groundwater flow in shallow alluvial aquifers is influenced by surface water-groundwater interaction, where there is a hydraulic connection. This is observed along Gowrie Creek, which flows west into the Condamine River Basin, and it is expected that groundwater in the shallow Gowrie Creek alluvium has a similar trend. East of the GDR, the Project crosses Rocky Creek, Oaky Creek, and Six Mile Creek which flow east, and feed Lockyer Creek, and it is expected that groundwater flow in the shallow alluvium follows the surface water pathways (refer EIS Appendix N: Groundwater technical report).

Groundwater quality within the MNES study area indicate generally fresh to brackish and slightly alkaline conditions. There are numerous moderate and low potential aquatic GDEs (from regional studies) within the MNES study area, including Gowrie, Oaky, Six Mile, and Lockyer creeks (and their tributaries). Available surface water and groundwater quality and level data indicate there is potential for surface water and groundwater connectivity within the MNES study area. There are numerous moderate potential terrestrial GDEs (from regional studies) in the MNES study area.

It is anticipated there is interaction between watercourses and shallow groundwater in the associated alluvial sediments, particularly where drainage channels are more deeply incised, and groundwater levels are shallow. This is considered to occur proximal to Gowrie, Oaky, Rocky and Six Mile creeks. The degree of interconnection varies laterally due to local variations in alluvial sediment lithology, underlying bedrock geology and drainage channel morphology, as well as seasonally due to changes in groundwater elevations. At times watercourses may change from gaining systems (receiving baseflow from shallow groundwater) to losing systems (with surface water locally recharging the alluvial sediments).

In relation to MNES that are not identified as controlling provisions for the Project under the EPBC Act, there are no World heritage areas, National heritage areas, Commonwealth marine areas or Great Barrier Reef Marine Park areas located within or in close proximity to the MNES study area. The closest wetland of international importance (Ramsar) is Moreton Bay, which is 50 to 100 km downstream and is considered sufficiently displaced such that potential downstream impacts will be negligible. Therefore, these MNES are not discussed further in this document.

4.3 Results of desktop study

The following subsections provide a comprehensive description of the desktop study results within the Project MNES area and broader landscape.

The results of the database searches are presented in full in Appendix D. Results associated with previous surveys and surveys conducted concurrently with the EIS field investigations (i.e. additional ecological surveys associated with siting of geotechnical assessment locations) have been incorporated into the predictive habitat mapping and the relevant sections of this EIS and has informed the impact assessment section of this document where appropriate.

4.3.1 Flora

4.3.1.1 Threatened flora species

A total of 21 threatened flora species identified under the provisions of the EPBC Act are predicted to occur within the MNES study area (refer Table 4.1) (refer Appendix B for species profiles). Of these, 14 species have been identified exclusively from the EPBC Act protected matters search report (Australian Government 2018a) which is a predictive search tool that does not rely in specimen backed records. The location of specimen backed records for threatened flora species, derived from database sources (e.g. Herbrecs and AoLA) is provided in Figure 4.2.

A total of four species listed under the provisions of the EPBC Act are considered likely to occur within the MNES study area based on specimen-backed records in the WildNet, and AoLA databases and/or the presence of suitable habitat (refer Table 4.1).

A total of 12 species listed under the provisions of the EPBC Act are considered possible to occur within the MNES study area based on the presence of suitable habitat (refer Table 4.1).

A total of five species listed under the provisions of the EPBC Act are considered unlikely to occur within the MNES study area based on the absence of specimen-backed records in the WildNet and AoLA databases and/or the absence of suitable habitat (refer Table 4.1).

Information related to the ecology, biology and distribution for species listed in Table 4.1 is provided in Appendix C.

Table 4.1 Threatened flora species identified from database searches

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Asteraceae	*Picris evae*	Hawkweed	V	✓	✓	✓	✓	Likely
Asteraceae	*Rhaponticum australe*	Austral cornflower	V	✓	✓	✓	✓	Likely
Brassicaceae	*Lepidium peregrinum*	Wandering pepper-cress	E		✓		✓	Possible
Fabaceae	*Sophora fraseri*	Brush sophora	V	✓	✓		✓	Likely
Haloragaceae	*Haloragis exalata velutina*	Tall velvet sea-berry	V		✓		✓	Unlikely, species distribution is outside of the Project area and habitat unlikely to be present.
Orchidaceae	*Bulbophyllum globuliforme*	Miniature moss-orchid	V		✓		✓	Possible
Orchidaceae	*Sarcochilus hartmannii*	Waxy sarcochilus	V		✓		✓	Possible
Orchidaceae	*Sarcochilus weinthalii*	Blotched sarcochilus	V	✓	✓		✓	Possible
Poaceae	*Arthraxon hispidus*	Hairy-joint grass	V		✓		✓	Possible
Poaceae	*Bothriochloa bunyensis*	Bunya Mountains bluegrass	V	✓	✓	✓	✓	Possible
Poaceae	*Dichanthium queenslandicum*	King blue-grass	E		✓		✓	Possible
Poaceae	*Dichanthium setosum*	Bluegrass	V		✓		✓	Possible

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Poaceae	*Paspalidium grandispiculatum*	A grass	V		✓		✓	Possible
Proteaceae	*Grevillea quadricauda*	Four-tailed grevillea	V	✓	✓		✓	Possible
Proteaceae	*Macadamia integrifolia*	*Macadamia nut*	V		✓		✓	Unlikely, species has a coastal distribution. Planted specimens (i.e. not in the wild) may be present but these are considered beyond the intent of the EPBC Act listing
Ranunculaceae	*Clematis fawcettii*	*Stream clematis*	V		✓		✓	Possible
Rutaceae	*Leionema obtusifolium*	*Blunt-leaved leionema*	V				✓	Possible
Rutaceae	*Phebalium distans*	*Mt Berryman phebalium*	CE		✓		✓	Unlikely, outside of its range. Only known from a small area south of the Project
Santalaceae	*Thesium australe*	*Austral toadflax*	V		✓		✓	Likely
Simaroubaceae	*Samadera bidwillii*	*Quassia*	V		✓		✓	Unlikely, No records in wider area and species occurs between Mackay and Gympie (DAWE 2020)
Surianaceae	*Cadellia pentastylis*	*Ooline*	V		✓			Unlikely, outside of its range. Occurs west of the Great Dividing Range

Table notes:

CE = Critically Endangered E = Endangered
V = Vulnerable ✓ = species present within database record within the MNES study area ^ = ToR = Terms of Reference

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: MFIAD/GNILS/NWLT Z:\GIS\GIS_3200_G2HTasks\3320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig4.2_DesktopFlora_v4.mxd Date: 24/03/2021 14:22

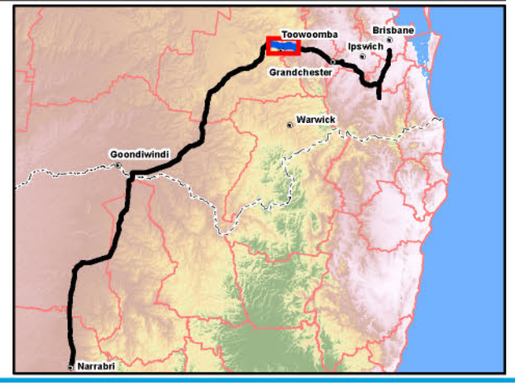
Highfields
Murphys Creek
Gowrie
TOOWOOMBA
LOCKYER VALLEY
Wellcamp
Toowoomba
Withcott
Helidon
Gowrie Ck
Klein Ck
New England Hwy
Fifteen Mile Ck
Murphys Ck
Alice Ck
Lockyer Ck
Six Mile Ck
Toowoomba Byp
Warrego Hwy
Toowoomba Conn Rd
Dry Ck
Oaky Ck
Rocky Ck
Little Oaky Ck
Garton Ck
Ruthven St
Hume St
Soda Spring Ck
Spring Ck
0
2
4
6
8
10
12
14
16
18
20
22
24
26

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Flora species records

- *Bothriochloa bunyensis*
- *Picris evae*
- *Rhaponticum australe*
- *Sophora fraseri*



A3 scale: 1:80,000

0 1 2 3 4 5km

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Integrating Community, Environment and Engineering

Issue date: 24/03/2021 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.2: Location of specimen backed records of MNES significant flora species derived from desktop assessments

4.3.1.2 Threatened ecological communities

The following TECs listed under the provisions of the EPBC Act were identified as potentially occurring within the MNES study area as provided by the EPBC Act Protected matters search tool:

- Lowland Rainforest of Subtropical Australia – Critically Endangered. None of the REs present (remnant or regrowth) within the MNES study area are analogous with this community (refer Table 3.3), with the nearest mapped community approximately 5 km north of the eastern tunnel portal. The Project is predominantly located above 300 m above sea level, with this TEC generally below 300 m above sea level.
- Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions – Endangered. Does not occur in SEQ. The land has been heavily impacted by current land use activities (clearing for grazing and agriculture) where the MNES study area is located within the Brigalow Belt. None of the REs present (remnant or regrowth) within the MNES study area are analogous with this community (refer Table 3.3).
- Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD (Natural Grassland TEC.) – Critically Endangered. Identified as potentially occurring within the MNES study area, 1 km northwest of the Project disturbance footprint (i.e. northwest of Gowrie, on the north side of the existing QR West Moreton System rail corridor). There is a single patch of remnant grassland which has been identified adjacent to Gowrie Creek, approximately 1.5 km northeast of the western tunnel portal, mapped as RE 11.3.21 which is analogous to the Natural Grassland TEC.
- The Project intersects the alluvial floodplains of Gowrie Creek, with pre-clearing mapping (pre-European settlement) indicating that the area between the West Moreton System and Gowrie Creek was RE11.3.21, Natural Grassland TEC. However, the grasslands in these areas are heavily attenuated and have been subject to anthropogenic activities for the past 50 years which is reflected in the current mapping (i.e. non-remnant). Despite this the grassland communities *within and adjacent the Project may* provide habitat for a number of threatened flora and fauna species, including some of the species listed in Table 4.1 and Table 4.3.
- Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions – Endangered. Does not occur in the SEQ bioregion. The land has been heavily impacted by current land use activities (clearing for grazing and agriculture) where the MNES study area is located within the Brigalow Belt bioregion. None of the REs present (remnant or regrowth) within the MNES study area are analogous with this community (refer Table 3.3). Noting that the nearest area of SEVT (based on the RE mapping and Commonwealth mapping) is associated with the Mount Kingsthorpe escarpment, approximately 1.2 km north of the Project (Ch -1.76 km). These areas may also provide habitat for a number of threatened flora and fauna species, including some of the species listed in Table 4.1 and Table 4.3.
- Weeping Myall Woodlands – Endangered. Does not occur in the SEQ bioregion. The land has been heavily impacted by current land use activities (clearing for grazing and agriculture) where the MNES study area is located within the Brigalow Belt bioregion. None of the REs present (remnant or regrowth) within the MNES study area are analogous with this community (refer Table 3.3).
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland – Critically Endangered. The Commonwealth mapping identifies a number of areas within the Toowoomba area as potentially supporting this community, including the vegetation along the Cotswold Hill escarpment and western facing escarpment between Birnam and Mount Kynoch as locations where the community is likely to occur. A review of RE mapping confirmed that there are two RE 11.8.8 and 11.8.2a (remnant and regrowth) which are analogous to the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland TEC within these locations. The communities are approximately 1.4 km southwest and 0.75 km northeast of the intermediate ventilation shaft at Cranley, respectively. A small patch is also present about 1.1 km north of the eastern tunnel portal.

- Several heterogeneous polygons of RE11.8.8 and RE11.8.2a have also been identified north of the tunnel alignment between Ch 8.0 km and Ch 9.0 km, along the western facing escarpment between in the Mount Kynoch area. These REs are analogous to the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland TEC, with the closest area located approximately 250 m north of the proposed tunnel alignment. A patch of RE11.8.2 is also present south of the tunnel approximately 450 m south east of the intermediate shaft access road. These areas may also provide habitat for a number of threatened flora and fauna species, including some of the species listed in Table 4.1 and Table 4.3.

Based on review of the RE mapping (i.e. current and pre-clearance) and aerial imagery, there are no remnant or regrowth REs analogous to any TEC located within the Project disturbance footprint. However, as noted in Section 3.2.5 the minimum patch threshold (e.g. 0.1 ha for Natural Grassland TEC) for some of these communities is significantly lower than what can be ascertained from the RE mapping (i.e. current and pre-clearance) and aerial imagery and field investigations were undertaken to verify the mapping (refer Section 4.4.1.3).

Profiles related to each of the TECs identified above, mapping produced by DAWE, relevant threat abatement/recovery plans and threatening processes are provided in Appendix B.

The amount of each TEC occurring within the MNES study area based on vegetation community mapping at a desktop level is detailed in Table 4.2 and is depicted in Section 4.4.1.3.

Table 4.2 Threatened ecological communities identified within the matters of national environmental significance study area based on desktop mapping

TEC Name	EPBC Act status	Extent (ha)	
		MNES study area	Disturbance footprint
Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD	CE	4.50	0.00
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE	193.63	0.00

4.3.2 Fauna

4.3.2.1 Threatened fauna species

A total of 32 threatened fauna species listed under the EPBC Act are predicted or are known to occur within the MNES study area (refer Table 4.3). Of the threatened species, 17 have been identified exclusively from the EPBC Act protected matters search report (Australian Government 2019) which is a predictive search tool that does not rely on specimen backed records. The location of specimen backed records for threatened fauna species, derived from database sources (e.g. BirdLife Australia, WildNet and AoLA) is provided in Appendix D.

Of the threatened species identified above (refer Table 4.3):

- Six are considered likely to occur within the MNES study area based on specimen-backed records in the Wildlife online and the AoLA databases and/or the presence of suitable habitat
- Sixteen are considered possible to occur within the MNES study area based on the presence of suitable habitat
- Ten are considered unlikely to occur within the MNES study area based on their distributional limits

Table 4.3 Threatened fauna species identified from database searches

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Birds								
Accipitridae	*Erythrotriorchis radiatus*	Red goshawk	V	✓	✓		✓	Possible
Apodidae	*Hirundapus caudacutus*	White-throated needletail	V, M	✓	✓	✓		Possible
Ardeidae	*Botaurus poiciloptilus*	Australasian bittern	E		✓		✓	Possible
Columbidae	*Geophaps scripta scripta*	Squatter pigeon (southern subspecies)	V	✓	✓	✓	✓	Unlikely. The species is typically associated with the western slopes of the Great Dividing Range. While there are several records of this species within the broader project context, the majority of these are older and there are no recent records (>1990s) within 5 km of the project disturbance footprint. In addition, significant habitat modification has occurred since these records and as such the species is not likely to have persisted within the area
Dasyornithidae	*Dasyornis brachypterus*	Eastern bristlebird	E				✓	Unlikely, species occurs in montane areas in eucalypt forests with a dense tussock grass layer (DAWE 2020b). Habitat does not occur and the species has never occurred in or near the MNES study area.
Falconidae	*Falco hypoleucos*	Grey falcon	V	✓		✓		Likely
Meliphagidae	*Anthochaera phrygia*	Regent honeyeater	CE		✓		✓	Possible
Meliphagidae	*Grantiella picta*	Painted honeyeater	V	✓	✓	✓	✓	Possible
Passeridae	*Poephila cincta cincta*	Southern black-throated finch	E		✓			Unlikely. Expert advice indicates that this species is locally extinct within SEQ (DAWE 2020a).
Psittacidae	*Cyclopsitta diophthalma coxeni*	Coxen's fig-parrot	E		✓		✓	Unlikely. No records close (within 50 km) to MNES study area and no reliable records of the species from the year 2000 onwards.
Psittacidae	*Lathamus discolor*	Swift parrot	CE		✓		✓	Possible

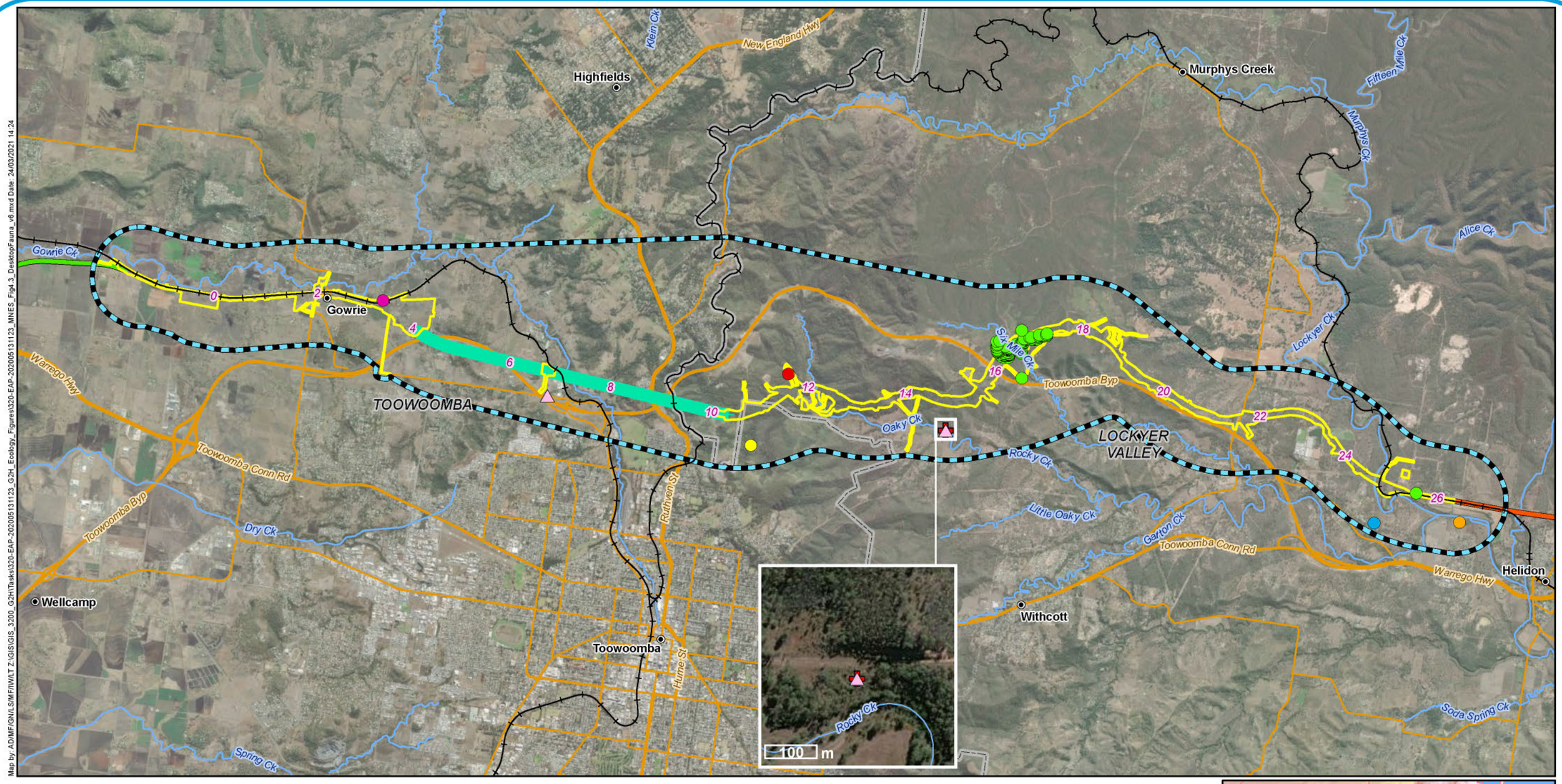
Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Rostratulidae	*Rostratula australis*	Australian painted snipe	E	✓	✓	✓		Possible
Scolopacidae	*Calidris ferruginea*	Curlew sandpiper	CE, M		✓		✓	Possible
Scolopacidae	*Numenius madagascariensis*	Eastern curlew	CE, M		✓		✓	Unlikely. Species is essentially a coastal specialist.
Turnicidae	*Turnix melanogaster*	Black-breasted button-quail	V	✓	✓	✓	✓	Likely
Fish								
Pericichthyidae	*Maccullochella peelii*	Murray cod	V		✓		✓	Possible
Mammals								
Dasyuridae	*Dasyurus hallucatus*	Northern quoll	E		✓			Unlikely. Nearest records in the Toowoomba area are all old (<1986) (AoLA 2020) and the species likely no longer occurs in the area.
Dasyuridae	*Dasyurus maculatus maculatus*	Spotted-tail quoll	E		✓		✓	Possible
Macropodidae	*Petrogale penicillata*	Brush-tailed rock-wallaby	V	✓	✓	✓	✓	Likely
Muridae	*Pseudomys novaehollandiae*	New Holland mouse	V		✓		✓	Possible
Petauridae	*Petauroides volans*	Greater glider	V		✓		✓	Possible
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	✓	✓	✓	✓	Likely
Potoroidae	*Potorous tridactylus tridactylus*	Long-nosed potoroo	V		✓		✓	Possible
Pteropodidae	*Pteropus poliocephalus*	Grey-headed flying-fox	V	✓	✓		✓	Likely
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared pied bat	V		✓		✓	Unlikely. Species never recorded in or near Toowoomba Range. Nearest record is from1994 and from Main Range National Park (AoLA 2020).
Vespertilionidae	*Nyctophilus corbeni*	South-eastern long-eared bat	V		✓		✓	Unlikely. Outside of species range and no suitable habitat present.
Reptiles								
Agamidae	*Tympanocryptis condaminensis*	Condamine earless dragon	E		✓		✓	Possible
Elapidae	*Furina dunmalli*	Dunmall's snake	V		✓		✓	Possible

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Pygopodidae	*Delma torquata*	Collared delma	V	✓	✓	✓	✓	Likely
Scincidae	*Anomalopus mackayi*	Five-clawed worm-skink	V		✓	✓	✓	Possible
Scincidae	*Coeranoscincus reticulatus*	Three-toed snake-tooth skink	V				✓	Unlikely. Species unknown from Toowoomba range (AoLA 2020) Largely occurs in wet rainforest and wet sclerophyll forest habitats (DAWE 2020a) which does not occur within or near the footprint.
Scincidae	*Egernia rugosa*	Yakka skink	V		✓		✓	Unlikely. Highly modified habitat present in the Gowrie area (species not known to occur in the Toowoomba Range or east) and no records within 60 km of the Project (AoLA 2020).

Table notes:

E = Endangered V = Vulnerable M = Migratory CE = Critically Endangered
✓= species present within database recorded within the impact MNES study area
^ = ToR = Terms of Reference

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community



Map by AD/MF/GN/LS/MF/IW/LT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig4.3_DesktopFauna_v6.mxd Date: 24/03/2021 14:24

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Significant fauna

- Australian painted snipe (*Rostratula australis*)
- Grey falcon (*Falco hypoleucos*)
- Collared delma (*Delma torquata*)
- Grey-headed flying-fox (*Pteropus poliocephalus*)
- Koala (*Phascolarctos cinereus*)
- Red goshawk (*Erythrotriorchis radiatus*)
- Squatter pigeon (southern subspecies) (*Geophaps scripta scripta*)
- White-throated needletail (*Hirundapus caudacutus*)



A3 scale: 1:80,000
0 1 2 3 4 5km

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Integrating Community, Environment and Engineering

Issue date: 24/03/2021 Version: 6
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.3: Location of specimen backed records of MNES significant fauna species derived from desktop assessments

4.4 Existing environment

The following subsections provide a description of the existing ecological values of the MNES study area based on the results of the field assessments. The results presented in this section detail the existing flora and fauna species (including weeds and pests), habitats, vegetation communities, and MNES.

4.4.1 Flora

4.4.1.1 Species richness

A total of 274 plant species were identified within the MNES study area during Project EIS field assessments. This included a total of 202 (74 per cent) native species, and 72 (26 per cent) non-native species (refer Appendix E).

Of the non-native species, 10 were identified as Weeds of National Significance (WoNS), consisting of:

- Feathered asparagus fern (*Asparagus plumosus*)
- Parthenium weed (*Parthenium hysterophorus*)
- Fireweed (*Senecio madagascariensis*)
- Madeira vine (*Anredera cordifolia*)
- Cat's claw creeper (*Dolichandra unguis-cati*)
- Common pest pear (*Opuntia stricta*)
- Velvety tree pear (*Opuntia tomentosa*)
- Blackberry (*Rubus anglocandicans*)
- African boxthorn (*Lycium ferocissimum*)
- Lantana (*Lantana camara*).

Non-native species were typically more abundant and diverse in areas of high anthropogenic disturbance when compared to those characterised by an intact canopy of native species such as identified as remnant vegetation/intact bushland. However, encroachment of non-native species, particularly those spread by birds (e.g. *Lantana camara* and *Lantana montividensis*) was evident in relatively undisturbed areas, particularly throughout remnant areas associated with the Toowoomba Range. These species in particular have the potential to outcompete, replace and exclude native flora species within such environments.

4.4.1.2 Threatened flora species

As noted in Section 4.3.1.1, there is the potential for a number of threatened flora species to occur throughout the MNES study area.

One threatened flora species listed under the EPBC Act was recorded during Project EIS field assessments and EMM (2019) (refer Figure 4.4). Two individuals of Brush sophora (*Sophora fraseri*) were recorded in eucalypt woodland adjacent to remnant Araucarian vine forest within the Toowoomba Range (refer Photograph 4.3 and Photograph 4.4). The species is associated with rainforests and vine forest habitats.



Photograph 4.3 Brush sophora located in Toowoomba Range



Photograph 4.4 Brush sophora habitat in Toowoomba Range

As identified in Figure 4.4, two other threatened species are known to occur within close proximity to the Project, however they were not detected during the field investigations:

- Austral cornflower (*Rhaponticum australe*) – grassland and woodland on dark clay soils mainly west of the Toowoomba Range in the MNES study area
- Hawkweed (*Picris evae*) – grassland, woodland and disturbed habitats on dark clay soils mainly west of the Toowoomba Range in the MNES study area

These species, along with Austral toadflax (*Thesium australe*) were also identified during the TSRC project in close proximity to the Project disturbance footprint.

The field investigations also confirmed habitat for a number of other flora species within the MNES study area comprising the following:

- Hawkweed (*Picris evae*)
- Austral cornflower (*Rhaponticum australe*)
- Wandering pepper-cress (*Lepidium peregrinum*)
- Brush sophora (*Sophora fraseri*)
- Tall velvet sea-berry (*Haloragis exalata* subsp. *velutina*)
- Miniature moss-orchid (*Bulbophyllum globuliforme*)
- Waxy sarcochilus (*Sarcochilus hartmannii*)

This information was used to inform the predictive habitat modelling for each of the MNES flora species. Predictive habitat mapping within the MNES study area for those species considered to have habitat potentially impacted by the Project are presented in Appendix G.

4.4.1.3 Threatened Ecological Communities

Ground-truthing surveys confirmed the presence of one TEC (Lowland Rainforest of Subtropical Australia TEC) within the MNES study area(refer Figure 3.2 and Figure 3.3). Further key diagnostic species such as *Eucalyptus coolabah*, White box (*Eucalypts albens*), Yellow box (*E. melliodora*), Blakely's red gum (*E. blakelyi*) and Weeping myall *(Acacia pendula)* associated with the TEC identified as potentially occurring (refer Section 4.3.1.2) were not encountered during the field investigations. A single patch (1.5 ha) of Critically Endangered Lowland Rainforest of Subtropical Australia TEC, has been confirmed (ELA 2019) as occurring approximately 100 m to the north-east of the eastern tunnel poral in the Toowoomba Range (refer Figure 4.2). The full extent of the patch could not be ascertained at the time due to survey restrictions. It is noted the location of this area is approximately 420 m above sea level (asl) which is above the typical altitude recognised as lowlands for this TEC (i.e 300 m asl) (refer Section 3.2.5). Aspect can result in the community being found at >300 m altitude on north-facing slopes. The TEC was limited to the basalt gullies in the area of investigation with this patch located on a northeast facing slope. The floristic characteristics of the patch included:

Dominant canopy tree species included *Ficus coronata, F. virens, Lophostemon confertus, Flindersia australis, Alectryon connatus, A. subdentatus, Aphananthe philippinensis.* Shrub species included *Denhamia celastroides, Elattostachys xylocarpa, Grevillea robusta, Mallotus philippensis, Notelaea microcarpa, Pittosporum revolutum.* Ground species and vines included *Pandorea pandorana, Smilax australis, Adiantum aethiopicum, A. atroviride, A. sylvaticum, Eustrephus latifolius, Pteris vittata,* and *Stephania japonica.*

The vegetation was analogous with RE 12.8.5 (complex notophyll vine forest on Cainozoic igneous rocks). SEVT communities in the Eastern Darling Downs subregion of the Brigalow Belt Bioregion, are contiguous with similar vegetation (i.e. seven SEVT REs) in the SEQ Bioregion. With RE12.8.21 (Low microphyll vine forest and semi-evergreen vine thicket +/- *Araucaria cunninghamii*) and RE12.9/10.15 (Low microphyll vine forest +/- *Araucaria cunninghamii* and semi-evergreen vine thicket.) confirmed as being present within the vicinity of the eastern tunnel portal. However, these areas not considered to be a TEC (refer Section 3.2.5).

As part of the Gowrie to Grandchester Rail Corridor Study the Gowrie to Grandchester future State transport corridor was aligned to avoid and/or minimise impacts on mapped vine thicket communities along this section of the Toowoomba Range.

Ground truthing activities in the Gowrie area described the presence of non-native grasslands and derived native grasslands within the Project disturbance footprint. This is reflective of the level of anthropogenic activities for the past 50 years. Some of the grassland also occur on Cainozoic igneous rocks on basalt plains and hills, which is a key landscape feature with the Gowrie area south of the West Moreton System.

Data derived from the Vegetation management regional ecosystem mapping dataset, indicates that heterogeneous polygons including remnant and regrowth vegetation analogous to the Critically Endangered Natural Grasslands TEC and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland TEC and Poplar box woodlands TECs occurs within the MNES study area, but not within the Project disturbance footprint (refer Section 4.3.1.2). The actual extent of occurrence of these communities within the MNES study area has not been confirmed during Project surveys. The location and extent of mapped TECs within the MNES Study area is presented in Figure 4.4 and Table 4.2.

Table 4.4 Extent of Threatened ecology communities identified within the matters of national environmental significance study area

Threatened ecological community	Extent (ha)	
	MNES study area	Disturbance footprint
Lowland Rainforest of Subtropical Australia – Critically Endangered.	1.5	0.00
Natural grassland on basalt and fine-textured alluvial plains of northern New South Wales and southern QLD – Critically Endangered.	4.50	0.00
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland – Critically Endangered.	193.63	0.00

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: MFLS/INV/LT Z:\GIS\GIS_3200_G2H\Tasks\3320-EAP-20200513123_G2H_Ecology_Figures\3320-EAP-20200513123_MNES_Fig4.4_ObservedFlora_v4.mxd Date: 24/03/2021 14:28

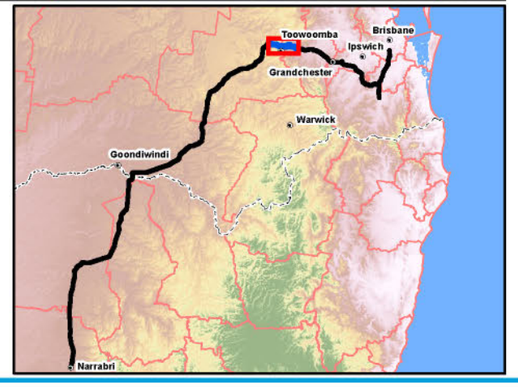
Highfields
Murphys Creek
Gowrie
TOOWOOMBA
LOCKYER VALLEY
Withcott
Toowoomba
Helidon
Gowrie Ck
Klein Ck
New England Hwy
Fifteen Mile Ck
Murphys Ck
Alice Ck
Lockyer Ck
Six Mile Ck
Toowoomba Byp
Warrego Hwy
Toowoomba Conn Rd
Oaky Ck
Rocky Ck
Ruthven St
Little Oaky Ck
Garton Ck
Hume St
Soda Spring Ck
0
2
4
6
8
10
12
14
16
18
20
22
24
26
0.5 Km

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Significant flora

- *Sophora fraseri*



A3 scale: 1:80,000

0 1 2 3 4 5km

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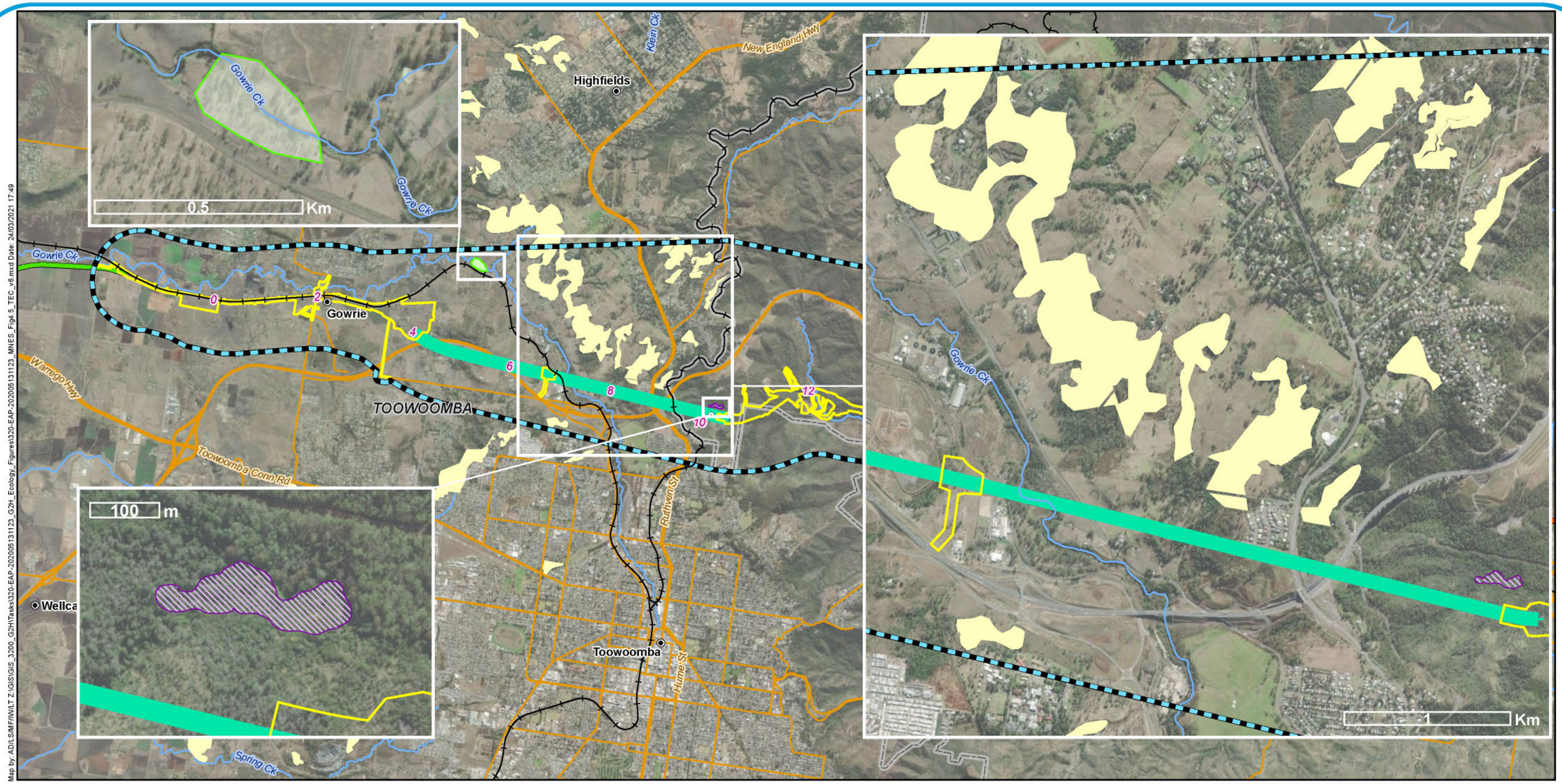
Issue date: 24/03/2021 Version: 4
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.4: Locations of observed MNES significant flora species within the MNES study area

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Legend

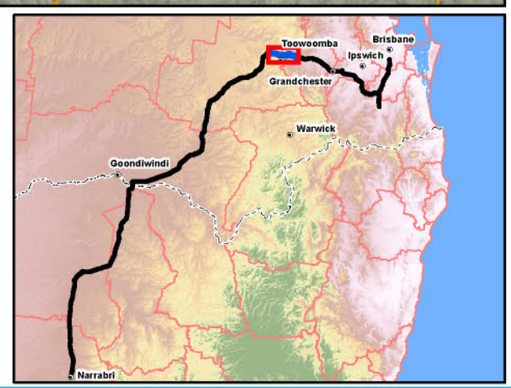
- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Predicted threatened ecological communities

- Natural grasslands of southern Queensland
- White box-yellow box- Blakely's red gum grassy woodland

Ground-truthed threatened ecological communities

- Lowland rainforest



A3 scale: 1:80,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 24/03/2021 Version: 5
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.5: Extent of Threatened Ecological Communities within the MNES study area

Additional ecological surveys are progressing to verify and where necessary delineate the State based and ground-truthed vegetation mapping. The survey works are being undertaken in accordance with Neldner et al. 2016 and will consider the key diagnostic characteristics and condition thresholds for each TEC (as identified in the Approved conservation advice for the respective TEC) where relevant to determine the extent to which the TEC actually occurs within or directly adjacent (i.e. 50 m) the Project disturbance footprint.

4.4.2 Fauna

This section outlines the fauna species richness observed within the MNES study area. This section also provides the threatened species listed under the provisions of the EPBC Act that were recorded within the MNES study area.

4.4.2.1 Species richness

Project EIS field investigations have identified a total of 105 fauna species (refer Appendix F), including 99 (94.3 per cent) native species and six (5.7 per cent) non-native species. Recorded species consisted of 75 (71.4 per cent) birds, 21 (20.0 per cent) mammals, eight (7.6 per cent) reptiles, one (0.9 per cent) amphibians.

Non-native species consisted of the following:

- Cane toad (*Rhinella marina*)
- Red deer (*Cervus elaphus*)
- Horse (*Equus caballus*)
- European hare (*Lepus europaeus*)
- European rabbit (*Oryctolagus cuniculus*)
- Common myna (*Acridotheres tristis*).

Given the nature of bushland areas within the MNES study area, their vagile nature and ability to persist in fragmented landscapes, it is to be expected that birds would constitute the largest percentage of observed species. However, their dominance of the recorded species is also likely to be an artefact of their detectability when compared to more cryptic species such as amphibians and reptiles.

4.4.2.2 Threatened fauna species

As noted in Section 4.3.2.1 a number of threatened species potentially occur throughout the MNES study area.

During Project EIS field investigations two threatened fauna species were confirmed within the MNES study area: Koala (*Phascolarctos cinereus*) through observation of individuals and signs (scats and scratches) (Arup 2016; ELA 2019a); and Collared delma (*Delma torquata*) through observation of one individual (refer Photograph 4.5) and recording of signs (skins and casts) (ELA 2019a). The presence of Koala and signs were noted throughout wooded areas of the alignment and in high density in some areas (Arup 2016). The presence of Collared delma were noted in several areas within the Toowoomba Range. The location of threatened fauna species identified during Project EIS field investigations is provided in Figure 4.6.

In addition, Collared delma (*Delma torquata*) and Black-breasted button-quail (*Turnix melanogaster*) have been identified within the MNES study area during concurrent studies for the nearby TSRC project in 2017. DTMR also tracked a number of koalas as part of this project and are currently assessing the effectiveness of the fauna sensitive design implement on this project. ARTC are in the process of sourcing this information from DTMR.



Photograph 4.5 Collared delma from Project surveys (source: S Wilson 2019)

Field investigations also confirmed the presence of suitable fauna habitat (foraging and breeding) including the following:

- Five-clawed worm-skink (*Anomalopus mackayi*) and Condamine earless dragon (*Tympanocryptis condaminensis*) – open woodlands and grasslands on cracking clays in the Gowrie Creek area
- Collared delma (*Delma torquata*) – rocky woodland habitat in the Toowoomba Range
- Regent honeyeater (*Anthochaera phrygia*) - box-ironbark woodlands
- Red goshawk (*Erythrotriorchis radiatus*) - eucalypt open forest and woodland in the Toowoomba Range
- Swift parrot (*Lathamus discolor*) – eucalypt woodlands
- Spotted-tail quoll (*Dasyurus maculatus maculatus*) – limited rocky outcrops/caves in eucalypt woodlands
- Greater glider (*Petauroides volans*) – large hollow-bearing trees in some areas of eucalypt woodlands
- Koala (*Phascolarctos cinereus*) - eucalypt woodlands throughout
- Black-breasted button-quail (*Turnix melanogaster*) – semi-evergreen vine thicket and vine forests in the Toowoomba Range

The availability of habitat types and their relevance to MNES fauna and flora are discussed further in Section 4.4.4.

This information was used, in addition to that contained within relevant recovery plans, conservation advice and/or listing advice, to inform the predictive habitat modelling and mapping for each of the MNES fauna species (refer Appendix G for species habitat maps). Potential habitat for MNES fauna species is spread throughout the Project alignment but is focused on the Toowoomba Range and foothills for many species. It is noted that whilst all areas of the MNES study area were not accessible, information derived from historic and concurrent surveys (refer Table 3.4) was used to inform the predictive mapping for MNES fauna species where applicable.

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: MFGN/AD/IW/LT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig4_6_ObservedFauna_v5.mxd Date: 24/03/2021 18:49

Kingsthorpe
Gowrie Ck
Gowrie
Highfields
Klein Ck
New England Hwy
Murphys Creek
Fifteen Mile Ck
Murphys Ck
Alice Ck
Lockyer Ck
TOOWOOMBA
Toowoomba Byp
Warrego Hwy
Toowoomba Conn Rd
Oaky Ck
Rocky Ck
Six Mile Ck
LOCKYER VALLEY
Little Oaky Ck
Withcott
Helidon
Warrego Hwy
Toowoomba Conn Rd
Carton Ck
Soda Spring Ck
Flagstone Ck
Rocky Ck
Lockyer Ck
0 1.5 km

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
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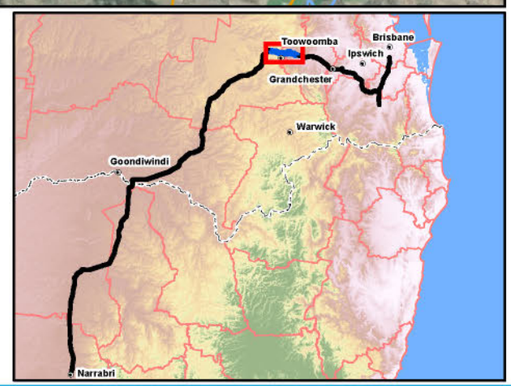
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Fauna species

- Collared delma (*Delma torquata*) cast skin
- Collared delma (*Delma torquata*) seen
- Koala (*Phascolarctos cinereus*) remains
- Koala (*Phascolarctos cinereus*) scats
- Koala (*Phascolarctos cinereus*) seen
- Koala (*Phascolarctos cinereus*) scats (Arup 2016)



A3 scale: 1:97,921

0 1 2 3 4 5km

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Issue date: 24/03/2021 Version: 5
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.6: Locations of observed threatened fauna within the MNES study area

4.4.2.3 Aquatic species

As noted in Table 4.3, one threatened aquatic species (Murray cod (*Maccullochella peelii*)) has potential to inhabit the watercourses associated with the MNES study area.

The Murray cod prefers microhabitats consisting of complex structural features in streams such as large rocks, snags (pieces of large submerged woody debris), overhanging stream banks and vegetation, tree stumps, logs, branches and other woody structures (DotEE 2018). The species was not detected during surveys within the MNES study area. The national recovery plan for the Murray cod (Koehn and Clunie 2010) notes the species is endemic to the Murray-Darling River system and still occurs throughout most of its historic range. Gowrie Creek is located in the upper catchment of the Condamine River, although habitat values in this section of the creek appears less likely to support the permanent presence of the species (refer Section 4.4.4.7).

4.4.3 Predicted habitat for threatened flora and fauna species

Predictive habitat mapping for threatened flora and fauna species, and TECs (refer Section 3.2.4 and Appendix A) indicates that potential habitat for 37 threatened species and three TECs occurs within the MNES study area (refer Appendix G). Areas of predicted habitat for these species and TECs is presented in Table 4.5 and mapped areas of habitat are provided in Appendix G.

The predictive habitat mapping also indicates that there is no habitat within the Project disturbance footprint for the following seven species: Bunya Mountains bluegrass (*Bothriochloa bunyensis*), Stream clematis (*Clematis fawcettii*), Wandering pepper-cress (*Lepidium peregrinum*), Waxy sarcochilus (*Sarcochilus hartmannii*), Brush-tailed rock-wallaby (*Petrogale penicillata*), Five-clawed worm-skink (*Anomalopus mackayi*) and Dunmall's snake (*Furina dunmalli*).

The predictive habitat mapping is based on a range of considerations including desktop and ground-truthed vegetation mapping, database search results for species records and the results of field surveys for the Project. The Project disturbance footprint encompasses a total of 456.81 ha. Under current QLD Government (DES) vegetation mapping this includes 112.80 ha of remnant vegetation and 106.48 ha of high-value regrowth vegetation (HVR) (refer to the EIS Appendix I: Terrestrial and aquatic ecology technical report). The remaining 237.53 ha has been mapped as non-remnant, much of which has been heavily modified especially in the Gowrie area where clearing for irrigation and cropping, transport infrastructure and rural residential has occurred. However it is noted that within non-remnant areas, mature trees, or interconnect stands of trees that may still provide habitat value and limited connectivity. However, generally in these areas, connectivity and refugia habitat is limited relevant to the Project disturbance footprint. As such these areas are unlikely to provide habitat for the majority of the flora and fauna species listed in Table 4.5. Nevertheless, cleared habitats, particularly associated cracking clay soils on the Gowrie Creek floodplain are known to support threatened flora species (Hawkweed (*Picris evae*) and Austral cornflower (*Rhaponticum australe*)) and may also provide habitat for some threatened flora species [e.g. King bluegrass *(Dichanthium queenslandicum*)] and Condamine earless dragon (*Tympanocryptis condaminensis*), as well as scattered ephemeral flooded areas following heavy rainfall events (for wetland birds).

The predictive estimation of habitat provided in Table 4.5 represents a highly conservative approach, accounting for MNES movement patterns, and where doubt existed regarding the potential of an area to provided habitat for a specific MNES, these areas were incorporated into the predicted estimation. The values provided in Table 4.5 are considered to represent the upper limit of available habitat within the MNES study area for each MNES.

It is noted the predictive estimate of *Potential habitat* for Koala encompasses 70.60 ha within the Project disturbance footprint (in addition to 189.01 ha of *Habitat critical to the survival of the species*).

For the purposes of this assessment *Habitat critical to the survival of the species* (i.e. koala habitat) has been identified using the MNES Guidelines and includes all mapped remnant and regrowth vegetation communities containing eucalypt species and includes drainage lines which may provide suitable riparian habitat trees located outside of known vegetation mapping (e.g. Gowrie Creek). As can be observed in Figure 4.3 and Figure 4.6 all records for koala were from eucalypt woodlands (remnant and regrowth) in the Helidon Hills and Toowoomba Range areas. These areas were considered to be *Habitat critical for the survival of the species* (refer Appendix G).

Potential habitat for the species is based on a 1 km buffer placed on recent species records (refer Figure 4.3) located outside of mapped vegetation communities (remnant or regrowth) and aims to consider potential movement patterns on a local scale outside of *Habitat critical for the survival of the species* (refer Appendix A for methodology). *Potential habitat* encompasses habitat comprising scattered trees in grazing paddocks (in which the species has been known to use but do not provide the only movement opportunity/refuge to or between areas of habitat critical to the species survival) and grazing and cropped areas which may not feature trees at all.

As such, *Potential habitat* mapped for Koala is likely a significantly over-estimate with the main risk to the species in these areas being the barrier effect/fragmentation (i.e. generally north south movement, although it is noted the Project is located close to existing infrastructure (e.g. the Toowoomba Bypass) which may already pose an existing barrier to movement). A study by Barth et al (2019) noted that koalas use paddock trees and roadside vegetation during both breeding and non-breeding seasons, with these areas utilised significantly more than expected based on their availability within the landscape.

The extent of koala habitat will be subject to further investigation and refinement in consultation with DES and DAWE. Noting that under the Nature Conservation (Koala) Conservation Plan 2017 Koala Plan and the supporting South East Queensland Koala Conservation Strategy 2020–2025 (DES 2020d) (Koala Strategy) the Project will impact on 213.73 ha of koala habitat area (core). Koala habitat area (core) represent the best quality Koala habitat, based on modelling of biophysical measures (such as climate), suitable vegetation (for both food and shelter), and Koala sighting records (refer EIS Appendix I: Terrestrial and aquatic ecology technical report).

It should also be noted while there are large habitat area values associated with White-throated needletail (*Hirundapus caudacutus*) (constituting the entire MNES study area) this is an aerial foraging species which may forage over any habitat including heavily disturbed areas. As such, all ‘air-space’ above the Project may be considered habitat. Given this habitat (i.e. above the Project) will not be impacted by the Project construction/operation activities the species is not subject to further impact assessment.

Table 4.5 Predicted habitat for threatened flora and fauna species within the matters of national environmental significance study area

Species name	Common name	EPBC Act status	Predicted habitat within the MNES study area (ha)*				Predicted habitat within the Project disturbance footprint (ha)*			
			Total habitat	Potential habitat	Important habitat	Habitat critical to the survival of the species	Total habitat	Potential habitat	Important habitat	Habitat critical to the survival of the species
Threatened flora species habitat										
Arthraxon hispidus	Hairy-joint grass	V	382.32	382.32	N/A	0.00	9.18	9.18	N/A	0.00
Bothriochloa bunyensis	Bunya Mountains bluegrass	V	314.73	314.73	N/A	0.00	0.00	0.00	N/A	0.00
Bulbophyllum globuliforme	Miniature moss-orchid	V	115.01	115.01	N/A	0.00	2.36	2.36	N/A	0.00
Clematis fawcettii	Stream clematis	V	0.71	0.71	N/A	0.00	0.00	0.00	N/A	0.00
Dichanthium queenslandicum	King blue-grass	E	294.33	294.33	N/A	0.00	0.67	0.67	N/A	0.00
Dichanthium setosum	Bluegrass	V	294.33	294.33	N/A	0.00	0.67	0.67	N/A	0.00
Grevillea quadricauda	Four-tailed grevillea	V	97.05	97.05	N/A	0.00	1.02	1.02	N/A	0.00
Leionema obtusifolium	Blunt-leaved leionema	V	106.49	106.49	N/A	0.00	0.63	0.63	N/A	0.00
Lepidium peregrinum	Wandering pepper-cress	E	38.59	38.59	N/A	0.00	0.00	0.00	N/A	0.00
Paspalidium grandispiculatum	A grass	V	1,432.47	1,432.47	N/A	0.00	156.25	156.25	N/A	0.00
Picris evae	A hawkweed	V	1,657.52	1,367.01	N/A	290.51	31.88	31.88	N/A	0.00
Rhaponticum australe	Austral cornflower	V	721.36	719.95	N/A	1.41	63.02	63.02	N/A	0.00
Sarcochilus hartmannii	Waxy sarcochilus	V	88.55	88.55	N/A	0.00	0.00	0.00	N/A	0.00
Sarcochilus weinthalii	Blotched sarcochilus	V	414.82	350.55	N/A	64.27	3.14	3.14	N/A	0.00
Sophora fraseri	Brush sophora	V	605.22	534.08	N/A	71.14	31.05	28.69	N/A	2.36
Thesium australe	Austral toadflax	V	661.64	661.64	N/A	0.00	29.53	29.53	N/A	0.00

Species name	Common name	EPBC Act status	Predicted habitat within the MNES study area (ha)*				Predicted habitat within the Project disturbance footprint (ha)*			
			Total habitat	Potential habitat	Important habitat	Habitat critical to the survival of the species	Total habitat	Potential habitat	Important habitat	Habitat critical to the survival of the species
Threatened fauna species habitat										
Birds										
Anthochaera phrygia	Regent honeyeater	CE	1,732.82	1,732.82	N/A	0.00	156.25	156.25	N/A	0.00
Botaurus poiciloptilus	Australasian bittern	E	272.32	272.32	N/A	0.00	8.90	8.90	N/A	0.00
Calidris ferruginea	Curlew sandpiper	CE, M	272.32	272.32	N/A	0.00	8.90	8.90	N/A	0.00
Erythrotriorchis radiatus	Red goshawk	V	833.72	293.16	N/A	540.56	88.77	3.98	N/A	84.79
Falco hypoleucos	Grey falcon	V	3,322.29	3,041.30	N/A	280.99	211.69	145.56	N/A	66.13
Grantiella picta	Painted honeyeater	V	338.77	338.77	N/A	0.00	8.54	8.54	N/A	0.00
Hirundapus caudacutus	White-throated needletail^	V, M	7,153.28	4,362.80	2,790.48	0.00	427.35	226.16	201.19	0.00
Lathamus discolor	Swift parrot	CE	2,564.48	1,763.86	0.00	800.62	189.01	180.47	0.00	8.54
Rostratula australis	Australian painted snipe	E	272.32	0.00	N/A	272.32	8.90	0.00	N/A	8.90
Turnix melanogaster	Black-breasted button-quail	V	404.36	19.18	N/A	385.18	9.18	0.00	N/A	9.18
Mammals										
Dasyurus maculatus maculatus	Spotted-tail quoll	E	2,126.30	1,662.16	N/A	464.14	153.99	129.53	N/A	24.46
Petauroides volans	Greater glider	V	1,449.53	1,449.53	N/A	0.00	109.05	109.05	N/A	0.00
Petrogale penicillata	Brush-tailed rock-wallaby	V	10.75	10.75	N/A	0.00	0.00	0.00	N/A	0.00
Phascolarctos cinereus	Koala	V	3,997.55	1,155.61	N/A	2,841.94	259.61	70.60	N/A	189.01
Potorous tridactylus tridactylus	Long-nosed potoroo	V	1,724.10	1,724.10	N/A	0.00	156.25	156.25	N/A	0.00
Pseudomys novaehollandiae	New Holland mouse	V	1,716.92	1,716.92	N/A	0.00	156.25	156.25	N/A	0.00

Species name	Common name	EPBC Act status	Predicted habitat within the MNES study area (ha)*				Predicted habitat within the Project disturbance footprint (ha)*			
			Total habitat	Potential habitat	Important habitat	Habitat critical to the survival of the species	Total habitat	Potential habitat	Important habitat	Habitat critical to the survival of the species
Pteropus poliocephalus	Grey-headed flying-fox	V	2,790.60	0.00	N/A	2,790.60	201.19	0.00	N/A	201.19
Reptiles										
Anomalopus mackayi	Five-clawed worm-skink	V	43.10	41.26	1.84	0.00	0.00	0.00	0.00	0.00
Delma torquata	Collared delma	V	2,376.80	0.00	2,376.80	0.00	197.41	0.00	197.41	0.00
Furina dunmalli	Dunmall's snake*	V	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tympanocryptis condaminensis	Condamine earless dragon	E	371.37	371.37	N/A	0.00	16.22	16.22	N/A	0.00
Fish										
Maccullochella peelii	Murray cod	V	168.09	0.00	N/A	168.09	3.21	0.00	N/A	3.21

Table notes:

CE = Critically endangered E = Endangered V = Vulnerable M = Migratory
^ = Aerial species, all “air-space” above the Project may be considered habitat. However, these areas will remain unimpacted by the project. This species has not been subject to impact assessment.
* = No value (i.e. 0) represent areas where habitat modelling has indicated that no predicted habitat has been identified within a particular area. For these species, impact assessment has not occurred although their habitat requirements and ecology has been considered through the modelling process (refer Appendix A and Appendix B)

4.4.4 Flora and fauna habitat located within the matters of national environmental significance study area

A total of eight broad fauna habitat types have been identified within the MNES study area. The broad habitat types were delineated by grouping vegetation communities according to their vegetative structure, composition, and geomorphological characteristics. The condition of the various habitat types was derived from Project EIS field investigations, aerial photograph interpretation, RE mapping, relevant database searches, and previous experience within the MNES study area.

The MNES study area is characterised by non-remnant vegetation comprised of cleared pastures and cropping in the west and larger, contiguous extents of remnant vegetation in the east. The ecological value of these habitat varies depending on extant land use and its intensity. Whilst highly fragmented areas of regrowth native vegetation occur within the eastern portion of the Project disturbance footprint, mature eucalypt open forest and woodland is the dominant forest/woodland habitat type in the MNES study area. Although fragmented, relatively large continuous areas of remnant forest/woodland are concentrated in the central portion of the Project disturbance footprint, on the eastern face of the Toowoomba Range, although the Toowoomba Bypass alignment represents an existing barrier to wildlife movement in a north/south direction.

Mature eucalypt open forest and woodland is the dominant forest/woodland habitat type in the MNES study area. Areas of remnant forest/woodland range in size from small fragments less than 1 ha in size, which are often degraded as a result of weed invasion and structural simplification, to larger areas of forest/woodland greater than 130 ha in size. In addition, non-remnant linear vegetation along roadsides and drainage lines, regrowth vegetation and isolated paddock trees form a variegated landscape mosaic in an otherwise fragmented environment.

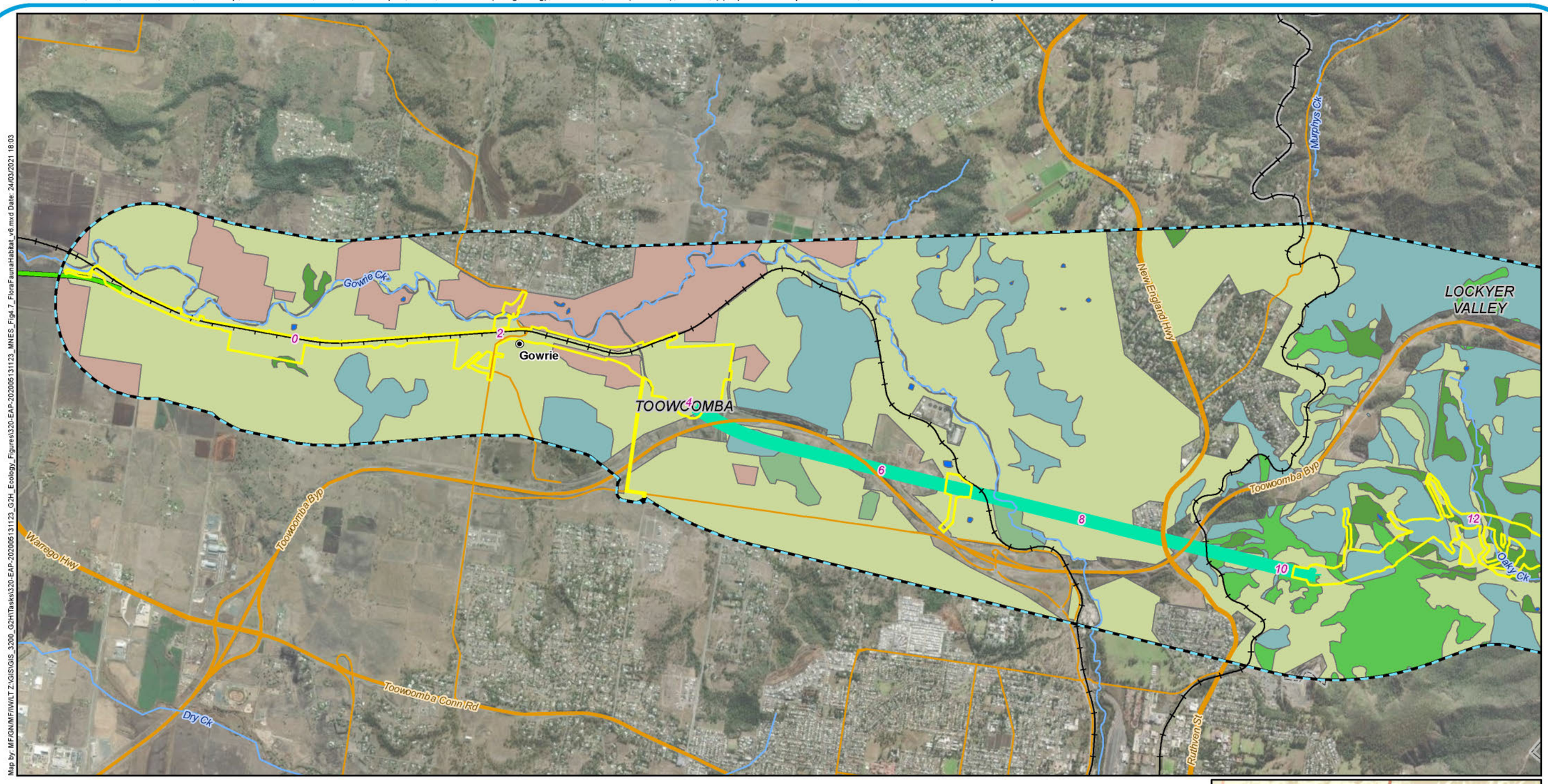
Each broad habitat type is discussed in further detail below and shown in Figure 4.7a-b. The following sections denote the State-based vegetation communities (REs) associated with the broad habitat types discussed. For detailed descriptions of the REs please refer to Appendix A within Appendix A of this report: Predictive habitat modelling methodology. An analysis of the quantity of fauna habitat contained within the MNES study area and within the Project disturbance footprint is presented in Table 4.6.

Table 4.6 Extent of flora and fauna habitat located within the matters of national environmental significance study area

Flora and fauna habitat type (refer Figure 4.7)	Analogous Regional Ecosystems (REs)	Extent (ha)	
		MNES study area	Project disturbance footprint
Mature eucalypt open forest and woodland (on sedimentary and igneous rocks and on basalt derived and alluvial plains)	REs 11.8.2a, 11.8.4, 11.8.5, 11.8.5a, 11.8.8, 12.3.3, 12.5.6, 12.8.14, 12.8.14a, 12.8.17, 12.9-10.2, 12.9-10.5a, 12.9-10.17, 12.9-10.17a	1,610.38 (20.91% of study area)	99.05 (21.68% of disturbance footprint)
Mature eucalypt riparian woodland	RE 11.3.25, 12.3.7	214.68 (2.79% of study area)	4.23 (0.93% of disturbance footprint)
Lowland Rainforest /Semi-evergreen vine thicket /wet sclerophyll forest	REs 12.8.9, 12.8.21, 12.9-10.15	170.25 (2.21% of study area)	7.5 (1.64% of disturbance footprint)
Regrowth Communities	High value regrowth (Category C) (excl. some developed areas)	847.47 (11.00% of study area)	90.04 (19.71% of disturbance footprint)
Grassland	REs 11.3.21, 11.8.11	3,432.16 (44.57% of study area)	212.67 (46.55% of disturbance footprint)
Wetlands	Other areas included mapped wetlands	37.38 (0.49% of study area)	0.19 (0.04% of disturbance footprint)
Waterways	Other areas including mapped waterways	24.44 (0.32% of study area)	0.87 (0.19% of disturbance footprint)

Flora and fauna habitat type (refer Figure 4.7)	Analogous Regional Ecosystems (REs)	Extent (ha)	
		MNES study area	Project disturbance footprint
Cultivated land	Non-remnant areas subject to anthropogenic impacts	400.14 (5.20% of study area)	11.92 (2.61% of disturbance footprint)
No Habitat present	Non-remnant areas including quarries and existing disturbance devoid of habitat	963.32 (12.51% of study area)	30.36 (6.65% of disturbance footprint)
Total area		**7,700.22**	**456.81**

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Map by: MF/GN/MF/IW/LT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-202005131123_G2H_Ecology_Figures\320-EAP-202005131123_MNES_Fig4.7_FloraFaunaHabitat_v6.mxd Date: 24/03/2021 18:03

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Fauna habitat

- Cultivated land
- Grassland
- Lowland Rainforest / Semi-evergreen vine thicket / wet sclerophyll forest
- Mature eucalypt open forest and woodland
- Mature eucalypt riparian woodland
- Regrowth
- Waterways
- Wetlands
- No habitat value present



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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Gowrie to Helidon

Figure 4.7a: Location of habitat types contained within the MNES study area

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

Map by: MF/GN/MF/NV/LT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_MNES_Fig4.7_FloraFaunaHabitat_v6.mxd Date: 24/03/2021 18:03

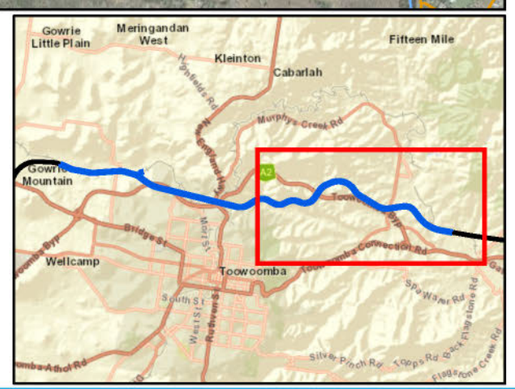
Toowoomba Byp
Oaky Ck
LOCKYER VALLEY
TOOWOOMBA
Six Mile Ck
Little Oaky Ck
Gatton Ck
Withcott
Lockyer Ck
Murphys Ck
Alice Ck
Rocky Ck
Toowoomba Conn Rd
Warrego Hwy
Helidon
12
14
16
18
20
22
24
26

Legend

- 5 Chainage (km)
- Localities
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- MNES study area
- Local Government Areas

Fauna habitat

- Cultivated land
- Grassland
- Lowland Rainforest / Semi-evergreen vine thicket / wet sclerophyll forest
- Mature eucalypt open forest and woodland
- Mature eucalypt riparian woodland
- Regrowth
- Waterways
- Wetlands
- No habitat value present



A3 scale: 1:40,000
0 0.5 1 1.5 2 2.5km

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Gowrie to Helidon

Figure 4.7b: Location of habitat types contained within the MNES study area

4.4.4.1 Mature Eucalypt open forest and woodland

On sedimentary and igneous rocks

This habitat is dominant in the Helidon Hills and the elevated areas associated with the Toowoomba Range. Areas of mature eucalypt open forest and woodland on sedimentary and igneous rocks within the MNES study area include areas dominated by Narrow-leaved ironbark (*Eucalyptus crebra*), Grey gum (*E. major*), White mahogany (*E. acmenoides*), Grey ironbark (*E. siderophloia*), Spotted gum (*Corymbia citriodora*), Brush box (*Lophostemon confertus*), and Swamp box (*L. suaveolens*). Many of these species provide foraging habitat for Koala (*Phascolarctos cinereus*), although Queensland bluegum (*E. tereticornis*) is particularly preferred. Examples of this habitat are shown in Photograph 4.6 and Photograph 4.7. Areas of remnant, mature eucalypt open forest and woodland within the MNES study area are represented by REs 12.5.6, 12.8.14, 12.8.14a, 12.8.17, 12.9-10.2, 12.9-10.5a, 12.9-10.7 and 12.9-10.17.

The condition and structure of these habitats varies greatly across the MNES study area, ranging from a simplified structure with sparse shrub and/or ground strata reflective of past land use and current management practices (logging, cattle grazing and vegetation thinning), to a complex vegetation structure with all strata (canopy, mid-storey and understorey) essentially intact. Invasive weeds including *Opuntia* species and Lantana (*Lantana camara*) were noted as commonly occurring in this habitat with dense infestations of Lantana observed in some areas. Important microhabitat refugia provided by this habitat type includes scattered tree hollows, hollow logs and termitaria (arboreal and terrestrial). Areas with abundant surface rocks will provide important shelter habitat for Collared delma (*Delma torquata*) (refer Photograph 4.7).



Photograph 4.6 Eucalypt forest on sedimentary rock in the MNES study area



Photograph 4.7 Eucalypt forest on sedimentary rock in the MNES study area

Canopy species present in this habitat type provide a range of trunk and limb hollows (of a variety of size classes) which potentially provide suitable habitat for Microchiropteran bats, gliders, possums, birds (including parrots, cockatoos and owls), arboreal snakes and monitors. Standing dead trees (stags) also provide roosting sites, nesting dens and breeding locations for a similar range of species. Where mature eucalypt open forest and woodlands (on sedimentary and igneous rock) occur as fragmented/isolated patches in largely cleared agricultural landscapes, they are somewhat restricted in their capacity to support woodland and forest species and are more likely to offer habitat value to transitional species and support mammal and bird species typical of disturbed areas. Canopy arthropods are relatively abundant in eucalypt forest and woodlands and provide a valuable foraging resource to birds and mammals. Eucalypt forests and woodlands also provide an important source of nectar, potential for threatened species such as Regent honeyeater (*Anthochaera phrygia*), Swift parrot (*Lathamus discolor*) and Grey-headed flying-fox (*Pteropus poliocephalus*). Red goshawk (*Erythrotriorchis radiatus*) may occur where there are extensive woodlands supporting an abundance of birds.

Areas of mature eucalypt open forest and woodland within the MNES study area may provide suitable habitat for a range of other MNES fauna species where appropriate habitat values are present for the species. The required habitat elements to support MNES species (e.g. large tree hollows, large fallen timber) are scattered throughout. Large tree hollows provide daytime resting habitat for arboreal species such as Greater glider (*Petauroides volans*). Long-nosed potoroo (*Potorous tridactylus tridactylus*) may occur where a dense understorey and grassy ground layer is present, including where *Lantana camara* has invaded. The presence of large rocks/cliffs may support habitat for Spotted-tail quoll (*Dasyurus maculatus maculatus*) and Brush-tailed rock wallaby (*Petrogale penicillata*), although no such habitat areas were observed within or near the Project disturbance footprint. Threatened flora species that may occur within this habit include Four-tailed grevillea (*Grevillea quadricauda*), Blunt-leaved leionema (*Leionema obtusifolium*), and Brush sophora (*Sophora fraseri*).

On basalt derived and alluvial plains

Areas of mature eucalypt open forest and woodland on alluvial plains within the MNES study area are limited in extent and include areas dominated by Queensland bluegum (*Eucalyptus tereticornis*) (refer Photograph 4.8 and Photograph 4.9). This habitat type exists on floodplains and creek flats within the MNES study area and generally exhibits low structural complexity, particularly at lower strata levels. Ground cover is typically low due to of livestock use, and the understorey very sparse with an open canopy of large Queensland bluegum (*Eucalyptus tereticornis*). Weed species present included Lantana (*Lantana camara*) (with areas of dense infestations), *Opuntia* species and Small-leaved privet (*Ligustrum sinense*). Areas of remnant eucalypt open forest and woodland (on alluvial plains) within the MNES study area are represented by REs 11.8.2a, 11.8.4, 11.8.5, 11.8.8 and 12.3.3.



Photograph 4.8 Mature eucalypt forest on alluvial plain in MNES study area



Photograph 4.9 Mature eucalypt forest on alluvial plain in MNES study area

However, mature eucalypt trees on basalt derived and alluvial plains are known to provide important habitat, such as food and shelter, for a range of fauna species including birds, mammals, and reptiles. Threatened flora species that may potentially utilise these areas include Hairy-joint grass (*Arthraxon hispidus*), Bluegrass (*Dichanthium setosum*), *Paspalidium grandispiculatum*, Hawkweed (*Picris evae*) and Austral toadflax (*Thesium australe*). In particular this is favoured habitat for Koala (*Phascolarctos cinereus*). In addition, threatened fauna species that may occur in eucalypt open forest and woodland on alluvial plains within the MNES study area include Regent honeyeater (*Anthochaera phrygia*), Swift parrot (*Lathamus discolour*) and Grey-headed flying-fox (*Pteropus poliocephalus*).

During the wet season this habitat type commonly floods temporarily, effectively becoming a wetland habitat (riverine wetland). When flooded this habitat type is suitable for a range of wetland bird species, including ducks, geese, grebes, snipe, crakes, rails, egrets, and herons. Threatened fauna species that may utilise flooded eucalypt open forest and woodland on basalt derived and alluvial plains may include the Australian painted snipe (*Rostratula australis*), although the species is more likely to occur on open wetlands.

It is important to note that the definition of open forest and woodland habitats applied here excludes riparian vegetation along watercourses which has been classified as the habitat type; mature eucalypt riparian open forest and woodlands.

4.4.4.2 Mature eucalypt riparian woodland

Eucalypt riparian open forest and woodlands within the MNES study area include open forests and woodlands dominated by Queensland bluegum (*Eucalyptus tereticornis*) fringing drainage lines with associated species including *Melaleuca* spp., Moreton Bay ash (*Corymbia tessellaris*), *Angophora* spp., and River-oak (*Casuarina cunninghamiana*) (refer Photograph 4.10 and Photograph 4.11). This habitat type occurs exclusively along the edge of rivers, creeks and vegetated drainage lines within the MNES study area. Mature eucalypt riparian open forest and woodlands within the eastern portion of the MNES study area is often structurally complex at all strata levels and potentially supports the greatest diversity of wildlife taxa per hectare. Riparian habitat within the western portion (such as along Gowrie Creek west of the Toowoomba Range) is in very poor condition with substantial canopy tree removal and weed invasion. This includes dense infestation by Lantana (*Lantana camara*), Asparagus fern (*Asparagus africanus*), Madeira vine (*Anredera cordifolia*) and Cat's claw creeper (*Dolichandra unguis-cati*). Areas of remnant *Eucalypt* riparian open forest and woodland within the MNES study area are represented by RE 12.3.7 and 12.3.25.



Photograph 4.10 Mature eucalypt riparian woodland in MNES study area



Photograph 4.11 Mature eucalypt riparian woodland in MNES study area

A range of fauna, including birds, mammals, and reptiles, utilise this habitat type for foraging, breeding, and dispersal. The movement corridors provided by this habitat type are important for structural connectivity, in otherwise fragmented landscapes.

Threatened flora species that may utilise these areas of habitat include Hairy-joint grass (*Arthraxon hispidus*), Bunya Mountains bluegrass (*Bothriochloa bunyensis*), and Wandering pepper-cress (*Lepidium peregrinum*). MNES fauna species that may occur in mature eucalypt riparian open forests and woodland include Regent honeyeater (*Anthochaera phrygia*), Red goshawk (*Erythrotriorchis radiatus*) where it occurs within extensive tracts of remnant vegetation, Swift parrot (*Lathamus discolor*) and Koala (*Phascolarctos cinereus*). Greater glider (*Petauroides volans*) may occur where riparian woodland remains adjacent to tracts of floodplain woodland.

4.4.4.3 Lowland rainforest /Semi-evergreen vine thicket

Areas of lowland rainforest/semi-evergreen vine thicket within the MNES study area include low microphyll vine forest and semi-evergreen vine thicket. Characteristic species include *Lophostemon confertus*, *Brachychiton rupestris*, *Flindersia collina*, *F. australis*, *Alectryon diversifolius*, *A. subdentatus*, *Elattostachys xylocarpa*, *Erythroxylum* sp., *Psydrax odorata forma buxifolia*, *Diospyros geminata*, *Planchonella cotinifolia*, *Croton insularis*, *Bridelia exaltata* and *Bursaria incana*. Weed species present included Lantana (*Lantana camara*), Asparagus fern (*Asparagus africanus*), and Cat's claw creeper (*Dolichandra unguis-cati*). This fauna habitat type is mapped as RE 12.8.9, 12.8.21 and 12.9-10.15 and occurs on Cainozoic and Mesozoic sediments along gullies and drainage lines in the Toowoomba Range and foothills (refer Photograph 4.12).

Structural complexity is typically very high within this habitat type, with a closed shrub layer, sub-canopy and canopy, with, or without emergent Hoop pine (*Araucaria cunninghamiana*). A broad range of microhabitat refugia are often present, including tree hollows, hollow logs, fallen coarse woody debris, extensive leaf litter layer, rock crevices, and dense vine thickets. Lowland rainforest/Semi-evergreen vine thickets within the MNES study area provides habitat to forest-dependent wildlife taxa, which prefer dense, undisturbed habitat. Fruiting trees are often abundant, providing important foraging habitat for frugivorous birds and bats.

Threatened flora species likely to utilise this habitat include Miniature moss-orchid (*Bulbophyllum globuliforme*) (where Hoop Pine occurs), Stream clematis (*Clematis fawcettii*), Waxy sarcochilus (*Sarcochilus hartmannii*), and Blotched sarcochilus (*Sarcochilus weinthalii*). Threatened fauna species potentially utilising these areas as habitat include Black-breasted button-quail (*Turnix melanogaster*), Long-nosed potoroo (*Potorous tridactylus tridactylus*), Spotted-tail quoll (*Dasyurus maculatus maculatus*) and the Grey-headed flying-fox (*Pteropus poliocephalus*).



Photograph 4.12 Semi-evergreen vine thicket vegetation in the MNES study area



Photograph 4.13 Regrowth vegetation in the MNES study area

4.4.4.4 Regrowth communities

Areas of regrowth vegetation are present throughout the MNES study area, although largely in the Toowoomba Range and the Helidon Hills. Extant patches of regrowth vegetation within the MNES study area range from poor to moderate ecological condition, with some areas suffering from extensive weed invasion and disturbance from cattle grazing practices (refer Photograph 4.13). However, in instances where patches contain large trees with hollows, the ecological value of these areas significantly increases. Areas of regrowth habitat may provide foraging and perching habitat value for transitional fauna species and suitable microhabitats. In addition, where large, isolated hollow bearing trees are present, these features may provide forage, nesting and denning sites for arboreal mammals and foraging habitat for Swift parrot (*Lathamus discolor*), Koala (*Phascolarctos cinereus*), and Grey-headed flying-fox (*Pteropus poliocephalus*).

4.4.4.5 Grassland

Grassland habitats within the MNES study area include non-native grasslands, derived native grasslands and remnant grassland the latter of which may be consistent with the *Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD* TEC (analogous to RE 11.3.21). Non-native grasslands are dominated by exotic pasture grasses and are represented by areas of non-remnant vegetation (excluding cultivated land), previously cleared of native-vegetation for agriculture. Dominant pasture grasses include Rhodes grass (*Chloris gayana*), Pigeon grass (*Setaria sphacelate*), Green panic (*Megathyrsus maximus*), and Sabi grass (*Urochloa mosambicensis*). However, native grass species that may also occur include Native rats-tail grass (*Sporobolus creber*), Forest bluegrass (*Bothriochloa bladhii*), Blue grass (*Dicanthium sericeum*), and Blady grass (*Imperata cylindrica*) and *Astrebla* species.

Derived native grasslands are dominated by native grass species and are represented by areas of non-remnant vegetation (excluding cultivated land), previously cleared of woody species (i.e. trees and shrubs) for agriculture. Dominant grass species within these areas include Queensland panic (*Panicum queenslandicum*), Forest bluegrass (*Bothriochloa bladhii*), Bluegrass (*Dichanthium sericeum*), Digitaria (*Digitaria divaricatissima*), and Pitted bluegrass (*Bothriochloa decipiens*). However, exotic pasture grasses sometimes occur, such as Rhodes grass (*Chloris gayana*) (refer Photograph 4.14 and Photograph 4.15).



Photograph 4.14 Grassland habitat in the MNES study area



Photograph 4.15 Grassland habitat in the MNES study area

Non-native and native derived grasslands are considered as one fauna habitat type due to similarities in structure and floristics. Grassland is the most extensive fauna habitat within the MNES study area and is typically located on alluvial floodplains and creek flats. These grassland habitats are commonly utilised for agricultural purposes including livestock grazing and fodder harvesting.

Threatened flora species that may occur in this habitat type include King blue-grass (*Dichanthium queenslandicum*), Bluegrass (*Dichanthium setosum*), Wandering pepper-cress (*Lepidium peregrinum*), *Paspalidium grandispiculatum*, Hawkweed (*Picris evae*), Austral toadflax (*Thesium australe*) and Austral cornflower (*Rhaponticum australe*), particularly where grasslands are located on basalt derived (black) soils.

Grassland within the MNES study area provides foraging habitat for granivorous bird species such as finches, parrots and pigeons. Grassland habitats also provide important microhabitat refugia (i.e. soil cracks) for small ground fauna such as native rodents, skinks, and snakes. Scattered paddock trees occur across many grassland habitats, providing fauna habitat and connectivity in otherwise cleared and fragmented landscapes. Threatened fauna species that may utilise grassland habitat within the MNES study area include Condamine earless dragon (*Tympanocryptis condaminensis*) and Five-clawed worm-skink (*Anomalopus mackayi*) where black cracking clay soils occur. Furthermore, grassland may provide temporary habitat or refuge for migratory bird species when flooded.

4.4.4.6 Wetlands

Wetland habitats within the MNES study area include dams and reservoirs (lacustrine), and wetlands associated with the floodplains of watercourses (riverine). Wetland habitat encompasses a very minor portion within the Project disturbance footprint (0.19 ha). Artificially created wetlands (i.e. farm dams), which are abundant across agricultural landscapes, are included as they potentially provide suitable wetland alternatives for vertebrate fauna. Riverine wetlands associated with floodplains are ephemeral and typically vegetated by a mixture of native and non-native grasses and grass-like plants, and Queensland bluegum (*Eucalyptus tereticornis*). There are no mapped palustrine wetland REs within the MNES study area. Temporary flooded areas may occur on alluvial floodplains (refer Photograph 4.16 and Photograph 4.17).



Photograph 4.16 Wetland habitat in the MNES study area



Photograph 4.17 Wetland habitat in the MNES study area

Wetland habitats within the MNES study area are considered to provide suitable habitat for a variety of fish, amphibian, reptile (including turtles) and bird species. Larger wetlands potentially may provide important refuge habitat for many bird species, including dispersive species. MNES fauna species that may utilise wetland habitats within the MNES study area include the Australasian bittern (*Botaurus poiciloptilus)* and Australian painted snipe (*Rostratula australis*) although both of these species are reliant on the presence of dense vegetation either aquatic (in the case of the bittern) or as nearby cover (for snipe). It is noted farm dams are less likely to provide these habitat elements and floodplain wetlands are highly ephemeral. At the time of the EIS field surveys the study region had undergone an extended dry period with no water available on floodplain wetlands. Curlew sandpiper (*Calidris ferruginea*) may occasionally occur on larger dams in the region with shallow muddy areas for foraging habitat (such as Lake Cooby north of Gowrie).

There are 6.59 ha of State mapped wetlands (as mapped by DES) considered as ‘high ecological value’ (HEV) wetlands that occur within the MNES study area (upstream of drainage lines associated with Lockyer Creek), of which none lies within the current disturbance footprint and will not be directly impacted from activities associated with the Project.

Other wetland values within the MNES study area are represented through aquatic conservation assessment modelling. The catchment aquatic conservation assessment indicates a skew towards higher value riverine wetlands throughout both the Lockyer Creek and Condamine River Basin catchments, indicating the presence of sensitive wetlands throughout both catchments. No spring fed wetlands mapped on the QLD wetland mapping layer were identified within the MNES study area. Further information regarding wetland values are provided in EIS Appendix I: Terrestrial and aquatic ecology technical report.

4.4.4.7 Riparian zones/waterways

Riparian zones are an interface between terrestrial and aquatic ecosystems and also play a vital role supporting biodiversity. Healthy, native riparian vegetation reduces the water temperature of aquatic habitats by shading. When water temperature increases dissolved oxygen levels decrease, creating conditions which are difficult to endure for poikilothermic animals whose metabolic rates may exceed available oxygen in the rising temperatures. More sunlight in the riparian zone also increases the growth of soft leaved vigorous weeds and algae that can choke the stream channel.

In addition, riparian zones within the MNES study area, typically contain well developed vegetation communities and complex structural components (i.e. well-developed canopy, sub-canopy, shrub and ground layers) which provides important habitat for smaller species such as insectivorous birds, reptiles and mammals. In addition, proximity to permanent water sources also increases the importance of these areas as habitat. Within these zones, threatened aquatic fauna with a minor potential to occur includes Murray cod (*Maccullochella peeli peeli*). The species only has potential to occur in Gowrie Creek as other waterways are located outside of the distribution of the species. It is noted Gowrie Creek occurs within a very highly modified landscape within the MNES study area and aquatic habitat assessments recorded poor habitat values for supporting the species occurrence. In addition, some flora species associated with drainage systems and include species such as Hairy-joint grass (*Arthraxon hispidus*).

Vegetation associated with riparian zones provides an important role in facilitating fauna movement in otherwise fragment environments and as such are pivotal in the movement of genetic material within populations and ecosystems and ensures correct ecosystem function and processes are maintained.

Aquatic habitat values were assessed across a 100 m assessment reach at 10 riparian sites within the MNES study area including Lockyer Creek, Gowrie Creek, and Rocky Creek. The habitat assessment scores noted that most of the aquatic habitat across the MNES study area was typically in fair condition. Gowrie Creek demonstrated the poorest physical habitat site condition while higher physical habitat site condition was noted from Rocky Creek and Lockyer Creek. Further information regarding riverine habitat values is provided in EIS Appendix I: Terrestrial and aquatic ecology technical report.

4.4.4.8 Cultivated land

Small areas of cultivated land exist within the MNES study area, including irrigated and dryland crops, stubble fields and fallow fields. Common crops include sorghum, winter cereals, vegetables and legumes. The availability of soil cracks and other microhabitat refugia is greatly reduced by soil cultivation. Cultivated land typically occurs in low-lying areas on fertile clays and provides habitat for generalist bird species such as Torresian crow (*Corvus orrus*), Australian magpie (*Gymnorhina tibicen*), and Little corella (*Cacatua sanguinea*). Non-native fauna species are typically abundant in cultivated land habitats, including restricted matters (Category 3 invasive animals) such as Red deer (*Cervus elaphus*) and European rabbit (*Oryctolagus cuniculus*).

4.5 Matters of national environmental significance values and matters of national environmental significance

4.5.1 Ecological values

Consistent with the relevant legislation as stated in Section 2 of this report, the overarching ecological values adopted for the MNES study area, include:

- Australia's natural environmental and native flora and fauna
- Finite natural resources, including conservations parks, and wetlands
- Land conducive to the maintenance of existing landforms, ecological health, biodiversity, riverine and wetland areas
- Biodiversity.

4.5.2 Matters of national environmental significance

For the identified MNES, predictive habitat mapping has been used to assess the species potential to occur within the MNES study area (refer Appendix A). Based on this mapping there is the potential for 36 threatened species under the EPBC Act to inhabit the MNES study area including 16 species of plants, nine species of birds, seven species of mammals, three species of reptile and a species of fish. Mapping associated with this process is presented in Appendix G and the area of predicted habitat contained within the MNES study area and within the Project disturbance footprint is provided in Table 4.5. In instances where species/communities did not have *Potential habitat* contained within the MNES study area, these species were not subject to impact assessment and were no longer considered to constitute receptors as the risk of impacts to any of these species are considered low. The MNES identified within the MNES study area are listed in Table 4.7 along with their assigned sensitivity value as determined by Table 3.8.

Table 4.7 Identified terrestrial and aquatic ecology receptors within the matters of national environmental significance study area

Associated ecological value	Identified MNES	Assigned sensitivity (refer Table 3.8)	Justification
▪ Australia's natural environment and native flora and fauna ▪ Biodiversity	EPBC Act listed TECs: ▪ Lowland Rainforest of Subtropical Australia ▪ Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD ▪ White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland – Critically Endangered	High	▪ Protected by Commonwealth legislation ▪ Important for biodiversity ▪ Rare ▪ High sensitivity, high exposure to impacts
	Threatened terrestrial flora and fauna species listed under the provisions of the EPBC Act (including habitat): **Flora** ▪ Hairy-joint grass (*Arthraxon hispidus*) ▪ Bunya Mountains bluegrass (*Bothriochloa bunyensis*) ▪ Miniature moss-orchid (*Bulbophyllum globuliforme*) ▪ Stream clematis (*Clematis fawcettii*) ▪ King blue-grass (*Dichanthium queenslandicum*) ▪ Bluegrass (*Dichanthium setosum*) ▪ Four-tailed grevillea (*Grevillea quadricauda*) ▪ Blunt-leaved Leionema (*Leionema obtusifolium*) ▪ Wandering pepper-cress (*Lepidium peregrinum*) ▪ *Paspalidium grandispiculatum* ▪ Hawkweed (*Picris evae*) ▪ Austral cornflower (*Rhaponticum australe*) ▪ Waxy sarcochilus (*Sarcochilus hartmannii*) ▪ Blotched sarcochilus (*Sarcochilus weinthalii*) ▪ Brush sophora (*Sophora fraseri*) ▪ Austral toadflax (*Thesium australe*) **Fauna** ▪ Regent honeyeater (*Anthochaera phrygia*) ▪ Australasian bittern (*Botaurus poiciloptilus*) ▪ Curlew sandpiper (*Calidris ferruginea*) ▪ Red goshawk (*Erythrotriorchis radiatus*)	High	▪ Protected by Commonwealth legislation ▪ Rare ▪ High sensitivity, high vulnerability

Associated ecological value	Identified MNES	Assigned sensitivity (refer Table 3.8)	Justification
	■ Grey falcon (*Falco hypoleucos*) ■ Painted honeyeater (*Grantiella picta*) ■ Swift parrot (*Lathamus discolor*) ■ Australian painted snipe (*Rostratula australis*) ■ Black-breasted button-quail (*Turnix melanogaster*) ■ Spotted-tail quoll (*Dasyurus maculatus maculatus*) ■ Brush-tailed rock-wallaby (*Petrogale penicillata*) ■ Koala (*Phascolarctos cinereus*) ■ Long-nosed potoroo (*Potorous tridactylus tridactylus*) ■ New Holland mouse (*Pseudomys novaehollandiae*) ■ Grey-headed flying-fox (*Pteropus poliocephalus*) ■ Greater glider (*Petauroides volans*) ■ Five-clawed worm-skink (*Anomalopus mackayi*) ■ Collared delma (*Delma torquata*) ■ Condamine earless dragon (*Tympanocryptis condaminensis*) ■ Murray cod (*Maccullochella peelii*)		

5 Potential impacts and impact mitigation

Potential Project related impacts are described in the sections below. These impacts are then assessed against the identified MNES, with initial mitigation considered as part of 'initial impact mitigation' impact assessment. Project mitigation measures are then used to re-assess the significance of impact to determine residual risk of impact with all mitigation in place is also provided within this section.

Through information gathered during the Project EIS process, MNES within the receiving environment which have the potential to be subject to significant impacts, have been identified. Mitigation measures have been developed to reduce the potential magnitude of impacts. Impact assessment methods to be adopted, depending on the nature of the environmental value being assessed, are described in Section 5.1.3.

5.1 Description of potential impacts

5.1.1 Project activities

Infrastructure activities proposed as part of the Project have been categorised into construction, commissioning and reinstatement and operations. A description of Project related activities and the duration of their disturbance is provided in Table 5.1.

Table 5.1 Description of Project related activities associated with Project delivery

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.7 for definitions)
Construction	Site preparation	Vegetation clearing	Permanent
		Topsoil stripping	Medium term/Permanent
		Construction of temporary site compounds	Medium term
		Construction of rail access roads	Permanent
		Installation of boreholes and construction water storage	Medium term
		Installation of offices, hardstands etc	Medium term
		Stockpiling	Medium term
		Artificial impoundment dewatering	Permanent
	Utility diversions (excluding enabling works)	Excavation	Temporary
		Trenching	Short term
		Modification, diversion and realignment of utilities and associated infrastructure	Short term/Medium term
	Drainage	Culvert installation	Medium term
	Structures	Construction of bridges over main waterways	Medium term
		Road/rail bridge construction	Medium term
	Civil works	Cutting construction	Medium term
		Embankment construction using cut to fill from rail alignment and borrow to fill from external borrow sources, where required	Medium term
		Construction of temporary haul roads	Medium term
		Drainage controls	Medium term
	Road works	Road realignment	Permanent
		Construction of permanent rail maintenance access roads	Permanent

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.7 for definitions)
	Rail logistics	Sleeper stockpiling	Medium term
		Rail stockpiling	Medium term
	Rail construction	Drilling	Temporary
		Ballast installation	Short term
		Sleeper placement	Short term
		Rail placement	Short term
		Installation Train signals and communications infrastructure	Short term
		Demobilising site compounds	Short term
	Tunnel construction	Removal of construction material and waste	Temporary
		Roadheader excavation	Short term
		Blasting	Temporary
		Removal of redundant structures	Temporary
		Decommissioning work site signs	Temporary
		Decommissioning access roads	Short term
		Forming and stabilising of spoil mounds	Short term
	Signals and communications installation	Removal of temporary fencing	Temporary
Commissioning and reinstatement	Demobilisation/ reinstatement	Establish permanent fencing	Permanent
		Restoration of disturbed areas, including revegetation where required	Short term
	Spoil mounds	Conversion of haul roads and construction access roads into permanent roads	Medium term
	Fencing	Train services	Permanent
	Restoration	Minor maintenance works	Temporary
	Road works	Bridge and culvert inspections	Temporary
		Sleeper replacement	Temporary
		Rail welding	Temporary
		Rail grinding	Temporary
		Ballast dropping	Temporary
		Track tamping	Temporary
		Major periodic maintenance	Temporary
Operation	Train operations	Train movement along rail	Permanent
	Operational maintenance	Ongoing vehicle movement within rail corridor	Permanent

5.1.2 Potential impacts to matters of national environmental significance

5.1.2.1 Habitat loss and degradation from vegetation clearing/removal

The Project disturbance footprint encompasses a total of 456.81 ha. Under current QLD Government (DNRME) vegetation mapping 112.81 ha of remnant vegetation and 104.18 ha of high-value regrowth vegetation (HVR) is present within the Project disturbance footprint (refer EIS Appendix I: Terrestrial and aquatic ecology technical report). The remaining 239.82 ha (52.5 per cent of the Project disturbance footprint) has been largely heavily modified (clearing for agriculture/urban development, especially in the Gowrie area).

The removal of vegetation and construction of linear infrastructure resulting in habitat loss is likely to pose the largest risk of adverse impacts for biodiversity arising from the Project. The impact may be direct in the form of vegetation and habitat removal, or indirect, as fauna and flora diversity may become reduced due to shortages in available habitat resources. Habitat loss and degradation can also occur due to the increased risk of fire during construction and maintenance activities. Small-scale clearing within largely intact patches of vegetation can cause localised depletion of some species (Kutt et al. 2012) and is particularly relevant to species with small home ranges, or reduced ability to disperse (e.g. *Delma torquata*). Vegetation clearing, and habitat loss are likely to occur during the construction phase activities.

Habitat loss and degradation has the potential to impact upon all MNES (including their associated habitats) identified in this assessment. Of the threatened species identified, the greatest amount of predicted habitat to be removed by the Project (refer Table 4.5) is to the following:

- *Paspalidium grandispiculatum* (a grass) – 156.25 ha of potential habitat
- Austral cornflower (*Rhaponticum austral*) – 63.02 ha of potential habitat
- Brush sophora (*Sophora fraseri*) – 31.05 ha including 2.36 ha of critical habitat
- Regent honeyeater (*Anthochaera phrygia*) – 156.25 ha of potential habitat
- Red goshawk (*Erythrotriorchis radiatus*) – 88.77 ha including 84.79 ha of critical habitat
- Grey falcon (*Falco hypoleucos*) – 211.69 ha including 66.13 ha of critical habitat
- Swift parrot (*Lathamus discolour*) – 189.01 ha including 8.54 ha of critical habitat
- Spotted-tail quoll (*Dasyurus maculatus maculatus*) – 153.99 ha including 24.46 ha of critical habitat
- Greater glider (*Petauroides volans*) – 109.05 ha of potential habitat
- Koala (*Phascolarctos cinereus*) – 259.61 ha including 189.01 ha of critical habitat
- Long-nosed potoroo (*Potorous tridactylus tridactylus*) – 156.25 ha of potential habitat
- New Holland mouse (*Pseudomys novaehollandiae*) – 156.25 ha of potential habitat
- Grey-headed flying-fox (*Pteropus poliocephalus*) – 201.19 ha of critical habitat
- Collared delma (*Delma torquata*) – 197.41 ha of important habitat.

Whist it is acknowledged that the SEQ and Brigalow Belt bioregions exist in a highly modified state and potential vegetation removal associated with the Project is considered to be relatively small when compared to historical broad scale vegetation clearing that has occurred in the region for agricultural purposes, this does not diminish the significance of such loss. Vegetation clearing and habitat loss that cannot be avoided, particularly in high constraint areas, is likely to result in permanent impacts to threatened biodiversity values, including the adversely impact the viability of an existing population already impact by historic activities.

5.1.2.2 Fauna species injury or mortality

Physical trauma to fauna is a direct impact that has the potential to reduce local population size and has the potential to create "source/sink" dynamic, but this may not necessarily alter population size (Furrer and Pasinelli 2016). However, changes in the mortality rate can affect population viability and may be a critical factor in a fragmented landscape where population sizes are fairly small and/or poorly connected. The impact of mortality on population viability is particularly pronounced for longer-lived, slow breeding species, such as the Koala (*Phascolarctos cinereus*) (i.e. K-selected species) and is less pronounces in those that are R-selected (e.g. those species with larger reproductive outputs and shorter lifespans) (Oli 2004).

Physical trauma to fauna is a direct impact that reduces local population numbers. Physical trauma to MNES fauna has the potential to occur during all phases of the Project with the highest potential likelihood during construction activities that involve vegetation clearing, earthworks, trenching and increased labour force in the fields (through the movement of vehicles). Species most at risk of injuries and mortality are those that are cryptic, difficult to detect and with poorly developed dispersal mechanisms (e.g. Collared delma (*Delma torquata*)). However, larger species with defined territories and movement patterns (e.g. Greater glider (*Petauroides volans*), and Koala (*Phascolarctos cinereus*)) are less likely to be at risk to direct mortality where appropriate mitigation measures are applied (i.e. pre-clearance surveys, temporary and permanent exclusion fencing and the use of fauna spotters during clearing).

This potential impact will be proportionate to the extent of vegetation and habitat potential for species that is removed and has the potential to impact MNES, including threatened fauna species listed under the provisions of the EPBC Act.

Some listed diurnal (active during the day) and mobile species, such as listed birds, may move away from areas being disturbed (i.e. vegetation removal) and may not be adversely impacted in terms of direct physical trauma unless fauna are nesting. However, other listed species that are less mobile (i.e. ground-dwelling reptile, mammal species and aquatic species), or those that are nocturnal and nest or roost in tree or tree hollows during the day (i.e. arboreal mammals such as listed gliders and Koala), may find it difficult to move away from roosts or active breeding places.

There is the potential for fauna injury or mortality during all phases of the Project through vehicle collision, but particularly when high volumes of vehicle activity occur or during the operational stages of the rail. Vehicle collision is a direct impact that reduces local population numbers and is a common occurrence in Australia (Coffin 2007; Rowden et al. 2008). The development of temporary construction tracks, as well as the general use of permanent access tracks and roads across the Project disturbance footprint will result in increased vehicle movements that may cause injury or death to fauna by vehicle strike. In addition, once operational, train strike may also occur. Mammals, reptiles, amphibians and birds are all at risk of vehicle strike, particularly common species (e.g. macropods) that are tolerant of disturbance and/or those species that can utilise roads for movement pathways or as foraging habitat.

In addition, entrapment of wildlife in utility diversions (e.g. trenches) or other excavations associated with the Project may also cause physical trauma to fauna. For example, open trenches for underground utilities, or other pits are known to be effective at trapping a wide variety of wildlife and often result in mortality (Ayres and Wallace 1997; Doody et al. 2003; Woinarski et al. 2006). Species most likely to become trapped in pits or other excavations during construction of the Project are ground dwelling species that are capable of moving across modified areas (e.g. Collared delma (*Delma torquata*), Long-nosed potoroo (*Potorous tridactylus tridactylus*) and the New Holland mouse (*Pseudomys novaehollandiae*)) and arboreal, which descend to the ground to disperse such as Koala (*Phascolarctos cinereus*).

Given the nature of the Project, there is potential for some species such as the Greater glider (*Petauroides volans*) to be struck by trains during periods of dispersal and movement (e.g. whist gliding over the alignment). This may be the case where the alignment is at ground level and traverses through predicted habitat on either side of the corridor (i.e. not in locations of high embankments, bridges or cuttings).

Aquatic fauna may be injured or killed during construction within waterways, such as the construction of culverts and bridges and associated temporary impoundments required during construction. Species most susceptible to death or injury include smaller and/or sessile species such as freshwater invertebrates. Species such as Murray cod are less likely to be at risk to direct mortality where appropriate mitigation measures are applied (e.g. fish salvage activities as part of temporary dewatering events).

The unmitigated potential occurrence of fauna species injuries or mortalities resulting from the Project can be permanent, where mortality to the species occurs, or temporary where the species is rehabilitated and re-released (refer Table 3.7 for definitions associated with timeframes).

5.1.2.3 Reduction in biological viability of soil to support plant growth due to soil compaction

Compaction of soil as a result of the Project activities may result in direct impacts to soil consistence (i.e. the strength and coherence of a soil) and soil structure (i.e. the arrangement of soil particles). Changes to soil consistence and structure can affect the productive capacity of the soil for agricultural practices, the suitability of the soils for various land uses, how the soil and landscape will respond to management practices, and the flow paths by which water moves within the soil and landscape (Fitzpatrick et al 1999).

Reduction in soil viability may negatively impact threated flora such as Hairy-joint grass (*Arthraxon hispidus*), King blue-grass (*Dichanthium queenslandicum*), Bluegrass (*Dichanthium setosum*), Hawkweed (*Picris evae*), Austral cornflower (*Rhaponticum australe*), Brush sophora (*Sophora fraseri*) and Austral toadflax (*Thesium australe*). Impacts to soil may also have flow on effects to other threatened fauna species through degradation of their associated habitat.

The most direct effect of soil compaction is an increase in the bulk density of soil which can restrict plant root growth and function. Due to the increase in bulk density, large pores essential for water and air movement in soil are primarily affected. This influence over water and air movement can impact root penetration, seedling emergence and plant growth (Fitzpatrick et al 1999; Duiker 2005). This will act directly upon recruitment processes and may impact upon a species/communities ability to recolonise following disturbance.

Soil biota may also be affected by compaction, for example earthworm numbers and activity can be reduced in compacted soils and compaction may impact upon the growth of fungi that are a potential food source for threatened species such as the Long-nosed potoroo (*Potorous tridactylus tridactylus*). In addition, water infiltration and percolation are slower in compacted soils, thereby inhibiting root growth, leading to the potential reduced uptake of immobile nutrients such as phosphorus and potassium; and increased nitrogen losses can be expected because of prolonged periods of saturated conditions in compacted soils.

The unmitigated potential impacts of soil compaction resulting from the Project are generally short term and temporary (refer Table 3.7 for definitions associated with timeframes).

5.1.2.4 Displacement of threatened flora and fauna species by invasion of weed and pest species

Weed and pest species have the potential to impact on terrestrial and aquatic biodiversity as native species can become displaced through predation and competition. Pest species can also damage native vegetation by grazing and trampling (Adair and Groves 1998; Clarke et al 2000; Thorp and Lynch 2011) or through direction competition/predation (e.g. *Gambusia holbrooki* within aquatic ecosystems). Therefore, weed and pest species may reduce the extent of available habitat and hence population size for specific threatened species. This may have the effect of increasing mortality and reducing the size and viability of population sizes though resource limitation and associated stresses.

Proliferation of weed and pest species is an indirect impact (i.e. not a direct result of the Project activities) that may have cumulative effects as each Project activity, as well as agricultural practices and other resource Project activities, may act in conjunction to increase the chances of weed and pest proliferation throughout the Project disturbance footprint and adjoining areas. Proliferation of weed and pest species has the potential to occur during all phases of the Project, especially during the construction phase, however the highest likelihood of weed and pest species occurring is from vegetation clearing and soil disturbance from local agricultural land practices.

The effects of proliferation of weed and pest species may not be noticeable immediately or even in the short-term, as visible signs may take several months or seasons to impact on ecological MNES. These potential impacts are likely to be long-term and affect all ecological MNES in the Project disturbance footprint, including affecting the quality and integrity of TECs, remnant vegetation, habitat for threatened species, wetlands and waterways.

Non-native species comprised 26 per cent of the flora species recorded in the MNES study area (refer Appendix E). Of these, 17 flora species were restricted matters, listed under the provisions of the Biosecurity Act 2014 (Qld). Weed species such as Lantana (*Lantana camara*) are noted as a potential threat to a number of MNES species (e.g. *Grevillea quadricauda*). Lantana was identified as common throughout the MNES study area with dense infestations in some areas. Other common species included Climbing asparagus fern (*Asparagus africanus*), Small-leaved privet (*Ligustrum lucidum*), Creeping lantana (*Lantana montevidensis*) and *Opuntia* species. Without appropriate management strategies, the Project activities have the potential to disperse weeds into areas of remnant vegetation where weed species are currently limited, occur in low densities, or into MNES habitat for species with highly specific habitat requirements where weed encroachment has been identified as a threatening process (e.g. Collared delma - *Delma torquata*). However, pest and weed invasion may benefit some species some MNES by supplying an abundant food source which would otherwise be unavailable (e.g. non-native plants as a food source for the Brush-tailed rock-wallaby - *Petrogale penicillata*) or providing suitable sheltering and foraging habitat (Lantana for Black-breasted button-quail (*Turnix melanogaster*) and Long-nosed potoroo (*Potorous tridactylus tridactylus*)).

Project activities also have the potential to introduce new weed species into the MNES study area. The most likely causes of weed dispersal and introduction associated with the Project include earthworks, movement and disturbance of soil and attachment of seed (and other propagules) to vehicles and machinery during all phases. Weed dispersal by vehicles along access tracks and roads is a key source of weed invasion (Birdsall et al 2012). Weed invasion is an indirect impact that may degrade the quality of habitats, potentially resulting in habitat loss.

Soil disturbance during construction may increase the risk of invasion from weed and/or pest species, which can further reduce habitat quality and compromise the integrity of adjacent areas such as those occupied by the Lowland Rainforest TEC (refer Appendix B).

Large areas of the MNES study area have significant weed growth, particularly non-native grasses, which have been introduced as part of historic agricultural land use of the area. Therefore, the potential for habitat modification from weed invasion resulting from the Project is highest where Project activities take place in relatively intact areas, such as those identified as containing in-tact remnant vegetation that currently has low weed diversity and abundance.

Unmitigated Project activities have the potential to disperse pest (animal) species from the MNES study area into the surrounding landscape, due to habitat removal, noise disturbance, and human presence during the construction and operation phases of the Project. Construction of access tracks and the rail infrastructure through large patches of intact vegetation may result in the establishment of pest species (particularly predators such as foxes and cats) into areas where they are currently absent or in low numbers (Catling and Burt 1995). Therefore, unmitigated potential impacts of the displacement of native species through the invasion of non-native may be temporary or irreversible (refer Table 3.7 for definitions associated with timeframes).

5.1.2.5 Reduction in the connectivity of biodiversity corridors

Biodiversity corridors (including those associated with waterways) can be defined as systems of linear habitat which enhance the connectivity of wildlife populations and may help to overcome the main consequences of habitat fragmentation (Wilson and Lindenmayer 1995). Corridors can assist ecological functioning at a variety of spatial and temporal scales from daily foraging movements of individuals, to broad-scale genetic gradients across biogeographical regions and fragmentation of such corridors have been identified as important threatening process to MNES such as Spotted-tail quoll (*Dasyurus maculatus maculatus*) and Koala (*Phascolarctos cinereus*) (refer Appendix B).

The QLD biodiversity corridor mapping for the SEQ and the Brigalow belt Biodiversity Planning Assessments (DES 2016b and 2018a respectively) portrays tracts of vegetation considered significant for the spread and movement of flora and fauna. A corridor of 'State' importance is located within the MNES study area associated with the Toowoomba Range. Connectivity is present north and south of the MNES study area, and this is evident on the coastal facing slope of the range associated with steep topography, as well as drainage lines.

Outside of the Toowoomba Range the Project disturbance footprint exists in a generally fragmented environment. However, functional connectivity is retained through local linkages of remnant and regrowth vegetation, associated with roadside and riparian corridors linking larger patches of vegetation on private land. These linkages are likely to provide landscape permeability for vagile MNES such as birds and bats.

The potential impacts of linear infrastructure traversing this biodiversity corridor includes habitat fragmentation, edge effects and barrier effects resulting in reduced population size and connectivity. These potential impacts are discussed further in the sections below. An additional potential impact upon biodiversity corridors resulting from the Project is the proliferation of weeds and pest species, as mentioned previously.

Nevertheless, the Project includes a tunnel section where it intersects the elevated area within the Toowoomba Range allowing fauna movement above this section of the corridor. It is also noted the Project is located close to the existing TSRC project and the range is also bisected by the Toowoomba Connection Road (to the south of the Project) and the West Moreton System rail line (to the north). Given the highly disturbed nature of the landscape surrounding the Project the unmitigated potential impacts to biodiversity corridors resulting from the Project are likely to be relatively minor.

5.1.2.6 Edge effects

Edge effects refer to the changes in environmental conditions (e.g. altered light levels, wind speed, temperature) that occur along the edges of habitats. These new environmental conditions along the habitat edges can promote the growth of different vegetation types (including weed species), promote invasion by pest animals specialising in edge habitats, or change the behaviour of resident native animals (Moenting and Morris 2006). Edge zones can be subject to higher levels of predation by introduced mammalian and native avian predators. The distance of edge effect influences can vary and has been previously recorded from 50 m to greater than 1 km from an edge (Forman et al 2000; Bali 2005).

In large habitat patches with low edge to area ratios (such as in the Toowoomba Range), Project activities (vegetation clearing, temporary and permanent) may result in fragmentation and reduction of existing habitat along with associated edge effects.

Edge effects have the potential to impact on the range of flora and fauna species identified as potentially occurring in the MNES study area, especially upon the species with specific micro-habitat requirements that are less tolerant to disturbance (e.g. Collared delma (*Delma torquata*), New Holland mouse (*Pseudomys novaehollandiae*)). Conversely, some threatened plant species appear to respond positively to edge effects, particularly ground disturbance, and colonise these edge areas reasonably quickly (Hairy-joint grass (*Arthaxon hispidus*), Hawkweed (*Picris evae*), and Austral cornflower (*Rhaponticum australe*)).

It is anticipated that threatened species (including habitat for Spotted-tail quoll (*Dasyurus maculatus maculatus*), Collared delma (*Delma torquata*) and New Holland mouse (*Pseudomys novaehollandiae*)) may be impacted greatest from edge effects, where avoidance of vegetated areas is not practicable.

The unmitigated potential impacts of edge effects resulting from the Project are considered to be long term and irreversible (refer Table 3.7 for definitions associated with timeframes).

5.1.2.7 Habitat fragmentation

Habitat fragmentation relates to the physical dividing up of a continuous habitat into separate smaller fragments (Fahrig 2002). The habitat fragments tend to be smaller and separated from each other by a matrix of less suitable habitat. The new habitat type situated between fragments is often artificial and less suitable to the species remaining within these newly created fragments (Bennett 1987) or is generally only used by adaptive and aggressive generalist species (i.e. Noisy miners (*Manorina melanocephala*) (Loyn et al. 1983)) which further decreases population levels of other species remaining in the fragments. Fragmentation reduces patch size, thereby increases edge effects within a patch and reducing the area of undisturbed 'core' habitat for the fauna species present in an area.

The landscape in which the western portion of the Project is situated is highly fragmented with most vegetation occurring as small fragments due to agricultural practices such as pasture, cropping and horticulture. The Project activities will contribute to further fragmentation along with the associated edge effects and reduction in habitat. This effect will largely impact habitat associated with the area between Helidon and the top of the Toowoomba Range. The range is already subject to fragmentation due to existing roads (Toowoomba Bypass and Toowoomba Connection Road) and rail infrastructure located to the south and north of the alignment respectively. Habitat fragmentation has been identified as important threatening process to MNES such as Spotted-tail quoll (*Dasyurus maculatus maculatus*) and Koala (*Phascolarctos cinereus*) (refer Appendix B). In addition, if alignment clearing exceeds glide distance for the Greater glider (*Petauroides volans*), the project, when combined with adjoining ARTC projects will represent a significant barrier for this species.

This is due to the importance of connectivity, dispersal opportunities and habitat quality for fauna species at a local scale and the cumulative impacts at a regional scale. In some instances the Project may not result in significant fragmentation of populations identified as relevant to the area (refer to species-specific population information in Section 5.3.4 and Section 5.3.5) given the capacity of the species to disperse widely across the landscape (e.g. Koala (*Phascolarctos cinereus*)).

Linear Project activities may however result in some small-scale localised fragmentation which has the potential to be detrimental to the dispersal of relatively sedentary species, such as small mammals, frogs and reptiles which can lead to crowding effects and increased competition within habitat patches. Mobile species such as larger mammals, birds and bats may not be affected by this small-scale fragmentation, as the landscape in which they currently exist is fragmented and the predicted level of fragmentation would not be enough to restrict their dispersal between habitat patches providing that mitigation measures are in place to facilitate dispersal in these species. It should be noted localised fragmentation may have a greater impact on vegetation communities such as the Lowland Rainforest TEC (refer Appendix B).

The unmitigated potential impacts of habitat fragmentation resulting from the Project are considered to be long term and irreversible (refer Table 3.7 for definitions associated with timeframes).

5.1.2.8 Barrier effects

Barrier effects (permanent and/or temporary) occur where particular species are either unable or are unwilling to move between suitable areas of habitat due to the imposition of a barrier. This can include a habitat type that has become unsuitable (e.g. cleared areas devoid of vegetation or structure) or a physical barrier such as a fence, alteration to a waterway or a culvert that that does not provide movement opportunities (particularly important to aquatic MNES species such as Murray cod (*Maccullochella peelii*)). As noted in the previous section (fragmentation) this impact is diminished somewhat in the Toowoomba Range due to existing barriers (i.e. the Toowoomba Bypass and QR West Moreton System rail corridor).

Species most vulnerable to barrier effects include uncommon species, smaller ground-dwelling species, and relatively sessile species with smaller home ranges. Terrestrial MNES most vulnerable to barrier effects include the Collared delma (*Delma torquata*), Brush-tailed rock-wallaby (*Petrogale penicillata*), Koala (*Phascolarctos cinereus*), Long-nosed potoroo (*Potorous tridactylus tridactylus*) and the New Holland mouse (*Pseudomys novaehollandiae*). In addition, if alignment clearing exceeds glide distance for the Greater glider (Petauroides volans), the project, when combined with adjoining ARTC projects will represent a significant barrier for this species.

Various Project activities may create temporary and/or permanent barrier effects, particularly those that may create a hard barrier that restricts fauna movement (e.g. operational and construction access tracks, temporary waterway barrier works such as the construction of culverts within watercourses, operational rail corridor, construction laydown areas etc). This impact may affect MNES species such as Spotted-tail quoll (*Dasyurus maculatus maculatus*), Collared delma (*Delma torquata*), Long-nosed potoroo (*Potorous tridactylus tridactylus*) and the New Holland mouse (*Pseudomys novaehollandiae*). Mobile MNES species such as larger mammals, birds, and bats may not be affected to the same extent. However, in some instances the Project infrastructure/works may not present a barrier to populations identified as relevant to the area (refer to species-specific population information in 5.3.4 and Section 5.3.5) given the capacity of the species to disperse widely across the landscape (including heavily disturbed areas) and utilise Project infrastructure (such as culverts) (e.g. Koala (*Phascolarctos cinereus*)).

Human activity and infrastructure are likely to create a barrier as many species are known to avoid areas of human activity resulting in indirect habitat loss. Human presence may affect species in different ways. Some species display avoidance behaviour while others may habituate and become attracted to areas of human activity. Predators and prey may respond differentially to human activity, causing a disruption of community interaction and potentially disrupting ecological processes (Caro 2005). Human presence and activity are likely to produce avoidance responses in larger mammalian predators that are sensitive to disturbance (i.e. Quolls), while species such as macropods (i.e. kangaroos and wallabies) and smaller amphibian and reptile species are more likely to habituate to human presence.

Similarly, barrier effects may be experienced by native animals in the form of increased patrolling and predation by pest animals (e.g. foxes and wild dogs) along barriers, such as a cleared corridor, as prey becomes more exposed and easier to detect and catch.

Nevertheless, it is noted the Project design incorporates the tunnel (i.e. where no vegetation clearing will be required) and a number of viaducts that where the Project traverses the vegetated habitats associated with the Toowoomba Range, thereby allowing potential fauna movement across the alignment where these structures are located. The unmitigated potential impacts of barrier effects resulting from the Project are considered to be in most cases short term and temporary but may in some cases be long term and irreversible (refer Table 3.7 for definitions associated with timeframes).

5.1.2.9 Noise, dust, and light impacts

Noise, dust, and light are direct impacts that have the potential to occur as a result from the Project activities during all phases and may also have cumulative effects. The scientific understanding of the impacts of noise on fauna is limited. There are no current State or Commonwealth government policies or guidelines that recommend noise thresholds or limits associated impacts to fauna.

Studies overseas have shown that that noise, light, and vibration due to railways can lead to the reduction of species richness and abundance of some insects, amphibians, and birds, and to cause avoidance behaviour on predators. While reptiles, some bird species, small mammals, and large mammals seem to ignore rail traffic and benefit from the vegetation planted in the railway verges that provide food and shelter.

There are no specific noise guidelines for animals (wildlife and livestock) and very few studies that seem relevant to the Project. However, the United States of America Federal Rail Administration has an interim guideline of 100 decibels for wildlife and livestock (Federal Railroad Administration 2012). With studies indicating that this would be achieved within approximately 30 m from the rail track and as such the criteria would be met outside of the rail corridor.

Noise may adversely affect wildlife by interfering with communication, masking the sound of predators and prey, causing stress or avoidance reactions, and in some cases, may lead to changes in reproductive or nesting behaviour. Excessive noise may lead some species to avoid noisy areas, potentially resulting in the fragmentation of species habitat. On the other hand, many animals react to new noise initially as a potential threat, but quickly ‘learn’ that the noise is not associated with a threat (Radle 2007).

The Project may lead to localised increases of airborne dust levels during construction. Increased dust can result in respiratory issues in fauna, adverse impacts on plant photosynthesis and productivity (Chaston and Doley 2006), changes in soil properties ultimately impacting plant species assemblages' (Farmer 1993), and mortality and/or decrease in aquatic health on aquatic communities from the toxicity of poor water quality. Evidence of potential impacts on entire vegetation communities is scarce. Many studies focus on specific impacts to single species. Recent research on threatened flora in a semi-arid environment in Western Australia found no significant impact on plant health as a result of a range of dust accumulation loads caused by vehicle movements (Matsuki et al. 2016). The deposition of (unpaved) road dust on nearby freshwater wetlands caused by heavy traffic increases due to energy development projects found minimal impact on water quality or soils (Creuzer et al. 2016).

Artificial lighting may have a range of impacts across different groups of taxa and between species within these groups. Rodents may avoid brightly lit areas at night. Frogs and nocturnal reptiles may congregate at artificial lights to feed on insects attracted to light (Perry et al. 2008). Similarly, many microbat species may congregate at artificial lighting (Rich and Longcore 2006), although other species may avoid well-lit areas (Threlfall et al. 2013).

The likelihood of potential impacts is anticipated to be greatest where Project activities take place near vegetated areas and known habitat, during construction, decommissioning and rehabilitation phases. Operating rail lines will generate noise and vibration and it is likely that many species will habituate as a result of the regularity of generated noise.

The Project will result in minor light spill (i.e. "warm light" at level crossings and around the tunnel portals) into adjacent receiving environments (e.g. fauna habitat) due to the operation of plant and equipment throughout the construction phase of the Project and installation of lighting on infrastructure required for the operation of the Project. Impacts associated with light spill may include direct impacts (e.g. increased susceptibility to predation from increased light) or indirect impacts related to altered foraging and habituation in areas exposed to increased lighting. Light impacts associated with construction will be temporary in nature, however operational lighting impacts will be long term and localised (e.g. infrastructure) or transient in nature (i.e. vehicle movement). Whist light spill may impact negatively on many species, it may positively impact upon species such as microbats by attracting nocturnally flying insects upon which this species feeds.

It is noted that none of these impacts (noise, light and dust) are listed as threatening processes for the MNES species relevant to the Project as listed on DAWEs SPRAT database (2020). Ecological MNES affected by these potential impacts may include all threatened flora (impacts associated with dust) and terrestrial fauna species (impacts associated with noise and vibration) and aquatic species (impacts associated with dust, noise and vibration) listed under the provisions of the EPBC Act. The Lowland Rainforests of Subtropical Australia TEC may also be impacted to a lesser extent. These impacts are likely to be associated with dust alone (i.e. reducing photosynthetic processes following settlement of dust on the leaves of components of the TEC), although it is noted the nearest occurrence of this TEC is located approximately 100 m from the Project disturbance footprint. These types of impacts are likely to be short-term in duration and localised.

5.1.2.10 Increase in litter (waste)

The act of littering has the potential to impact the surrounding environment by causing injury to wildlife, poses threats to human health and is aesthetically displeasing. When discarded as litter, human-made materials such as plastic, glass and aluminium have the potential to cause external injury to wildlife, entanglement, and if accidentally ingested, may cause starvation or suffocation and as such negatively impact MNES species such as the Murray cod (*Maccullochella peelii*). Littered objects may also provide suitable habitat for disease-spreading insects, such as flies and mosquitoes (Healthy Land and Water 2019).

According to the National Litter Index, across Australia the most littered items are cigarette butts; and plastic objects are the most littered by volume of material. Cigarette butts and small plastic items are often mistaken for food resources and have been found in the stomachs of juvenile birds. In addition, littering of cigarette butts also poses a bushfire risk (Healthy Land and Water 2019).

Ecological MNES potentially affected by this impact includes all threatened flora (through alterations in recruitment and nutrient cycles) and fauna species (direct consumption, declines in habitat suitability and entanglement). This type of impact has the potential to be long in duration due to the varying times of decomposition; however, it is likely to be localised and manageable.

5.1.2.11 Aquatic habitat degradation

Activities related to the construction and operation of the Project are likely to impacts to water quality, thereby degrading habitats for aquatic fauna and flora. Erosion and sedimentation (refer Section 5.1.2.12), contamination and an increase in litter (refer Section 5.1.2.10) are all potential mechanisms that will adversely impact aquatic habitat. In addition, direct loss of waterway habitat may occur though activities associated with waterway crossings during construction and operation.

Physical habitat modification due to hydrological regime change may degrade current habitat morphological features including substrate composition, channel form and bank stability which may reduce aquatic ecological values. Further loss of ecological services may occur from a removal of riparian vegetation required for both watercourse and drainage feature infrastructure (within construction and operation phases), which may compound physical habitat modification from any changes to hydrological regimes. It is noted most waterways intersected by the Project are already subject to significant habitat modification due to adjacent land use.

The transport of sediment and eroded material can be washed off areas of exposed soil, stockpile locations, or localised areas in proximity to Project infrastructure (e.g. culverts and bridges) during rainfall events and thus may also affect terrestrial habitats. Transported sediments from the terrestrial environment may lead to increased sediment loads and turbidity within waterways and potentially increase nutrient loads. In addition to direct impacts to aquatic habitat degradation associated with erosion and sedimentation, flow on effects from increased sedimentation may impair the functioning of culverts should deposition be too high, exacerbating instream barrier effects (refer Section 5.1.2.8).

There is potential for contaminants and pollutants associated with construction and operation of the Project to enter aquatic environments, resulting in the alteration or loss of potential habitat for terrestrial and aquatic species. Concrete, oil and grease and other chemicals associated with construction and operation may result in localised run-off into adjacent watercourses and waterbodies following rainfall events.

The disturbance and modification of some riparian zones and works within watercourses/wetlands during the construction phase of the Project has the potential to reduce the ecological integrity of the watercourse thereby impacting on structural aspects that support breeding and foraging requirements of aquatic species.

Aquatic habitat degradation is considered a threat to Murray cod (*Maccullochella peelii*) populations (NMCRT 2010), although this largely occurs at the catchment scale as a result of land clearing, pesticide use and irrigation abstraction and which influence water quality. Recruitment success for the species appears to be strongly linked to river flow, with good breeding years linked to a rise in river levels soon after spawning. The temporary impoundment of watercourses intersected by the Project in which the species may occur (Gowrie Creek) is not expected to pose a risk to the species, provided creek flows return to pre-construction levels. Potential threats are more likely to be realised through impacted water quality (e.g. increased turbidity) near the Project disturbance footprint (localised to construction works) although this is only expected to be temporary in nature.

5.1.2.12 Erosion and sedimentation

Terrestrial impacts associated with erosion and sedimentation include compaction of soil, loss of soil structure, nutrient degradation, and increased soil salinity all of which can lead to reductions in the carrying capacity of the terrestrial environment as a result of decreasing habitat value.

Erosion and subsequent sedimentation can be damaging to the ecological health of waterways and the surrounding terrestrial environment and may be a proximate cause of environmental degradation. Mobilised coarse sandy-sediment tends to accumulate in areas of slow-flow and may smother bottom-dwelling organisms and their habitats. Deep permanent river pools, that are valuable habitats for aquatic fauna and refuges for wildlife during summer and drought, may become filled by course sediments, which may render them ineffective in relation to their ability to support aquatic and terrestrial species.

Large sediment accumulations can cause upstream flooding or deflect the flow into the adjacent stream bank or even onto adjacent land, causing further erosion and transported sediments can fill the deep permanent pools of rivers to ruin this critical refuge habitat.

In addition to secondary impact of erosion and sedimentation on aquatic habitats, the primary impact of erosion on terrestrial habitat has the potential to occur in relation to Project activities. As indicated above, these would be expected to occur within areas of exposed soil, stockpile locations, or localised areas in proximity to Project infrastructure (e.g. culverts and bridges) during rainfall events. The changes to overland flow paths from erosion have the potential to have localised direct impact on terrestrial habitat. These impacts are principally associated with a loss of substrate stability around vegetation and may result in a loss of vegetation quality and cover.

5.1.2.13 Tunnelling impacts – Toowoomba Range

The construction and operation of the proposed tunnel through the Toowoomba Range may have potential to cause a number of localised impacts to habitats located above and adjacent to the tunnel, in the absence of mitigation, including subsidence, discharge of water into the surrounding environment, groundwater drawdown, and vibrations caused by the tunnel construction. The tunnel is proposed to be 6.24 km long extending from Ch 3.7 to Ch 10.4 of the alignment with an excavated cross-section of approximately 12.2 m diameter and a finished internal diameter of approximately 10.8 m. The topography of the Toowoomba Range where the tunnel underlies ranges from 450 m AHD (Toowoomba Plateau), at the eastern portal, to 643 m AHD traversing under the New England Highway and Toowoomba Bypass at Mount Kynoch. At its' deepest point the tunnel reaches a depth of approximately 200 metres below ground level (mbgl).

Habitat that may potentially support a number of threatened MNES flora species is identified as present above the tunnel area in both the cleared and vegetated areas (refer species habitat mapping in Appendix G). The field-verified occurrence of Lowland rainforest TEC is located approximately 100 m north of the eastern portal of the tunnel.

The Great Dividing Range (GDR) is the highest point across the alignment, is a recharge area, and divides the east (coastal) and west (inland) flowing watercourses. West of the GDR, the main watercourse is Gowrie Creek, which flows in the westerly direction. East of the GDR there are numerous watercourses and their ephemeral gullies which flow in the valleys between the ridges, with the main watercourses incised in the underlying Marburg Subgroup rocks (mainly the Koukandowie Formation). East of the GDR, the Project intercepts various ephemeral watercourses (Six Mile, Oaky, and Rocky creeks) and Lockyer Creek, which is the main drainage system in the Lockyer Valley.

The geology and hydrogeological regime are influenced by the GDR, where the GDR is a regional groundwater divide. West of the GDR is associated with the MRV and east of the GDR transitions to the Koukandowie Formation, which is outcropped by Gatton Sandstone. The MRV, specifically an informal sub-unit referred to as the Toowoomba Volcanics, is up to 330 m thick along the escarpment at Toowoomba (Willey 2012). The tunnel intersects the MRV from Ch 4.10 km to Ch 4.53 km and Ch 8.45 km to Ch 9.05 km and intersects the Koukandowie Formation from Ch 4.53 km to Ch 8.45 km and Ch 9.05 km to Ch 10.00 km. The tunnel intersects crater rim and colluvium units at the eastern portal (refer EIS Chapter 9: Land Resources for further detail).

Potential ground-borne vibration and associated ground-borne noise due to tunnel construction works has been assessed in a conservative fashion relying on technical assumptions for the vibration emitted by the excavation activity and the surrounding geotechnical conditions (refer EIS Chapter 15: Noise and Vibration for further information). The assessment considered the closest sensitive (human) receptors to the tunnel were not expected to experience vibration or ground-borne noise levels that could trigger the assessment criteria. There are no guidelines regarding potential impacts of ground vibration to fauna. Vibration impacts are very likely to be similar to those described for noise (refer EIS Chapter 15: Noise and Vibration) In addition, vibration impacts will be restricted to the construction period. As such, any potential impact on MNES fauna is likely to be minor at worst and temporary.

Groundwater

Groundwater levels and flow direction in the Toowoomba region are influenced by the GDR. Groundwater flows from the GDR to the east and west, which indicates the GDR is a groundwater divide in the region. There is limited long-term groundwater level data within the groundwater study area west of the GDR. From the highest point of the GDR and the apex of the groundwater divide, groundwater flow gently flows west of the GDR following topography. East of the GDR, shallow groundwater follows the escarpment, with steep relief, towards Helidon. The flow direction of the alluvial aquifer is typically represented by the surface water catchment boundaries, which correlates well with the groundwater divide observed.

The water table occurs in the alluvial/colluvial sediments or outcropping MRV across much of the groundwater study area west of and within the GDR. The Koukandowie Formation, east of the GDR, and the Gatton Sandstone in the eastern portion of the alignment form the upper (water table) aquifer in these areas.

Groundwater levels in the MRV aquifer are difficult to correlate due to abstractions and the nature of fractured rock aquifer. The large variations in groundwater levels are considered to be a result of the isolated fracture networks within the MRV, various confining attributes of the units within the MRV, and/or local influence from abstraction. There is limited groundwater data available along the Toowoomba Range tunnel alignment. Groundwater levels obtained from landholder bores and Project bores show groundwater levels are highly variable in the vicinity of the tunnel with shallow groundwater ranging from 12.4 mgbl (in the Koukandowie formation) at the eastern tunnel portal (Ch 10.4 km of alignment) to 14.5 mgbl and 14.9 mgbl in the MRV aquifer (Ch 3.4 km and Ch 8.2 km of alignment respectively). Deeper groundwater occurs within the MRV aquifer (93.7 mgbl at Ch 8.2), the Walloon Coal Measures (54.9 mgbl at Ch 67.2 km) and the Koukandowie Formation (101.24 mbgl at Ch 5.6 km).

The vegetation in the Toowoomba Range over the tunnel area largely comprises cleared or partially cleared lands interspersed with patches of sparse Mountain coolabah (*Eucalyptus orgadophila*) open woodland. The tunnel also crosses under a patch of Queensland blue gum (*E. tereticornis*) woodland along Gowrie Creek (the tunnel is approximately 100 mbgl at this point). The final eastern portion of the tunnel (approximately 1 km in length) passes under regrowth and remnant vegetation comprising a mixture of eucalypt woodlands/open forest and vine forest. Of the tree species present Queensland blue gum is known to access shallow alluvial groundwater. Of the 11 MNES flora species that may potentially occur in habitat located above the tunnel (refer habitat mapping within Appendix G) none are identified as being dependent on groundwater (refer Appendix B and Table 5.2). Similarly, there is no evidence the Lowland rainforest TEC is reliant on groundwater (refer Appendix B and Table 5.2).

Lowered groundwater levels due to long-term seepage into the tunnel has the potential to impact groundwater users and vegetation such as deep-rooted trees (GDEs). Mapping of GDEs (from the BoM GDE Atlas) indicates there are numerous moderate and low potential aquatic GDEs within the wider area, including creeks in the vicinity of the tunnel such as Gowrie Creek and Oaky Creek and their tributaries. Available surface water and groundwater quality and level data indicate there is potential for surface water and groundwater connectivity within the MNES study area. Near Gowrie Creek the ecosystems are intermittently connected to aquifers with brackish salinity in unconsolidated Quaternary alluvium, associated with catchment constrictions. Towards the GDR and in the upper reaches of Oaky Creek the ecosystems are intermittently connected to aquifers with freshwater quality in permeable rock (basalt) and in low rainfall areas. There are no potential subterranean GDEs and no registered groundwater springs within the MNES study area and no spring-fed wetlands were identified during the aquatic and terrestrial ecology field works.

There are numerous low and moderate potential terrestrial GDEs (from regional studies) in the MNES study area where surface vegetation potentially draws on groundwater. Near Gowrie Creek the ecosystem (associated with Queensland blue gum) may be intermittently connected to aquifers with brackish salinity in unconsolidated Quaternary alluvium associated with catchment constrictions. Further east towards the eastern portal of the tunnel and in the upper tributaries of Oaky Creek, the GDEs are in low rainfall and low capacity permeable rock, associated with basalt (MRV). Ground-truthing of the mapped GDEs has not been undertaken. Further investigation, post-EIS, will be undertaken during optimal conditions to confirm the presence of mapped GDEs in the MNES study area.

Preliminary predictive numerical modelling of the undrained tunnel through the Toowoomba Range was carried out to estimate potential groundwater drawdown impacts. The construction phase groundwater level drawdown extent for the tunnel indicates at approximately 107 weeks (when maximum groundwater inflow to the tunnel is expected to occur) groundwater level drawdown in the shallow MRV aquifer has a short extent along the tunnel alignment (less than 1 km) and 200 m north and south. The drawdown impact to the deeper MRV aquifer extends approximately 2 km along the tunnel alignment (from the eastern portal) and 1 km north and south. The groundwater drawdown extent and level are most significant in the Koukandowie Formation which extends approximately 5 km along the tunnel alignment, 1 km south of the alignment and reaches drawdown depths up to 35 m near the eastern portal area (within the Project disturbance footprint).

The maximum groundwater inflow to the western portal occurs during construction at 34 weeks within the shallow MRV. The resulting groundwater level drawdown reaches 5 m and is very localised to the western portal.

The maximum groundwater inflow to the intermediate ventilation shaft occurs at 62 weeks, which intercepts all modelled aquifers (shallow and deep MRV and Koukandowie Formation). The predictive modelling results indicate groundwater level drawdown is localised at Ch 6.83 km of the tunnel alignment, at the location of the intermediate ventilation shaft. The long-term groundwater level drawdown is expected to recover along the tunnel alignment, except at the western portal, as the tunnel will be constructed undrained. Operation phase groundwater drawdown is negligible across all groundwater units. Groundwater drawdown is predicted to be limited to the portals and shaft, within the Project footprint, with a maximum predicted drawdown of 5 m within the shallow MRV localised to the western portal. As such, any potential impacts on GDEs (should they actually be found to occur in the impact area) is expected to be limited to localised areas and largely temporary, during the construction phase.

Aboveground subsidence may result from both the tunnelling process itself, or as a result of settlement caused by subsequent groundwater drawdown processes caused by the tunnel. Groundwater drawdown can result in settlement of compressible substrates and possible damage to adjacent or above-ground structures. Early drawdown effects due to seepage into the tunnel has the potential to cause settlement of compressible materials, and damage to buildings, infrastructure (including rail/road and pipelines) or vegetation communities within areas of settlement. The greatest potential risk occurs where groundwater is shallow, soils are compressible, and buildings/structures are nearby; for example, areas within proximity to the Gowrie Creek floodplain.

Impacts to native vegetation from potential subsidence will be localised and are therefore difficult to predict beforehand. Potential impacts on remnant vegetation may include the following: trees may become destabilised by surface movement causing tree falls and slumping; surface or tension cracking may sever or damage vegetation root systems causing tree death; ground fracturing and surface cracking may cause localised changes to soil hydrology with follow-on adverse impacts to surface vegetation.

Reduced groundwater levels due to dewatering and/or seepage into the tunnel are not considered to present a risk of settlement due to the competent sedimentary bedrock material being tunnelled (that is, MRV and Koukandowie Formation). At worst subsidence potential is considered limited to the western portal of the Toowoomba Range tunnel, in the area of the Toowoomba Bypass. Overall, the potential for settlement due to subsidence from the tunnel appears to be low. It is anticipated that the potential for settlement will be confirmed as part of ongoing geotechnical investigations and will inform final design (refer EIS Chapter 14: Groundwater for further detailed information).

Ground-borne vibration

Potential ground-borne vibration and associated ground-borne noise due to tunnel construction works has been assessed in a conservative fashion relying on technical assumptions for the vibration emitted by the excavation activity and the surrounding geotechnical conditions (refer EIS Chapter 15 : Noise and Vibration for further information). The assessment found the following:

- There are 22 properties within an approximate distance of 260 m from the works which will exceed guideline ground-borne noise criteria for daytime hours
- There are 72 properties within an approximate distance of 390 m from the works which will exceed guideline ground-borne noise criteria for night-time hours.

Nevertheless, it is noted there are no guidelines and little research information regarding the potential impacts of construction ground vibration on fauna. A tunnelling Project in New Zealand adopted human vibration limit criteria to identify potential impact zones on wetland bird species and thereby informing fauna relocation activities (Norman Disney and Young 2020). Vibration impacts are very likely to be similar to those described for noise (refer EIS Chapter 15: Noise and vibration). Following the completion of construction, vibration will be restricted to train movements (i.e. regular events of relatively short duration). As such, any potential impact on MNES fauna is likely to be minor at worst and temporary.

5.1.3 Assessment of potential impacts to matters of national environmental significance associated with air quality, surface water and hydrology, groundwater, and noise and vibration

An assessment of potential Project related impacts associated with air quality, surface water and hydrology, groundwater, and noise and vibration were undertaken for the identified MNES. This assessment is summarised in Table 5.2. Potential impacts identified within Table 5.2 were incorporated into the assessments of initial impact magnitude as shown in Section 5.3.2.

Specific impacts associated with the relevant MNES are discussed in Sections 5.3.2, 5.3.3, 5.3.4 and 5.3.5.

Table 5.2 **Assessment of potential impacts related to air quality, surface water and hydrology, groundwater, and noise and vibration upon the identified matters of national environmental significance**

MNES category	Discipline	Project phase	Key findings in relation to discipline and the identified MNES	Reference for further information and mitigation measures
Threatened Ecological Communities	Air quality	Construction	Air quality has not been identified as a threatening process to TECs (i.e. Lowland Rainforest of Subtropical Australia) (refer Appendix B) and is not likely to impact upon TECs identified within the MNES study area	▪ EIS Chapter 12: Air quality ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.3 – Significant impact assessment ▪ Appendix B – TEC information and threatening processes
		Commissioning and reinstatement		
		Operation		
	Surface water and hydrology	Construction	The identified TEC (i.e. Lowland Rainforest of Subtropical Australia) is not identified as being susceptible to alterations to hydrology (refer DSEWPaC 2011d). While not listed as a threatening process, significant alterations to hydrology may impact upon this TEC. Nevertheless, significant deviations in hydrological processes are not considered likely to occur in or near the identified occurrence of TEC as a result of the Project.	▪ EIS Chapter 13: Surface water and hydrology ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.3 – Significant impact assessment ▪ Appendix B – TEC information and threatening processes
		Commissioning and reinstatement	No significant impact expected during this stage	
		Operation	No significant impact expected during this stage	
	Groundwater	Construction	The identified TEC (i.e. Lowland Rainforest of Subtropical Australia) is not identified as being susceptible to alterations to hydrology including groundwater drawdown (refer DSEWPaC 2011d). Nevertheless, there are no significant impacts expected to occur to groundwater that are likely to impact upon the identified TEC.	▪ EIS Chapter 14: Groundwater ▪ EIS Appendix N: Groundwater technical report ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.3 – Significant impact assessment ▪ Appendix B – TEC information and threatening processes
		Commissioning and reinstatement		
		Operation		
	Noise and vibration	Construction	Noise and vibration have not been identified as a threatening process to the identified TEC (i.e. Lowland Rainforest of Subtropical Australia) (refer Appendix B) and is not likely to impact upon TECs identified within the MNES study area	▪ EIS Chapter 15: Noise and vibration ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.3 – Significant impact assessment ▪ Appendix B – TEC information and threatening processes
		Commissioning and reinstatement		
		Operation		

MNES category	Discipline	Project phase	Key findings in relation to discipline and the identified MNES	Reference for further information and mitigation measures
Threatened flora species	Air quality	Construction	Air quality has not been identified as a threatening process to any of the flora MNES identified (refer Appendix B). Whilst it is acknowledged that particulate matter (e.g. dust during the construction period) has the potential to settle on foliage, this is not expected that this will significantly impede photosynthetic processes. Impact associated with air quality are not likely to result in an impact to MNES flora species within the MNES study area.	▪ EIS Chapter 12: Air quality ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.4 – Significant impact assessment ▪ Appendix B – species information and threatening processes
		Commissioning and reinstatement		
		Operation		
	Surface water and hydrology	Construction	Some of the identified flora MNES (e.g. *Arthraxon hispidus* and *Clematis fawcettii*) are susceptible to alterations to hydrology (refer Appendix B). Whilst listed as a threatening process on these species, significant alterations to hydrology are not likely to occur to the species predicted habitat as part of the Project's construction.	▪ EIS Chapter 13: Surface water and hydrology ▪ EIS Appendix M: Hydrology and Flooding ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.4 – Significant impact assessment ▪ Appendix B – species information and threatening processes
		Commissioning and reinstatement	No significant impact expected during this stage	
		Operation	No significant impact expected during this stage	
	Groundwater	Construction	Some of the identified flora MNES (e.g. *Arthraxon hispidus and Clematis fawcettii*) are susceptible to alterations to hydrology but are not identified as groundwater dependent (refer Appendix B). Nevertheless, there are no significant impacts expected to occur to groundwater that are likely to impact upon the any of the identified flora MNES as a result of Project activities.	▪ EIS Chapter 14: Groundwater ▪ EIS Appendix N: Groundwater technical report ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.4 – Significant impact assessment ▪ Appendix B – species information and threatening processes
		Commissioning and reinstatement	No significant impact expected during this stage	
		Operation	No significant impact expected during this stage	
	Noise and vibration	Construction	Noise and vibration have not been identified as a threatening process to any of the identified MNES flora species (refer Appendix B) and are not likely to impact upon flora MNES identified within the MNES study area.	▪ EIS Chapter 15: Noise and vibration ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.4 – Significant impact assessment ▪ Appendix B – TEC information and threatening processes
		Commissioning and reinstatement		
		Operation		
Threatened fauna species	Air quality	Construction	The greatest Impacts associated with air quality (i.e. dust) will be during the construction period. Whilst not identified as a threatening process to MNES fauna species *per se*, particulate matter (e.g. dust) may settle on plants and in waterways. Once in waterways it may result in declining water quality. However, despite these potential impacts, significant impacts to MNES fauna species are not expected to occur as a result of air quality.	▪ EIS Chapter 12: Air quality ▪ Section 5.2 – Impact mitigation ▪ Section 5.3.5 – Significant impact assessment

MNES category	Discipline	Project phase	Key findings in relation to discipline and the identified MNES	Reference for further information and mitigation measures
		Commissioning and reinstatement	No significant impact expected during this stage	■ Appendix B – species information and threatening processes
		Operation	No significant impact expected during this stage	
	Surface water and hydrology	Construction	One identified MNES fauna species is aquatic: Murray cod. The species may only potentially occur in Gowrie Creek with reference to the Project. Whilst this species is susceptible to declines in water quality, any impact associated with construction is considered to be short-term and temporary. It is not expected that water quality will decline to the point at which this aquatic species will be adversely impacted	■ EIS Chapter 13: Surface water and hydrology ■ EIS Appendix M: Hydrology and Flooding ■ Section 5.2 – Impact mitigation ■ Section 5.3.5 – Significant impact assessment ■ Appendix B – species information and threatening processes
		Commissioning and reinstatement	No significant impact expected during this stage	
		Operation	Significant deviations in hydrological (flooding) processes (e.g. time of submergence, area of inundation and peak levels) between the base/existing case and the developed case are not predicted to occur. This includes Gowrie Creek. During operation, the tunnel will require the release of groundwater draining into the tunnel via the eastern portal (into a tributary of Oaky Creek). The release of water is not predicted to be of a quantity to impact surface water or MNES values.	
	Groundwater	Construction	The Murray cod may only potentially occur in Gowrie Creek with reference to the Project. Whilst this species is susceptible to declines in water quality, the Project is not likely to significantly alter the existing quality of groundwater, to the point where it will impact upon the Murray cod. Some drawdown of groundwater is predicted to occur as a result of the construction and operation of the tunnel, including impacts to the MRV which interacts with Gowrie Creek (e.g. the construction of the tunnel has the potential to reduce groundwater levels up to 5 m within the deep MRV under Gowrie Creek during Week 107). However, the Project will also likely result in the continuous release of groundwater into Gowrie Creek which may benefit the health of that system. Other threatened species identified as potentially occurring in the Project disturbance footprint are not considered to be groundwater dependent species (refer Appendix B).	■ EIS Chapter 14: Groundwater ■ EIS Appendix N: Groundwater technical report ■ Section 5.2 – Impact mitigation ■ Section 5.3.5 – Significant impact assessment (refer **Table 5.34**) ■ Appendix B – species information and threatening processes
		Commissioning and reinstatement		
		Operation		
	Noise and vibration	Construction	Whilst noise and vibration have not been identified as a specific threatening process for MNES fauna species that have potential to occur within the MNES study area, animals typically show avoidance behaviours to foreign stimuli, including noise and vibration. Whilst such stimuli may result in little impact to vagile species such as the Grey-headed flying-fox and the Swift parrot, other less vagile species such as the Koala, Brush-tailed rock-wallaby and Spotted-tail quoll may avoid areas that are subject to acute noise and vibration events. Avoidance of areas subject to such stimuli is likely to occur during the construction phase and may result in a reduction in foraging efficiency.	■ EIS Chapter 15: Noise and vibration ■ Section 5.2 – Impact mitigation ■ Section 5.3.5 – Significant impact assessment ■ Appendix B – species information and threatening processes
		Commissioning and reinstatement		

MNES category	Discipline	Project phase	Key findings in relation to discipline and the identified MNES	Reference for further information and mitigation measures
		Operation	Whilst acute noise and vibration are known to result avoidance behaviours in animals, chronic noise and vibration, particularly when applied at regular intervals, are less likely to illicit a response. It is therefore likely that once operational, impacts associated with noise and vibration will not adversely impact upon MNES fauna species	

5.2 Impact mitigation

This section outlines both the flora and fauna impact mitigation measures included as part of the Project design and the mitigation measures that are proposed for the Project to manage predicted environmental impacts. The impacts are initially assessed with consideration of the Project design mitigation measures and then reassessed to determine residual risk after the inclusion of the proposed mitigation measures.

5.2.1 Design considerations

Development of the design has progressed in parallel with the impact assessment process. As a consequence, design solutions for avoiding, minimising or mitigating impacts have been incorporated into the design as appropriate and where possible.

Mitigation measures and controls that have been factored into the design for the Project are as follows:

- The Project is partially located within the existing QR West Moreton System rail corridor, as well as within the protected Gowrie to Grandchester future State transport corridor. As noted previously, the Gowrie to Grandchester future State transport corridor was assessed in detail in 2003 (refer Section 1.8.2) with detailed analysis of the potential environmental impacts posed by the Project. The Project design has been developed to utilise the existing rail corridor system and minimise land severance and impacts to natural and rural landscapes to the greatest extent possible.
- The Project disturbance footprint has been restricted to what is anticipated to be required to construct and operate the works in a safe and efficient manner. Restricting the temporary construction disturbance footprint and the permanent disturbance footprint minimises the extent of disturbance required to vegetation and habitats during construction and operation.
- The construction footprint defined in Project design has aimed to minimise clearing extents to that required to construct and operate the works. The rail corridor has a typical width of 40 m (new rail corridor) and extends wider where earthworks, structures and other associated infrastructure are required. For areas within the existing rail corridor, the existing width has been generally maintained (where possible). Where the existing width cannot be maintained, it is locally widened (where appropriate) to accommodate proposed works.
- The Project has avoided direct impacts on nationally or regionally protected areas such as the Lockyer Resources Reserve, Lockyer State Forest or Lockyer National Park.
- Clearing of vegetation will be restricted to the minimum required to enable the safe construction, operation and maintenance of the rail corridor, including minimising the disturbance of sensitive areas such as:
  - Habitat for critically endangered, endangered and vulnerable flora and fauna species
  - Critically endangered and endangered TECs
  - Riparian vegetation
  - Steep slopes and
  - In-stream habitats.
- Watercourse crossing structures (including culverts and bridges) have been designed to maintain aquatic fauna (e.g. for Murray cod) passage and minimise the risk of blockages in reference to the accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018)
- The Project incorporates bridge and culvert structures to maintain existing flow paths and flood flow distributions. These have been located and sized to minimise increases in peak water levels, velocities and duration of inundation
- Bridges have been designed to minimise impacts to the bed, banks and environmental flows of watercourses in accordance with requirements of the *Fisheries Act 1994*

- The Project has been developed to minimise impacts to watercourses, riparian vegetation and in-stream flora and habitats by adopting a crossing structure hierarchy where bridges are preferred to culverts to maintain connectivity for MNES species such as Murray cod and riparian fauna conduits that are important to MNES species
- 13 new bridge and viaduct structures are to be constructed to minimise disturbance of aquatic habitats during operations.
- Scour and erosion protection measures have been incorporated into the design in areas determined to be at risk, such as around culvert headwalls, drainage discharge pathways and bridge abutments
- The nominated rail corridor has been restricted to the land required to accommodate permanent infrastructure components of the railway, including earthworks, cross drainage and RMARs. Habitat for MNES species has been avoided wherever possible.
- The Toowoomba Range is a considered a biodiversity corridor of State significance. The Project design through the Toowoomba Range incorporates structural elements that are 'permeable' and will allow fauna passage following construction. As identified above, over 6 km of viaducts are proposed through the Lockyer Valley, including across floodplains, valleys and watercourses and the inclusion of the rail tunnel (6.24 km long) in the more elevated section of the range. Fauna will be able to move under viaducts and be able to utilise the unimpacted section of the range over the tunnel as a movement corridor. This will maintain connectivity for species such as the Brush-tailed rock-wallaby, Spotted-tail quoll, Koala and Long-nosed potoroo which occur or may occur in the area.
- Opportunities for the provision of fauna fencing and fauna movement solutions have been identified. These include fencing strategies to guide species such as Koalas to safe movement opportunities along the alignment including towards raised structures such as bridges and viaducts. These opportunities will be refined through the detailed design process and incorporated where appropriate.

5.2.2 Proposed mitigation measures

In order to manage Project risks during construction a number of mitigation measures have been proposed for implementation in future phases of Project delivery, as presented in Table 5.3. Further detail regarding species specific mitigation measures is provided in Table 5.6 and Table 5.7 and should be considered in conjunction with the more general measures detailed in this section.

These proposed mitigation measures have been identified to address Project specific issues and opportunities, address legislative requirements and accepted government plans, policy and practice. Information related to government threat abatement plans and recovery plans has been incorporated into the identified mitigation measures wherever applicable. Mitigation measures have been selected based on the best available information including government guidelines (e.g. DTMR's Fauna Sensitive Road Design Manual (DTMR 2010)) and mitigation measures used on similar projects that have been subject to legislative approval (refer footnotes to Table 5.3). It is acknowledged the effectiveness of these measures may not be subject to rigorous peer-reviewed analysis.

ARTC has reviewed a cross-section of available published literature on effectiveness of mitigation measures used on linear infrastructure. There is significant literature which corroborates ARTC's proposed mitigation measures as being effective:

- Installation and regular maintenance of fauna exclusion fences can help reduce wildlife mortality during construction. Wildlife crossing structures (underpasses and overpasses) have been constructed around the world and are used by many species to safely cross linear infrastructure (Bond and Jones 2008; VicRoads 2012; van der Grift et al. 2015; van der Ree et al. 2015a; Weller 2015).
- Wildlife crossing structures also improve traffic safety and contribute to the conservation of biodiversity by allowing animals to move safely across roads, thereby reducing the risk of collision (Smith et al. 2015)
- Wildlife crossing structures are the most effective approach to mitigate the barrier effect of linear infrastructure on wildlife movement (Taylor and Goldingay 2010; Smith et al. 2015)

- The combination of exclusion fencing with wildlife crossing structures are complementary, with the ability to avoid animal collisions and maintain infrastructure permeability (VicRoads 2012; Carvalho et al. 2017; Ghent 2018; Barrientos et al. 2019).
- VicRoads (2012) corroborates the use of bridge underpasses for the effective use of koala crossings
- The most effective stream crossings for fish, when long-span bridges are not an option, are culverts or shorter span bridges that simulate the natural channel (Ottburg and Blank 2015)
- Use of planting native species to the region was validated by Milton, et al. (2015).

ARTC is committed to implementing ongoing monitoring of the effectiveness of the measures with contingency (under an adaptive management framework) to change/improve management strategies where deleterious impacts to the identified environmental values are observed, or are not minimised, as per the objectives of the proposed measures.

Literature is in agreement that monitoring is a critical component of quantifying effectiveness of a specific mitigation measure (van der Ree et al. 2008; van der Grift et al. 2015). This is because the success of mitigation measures are heavily reliant on factors such as existing environment, potential habitat, species, climate, design components of the linear infrastructure, and operational frequency of the transport; due to these factors it is not feasible to be able to provide a quantification of effectiveness of the Project's mitigation measures (Ghent 2018).

For example, a comprehensive evaluation of the effectiveness of wildlife crossing structures requires a clear definition of success. Effectiveness is defined as the extent to which the goals of mitigation are reached. However, it is difficult to assess effectiveness without a specific and measurable goal. Therefore, ARTC recommends the SMART approach, that is, goals that are Specific, Measurable, Achievable, Realistic and Time framed (van der Ree et al. 2008; van der Ree et al. 2015b and 2015c; van der Grift et al. 2015). Van der Ree et al. (2007) proposed that the overall objective of wildlife crossing structures is to 'increase the permeability of a road corridor'. Criteria that can be used to measure effectiveness include:

- Rates of road-kill
- Habitat connectivity
- Biological requirements are met
- Allowance for dispersal and re-colonisation
- Maintenance of meta-population processes and ecosystem services.

It is also recommended that goals should be set for individual projects that are specific to species, location and the nature of the conflict. For example, a specific goal might be to ensure more than 90 per cent of individuals that approach a crossing structure successfully cross it, or to maintain the risk of extinction of a population to less than 5 per cent over the next 100 years.

Additional strategies as identified by the relevant threat abatement plan/recovery plans will be incorporated into the Project's mitigation strategies following the primary approval phase of the Project as part of detailed design. A summary of threat abatement plans and recovery plans applicable to the identified MNES is provided in Appendix B and Sections 5.3.4 and 5.3.5.

These proposed mitigation measures have been segregated with the phase during which they would be implemented:

- Detailed design
- Pre-construction
- Construction
- Operation.

Table 5.3 identifies the relevant Project phase, the aspect to be managed, and the proposed mitigation measure, which is then factored into the initial impact assessment (refer Section 5.3.2).

In addition, it is recognised that targeted surveys for most MNES flora and fauna species have not been carried out within the Project disturbance footprint as part of Project surveys detailed in this report. ARTC will undertake additional ecological surveys in accordance with relevant Commonwealth and/or State surveys guidelines to verify and further refine the habitat mapping and extent of local populations (where applicable) which will inform relevant approvals and management plans, along with necessary offset requirements and disturbance limits. These surveys will be a part of the Flora and Fauna Sub-plan as identified in the relevant tables within Section 5.3.2.

EIS Chapter 23: Draft Outline Environmental Management Plan provides further context and the framework for implementation of these proposed mitigation and management measures.

Table 5.3 Project impact mitigation and management measures

Delivery phase	Environmental value impacted	Mitigation and management measures
Detailed design	MNES	While the assessment assumes the entire Project disturbance footprint will be cleared, the disturbance footprint will be refined through detailed design as far as practical, to that required to safely and efficiently construct and operate the Project and avoid unnecessary clearing. This will involve inputs from the design team, construction contractor and where applicable, the constructing authority.
		Three EPBC Act TECs are known or have potential to occur within the vicinity of the Project footprint: Lowland Rainforest of Subtropical Australia; Natural grassland on basalt and fine-textured alluvial plains of northern New South Wales and southern QLD; and White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland. The following mitigation measures will be applied to the Project: ■ Pre-construction surveys will be carried out to confirm to what extent the identified TECs occur within, or adjacent to the Project footprint[1,2,3]. Surveys will be carried out using diagnostic criteria/condition threshold detailed in relevant Approved conservation advice for the community. Where TECs are found to occur condition assessment will be undertaken (using BioCondition assessment) with regular monitoring against initial assessment values. Corrective actions to minimise impacts are to be implemented where Project-associated impacts are identified. ■ If found to occur within the Project disturbance footprint - quantification of the area of TECs removed to enable the Environmental Offsets Delivery Strategy - Qld to be refined ■ The Soil Management Plan is to include soil conservation measures and erosion and sediment controls with specific reference/controls to identified TEC areas ■ The Biosecurity Management Plan will include reference to relevant guidelines to control potential deleterious pathogens including *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities both of which may impact eucalypt and rainforest species. ■ Design modifications during the detailed design phase will seek to maintain inundation regimes within any occurrence of a TEC potentially impacted by the Project as close to natural conditions as possible. ■ Annual monitoring of TECs retained within the Project footprint against the initial BioCondition assessment. Corrective actions to be implemented where Project-associated impacts are identified[3] ■ Rehabilitation of disturbed areas, within the Project footprint but outside of the rail corridor, using local native species
		Flora and fauna surveys will be undertaken within and immediately adjacent to the Project footprint where they are required to verify prior surveys and assessments, refine potential offsets, inform micro-siting of infrastructure, support secondary approvals and establish baseline conditions against which relevant outcomes of the Reinstatement and Rehabilitation Plan and monitoring activities can be compared. Methods and sequencing of surveys, including seasonal timing, will be in accordance with the relevant published State and Commonwealth survey guidelines and conservation advices for each target species (e.g. *Survey guidelines for Australia's threatened birds* (DEWHA 2010a)) or Queensland guidelines where Commonwealth guidelines do not exist (e.g. *Protected Plants Survey Guidelines* (DES 2020c)) Flora species to be targeted through these surveys include, but are not limited to the following species: ■ Hairy-joint grass (*Arthraxon hispidus*) ■ Bunya Mountains bluegrass (*Bothriochloa bunyensis*) ■ Miniature moss-orchid (*Bulbophyllum globuliforme*)

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Stream clematis (*Clematis fawcettii*) ■ King bluegrass (*Dichanthium queenslandicum*) ■ Bluegrass (*Dichanthium setosum*) ■ Hawkweed (*Picris evae*) ■ Austral cornflower (*Rhaponticum australe*) ■ Wandering pepper-cress (*Lepidium peregrinum*) ■ Four-tailed grevillea (*Grevillea quadricauda*) ■ Blunt-leaved leionema (*Leionema obtusifolium*) ■ *Paspalidium grandispiculatum* (a grass) ■ Waxy sarcochilus (*Sarcochilus hartmanii*) ■ Blotched sarcochilus (*Sarcochilus weinthalii*) ■ Brush sophora (*Sophora fraseri*) ■ Austral toadflax (*Thesium australe*) Fauna surveys, including terrestrial, aquatic habitats and breeding habitats (including burrows and hollow bearing trees/logs, existing culverts and structures). Fauna species to be targeted through these surveys include but not be limited to the following species: ■ Five-clawed worm-skink (*Anomalopus mackayi*) ■ Regent honeyeater (*Anthocharea phrygia*) ■ Australasian bittern (*Botaurus poiciloptilus*) ■ Curlew sandpiper (*Calidris ferruginea*) ■ Spotted-tail quoll (*Dasyurus maculatus maculatus*) ■ Collared delma (*Delma torquata*) ■ Red goshawk (*Erythrotriorchis radiatus*) ■ Grey falcon (*Falco hypoleucos*) ■ Painted honeyeater (*Grantiella picta*) ■ Swift parrot (*Lathamus discolor*) ■ Murray cod (*Maccullochella peelii*) ■ Greater glider (*Petauroides volans*) ■ Brush-tailed rock-wallaby (*Petrogale penicillata*) ■ Koala (*Phascolarctos cinereus*) ■ Long-nosed potoroo (*Potorous tridactylus tridactylus*) ■ New Holland mouse (*Pseudomys novaehollandiae*) ■ Grey-headed flying-fox (*Pteropus poliocephalus*) ■ Australian painted snipe (*Rostratula australis*)

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Black-breasted button-quail (*Turnix melanogaster*) ■ Condamine earless dragon (*Tympanocryptis condaminensis*) Where a species is detected this will be reported to the relevant agencies along with information on the species habit, habitat in which the species was identified and where possible, population size and local threatening processes. The information will be used to refine the predictive habitat mapping, significant residual impact assessment, disturbance limits, mitigation measures and offsets. Surveys of representative MNES habitat that will be impacted by the Project will be undertaken in accordance with the *Guide to determining terrestrial habitat quality - methods for assessing habitat quality under the Queensland Environmental Offsets Policy. Version 1.3* (DES 2020c) and the *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy* (DSEWPaC 2012a) to enable a condition assessment of vegetation communities that require offset for the Project.
		Based on the outcome of flora, fauna and MNES habitat surveys: ■ Work with the design team and construction team to implement measures to avoid and/or further minimise the extent of impacts (i.e. designate no-go zones, reduce the construction or operational footprint within or adjacent to communities or habitat for MNES, define clearing limits) ■ This information will inform staged and sequential clearing (i.e. clearing of non-habitat trees in area, then a wait period and then the clearing of the remaining habitat) ■ Identify suitable locations for the release of fauna that may be encountered during pre-clearing or clearing or for the salvaging of microhabitats.
		For any threatened flora species identified through surveys within the disturbance footprint, consult with relevant specialist to determine the feasibility of translocating or propagating specimens in accordance with relevant guidelines (e.g. *Guidelines for the Translocation of Threatened Plants in Australia* (Commander et al. 2018)), including the collection of seed. Feasibility will be assessed noting that not all species can be translocated or propagated and that for the majority of the species identified as potentially occurring with the Project disturbance footprint there is limited evidence of these species being successfully translocated, even though some are used in the horticultural industry.
		The following species-specific measures for MNES flora species listed as potentially present (refer list of species above): ■ Avoid works in areas that may support an important population of the species ■ Undertake protected flora surveys as per *Protected Plants Survey Guidelines* (DES 2020b) with a particular focus within areas predicted as supporting the species (refer species habitat mapping in Appendix G).
		The following species-specific measures for Murray cod (*Maccullochella peelii*) will be implemented: ■ Avoid clearing within and along major watercourses, through the use of bridge structures and the placement of pylons away from bed and banks ■ Pre-construction surveys of waterways identified as *potential habitat* of species (i.e. Gowrie Creek) to identify whether Murray cod occurs. Surveys will follow the *Survey guidelines for Australia's threatened fish* (DSEWPaC 2011a) ■ Where a temporary impoundment or diversion is required for construction purposes and the species is found to be present, the Flora and Fauna Sub-plan will include requirements for an appropriately qualified person to be consulted to make an assessment on the method of recovery, transport and release of fish. The Flora and Fauna Sub-plan will include requirements for the application of follow relevant State (DAF) fish salvage guidelines during construction activities.

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ The Biosecurity Management Plan will include measures to manage the risk of translocating non-endemic flora and fauna through dewatering and fish salvage activities ■ The Surface Water Sub-plan will be developed to include measures to maintain low flows during drought conditions and avoid fluctuations to water levels downstream during spawning period (i.e. Gowrie Creek) ■ The Reinstatement and Rehabilitation Plan will establish requirements for instream and riparian habitats impacted by Project works. This includes restoration of natural riparian vegetation and where possible, reinstatement of instream habitat to pre-construction state (e.g. replacement of large woody debris and ensure no or limited change to instream flows and allow fish passage).
		The following species-specific measures for Spotted-tail quoll (*Dasyurus maculatus maculatus*) Long-nosed potoroo (*Potorous tridactylus tridactylus*), New Holland mouse (*Pseudomys novaehollandiae*) and Brush-tailed rock-wallaby (*Petrogale penicillata*) will also be implemented: ■ Avoid works above the tunnel as this area is a key corridor to maintain movement during construction and operation of the Project ■ Targeted surveys for identified mammal species will follow the *Survey guidelines for Australia's threatened mammals* (DSEWPaC 2011c) and include the identification of species-specific habitat (refer species habitat mapping in Appendix G) and habitat features considered suitable for species presence (e.g. cliff faces/boulder piles for Brush-tailed rock-wallaby and Spotted-tail quoll) ■ The Flora and Fauna Sub-plan will include restricted works measures for implementation if the above mentioned species are observed within or adjacent to disturbance footprint to allow safe movement away from works area. These measures may include, but are not limited to the following: – Measures to remove carrion from the Project disturbance footprint (and the rail corridor), along with waste management measures – Pest control measures in known or potential habitat for the abovementioned species to consider risks to the species (e.g. use of baiting to control wild dogs. predation) – Salvage hollow logs and rocky outcrops removed from the Project disturbance footprint into adjoining habitat – Establish buffer zones around known key habitat and den sites – Where possible avoid clearing within the known habitat) during the breeding season where possible – Measures to manage the clearing of hollow logs and hollow bearing trees (e.g. tapping of tree prior to clearing, removal of hollows prior to clearing and grubbing activities).
		The following species-specific measures for Swift parrot (*Lathamus discolor*) will also be implemented: ■ Where possible through design, reduce the disturbance footprint in winter foraging habitat, including avoiding clearing for ancillary works ■ Incorporate winter foraging tree species into the landscape design and Reinstatement and Rehabilitation Plan.
		The following species-specific measures for Australian painted snipe (*Rostratula australis*), Curlew sandpiper (*Calidris ferruginea*) and Australasian bittern (*Botaurus poiciloptilus*) will also be implemented: ■ Targeted surveys to be undertaken of potential habitat following the *Survey guidelines for Australia's threatened birds* (DEWHA 2010a) where applicable ■ Should the above mentioned species or other target wetland species be found to occur, the Flora and Fauna sub-plan will include: – Clearing/construction works in potential habitat areas will be timed where possible to avoid wet conditions where habitat is likely to be most suitable

Delivery phase	Environmental value impacted	Mitigation and management measures
		– Restricted works/avoidance measures in place should nesting be detected. ■ The CEMP will include measures to minimise noise as much as feasible and the Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods ■ The Biosecurity Management Plan will include site hygiene and waste management measures to ensure pest predator fauna are not attracted to works areas or utilising Project disturbance footprint.
		The following species-specific measures for Collared delma (*Delma torquata*), Condamine earless dragon (*Tympanocryptis condaminensis*) and Five-clawed worm-skink (*Anomalopus mackayi*) will also be implemented: ■ Targeted pre-construction surveys to be undertaken as per *Survey guidelines for Australia's threatened reptiles* (DSEWPaC 2011b) where suitable habitat is identified (refer species habitat mapping in Appendix G) ■ The Flora and Fauna Sub-plan will include restricted works measures for implementation if the any of the abovementioned species is observed within or adjacent to disturbance footprint to allow safe movement away from works area. Other measures may include, but are not limited to the following: – Measures to ensure retrieval of potential habitat elements (e.g. loose surface rock, large fallen timber) during vegetation clearing and placement in adjacent unimpacted habitat – Erosion and sediment control measures in steep slopes (known *important habitat* for Collared delma) to avoid/minimise slippages – Measures to allow safe handling of fauna (where required) and repatriation in a suitable habitat away from site – Undertake pre-clearance ground surveys for threatened reptile species where pre-construction surveys have identified the species as occurring or likely to occur (refer species habitat mapping in Appendix G).
		The following species-specific measures for Red goshawk (*Erythrotriorchis radiatus*), Regent honeyeater (*Anthochaera phrygia*), Painted honeyeater (*Grantiella picta*), Black-breasted button-quail (*Turnix melanogaster*) and Grey falcon (*Falco hypoleucos*) will also be implemented: ■ Pre-clearing surveys of woodlands identified as potential habitat for the above mentioned species (refer species habitat mapping in Appendix G) will be undertaken to identify whether individuals occur and potentially nest (Red goshawk only) within the disturbance footprint. Surveys for nest sites within or near the disturbance footprint will be as per MNES guidelines where suitable nesting habitat (i.e. large emergent trees near water) are identified. ■ Where nesting is identified in pre-clearing surveys, the Flora and Fauna Sub-plan will include restricted works measures for construction to allow nesting to continue undisturbed (e.g. micro siting of works to avoid nests or maximise separation distance, 100 m buffer and signage around nests, no disturbance to nests until after breeding season (being until fledglings/offspring no longer use the nest/roost for habitat). Some limited works may occur in the buffer zone during this period (e.g. cultural heritage surveys).
		The following species-specific measures for Koala (*Phascolarctos cinereus*) will also be implemented: ■ Avoid works above the tunnel as this area is a key corridor to maintain movement during construction and operation of the Project ■ Pre-clearing surveys to be undertaken of woodlands (and other relevant habitats) identified as potential habitat of species (refer species habitat mapping in Appendix G) to identify whether individuals occur within disturbance footprint ■ Project design to incorporate fauna crossing structures to allow fauna movement across alignment. The location and frequency of the passages will be based on an understanding of local Koala movements and in consultation with relevant stakeholders (e.g. DTMR and local councils.

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Fauna and fencing in accordance with ARTC guidelines and DTMR's Fauna Sensitive Road Design Manual (DTMR 2010). Fencing extent will be determined by the availability of suitable habitat adjacent to alignment. ■ Viaducts and the bridge structures will assist in the retention of corridor(s) of at least 100 m width. While the tunnel will ensure a corridor over 5.5 km wide is maintained in the western portion of the Toowoomba Range. ■ The Flora and Fauna Sub-plan will include restricted works measures for implementation within or adjacent koala habitat to allow safe movement away from works area. These measures may include, but are not limited to the following: – Staged and sequential clearing within koala habitat in areas where koala have been identified as being present (e.g. undertake pre-clearing koala searches on the morning prior to clearing commencing). Clearing works will involve supervision from a koala spotter-catcher – Measures to allow safe handling of koalas (where required) and repatriation in suitable habitat away from site – Requirements for koalas subject to handling to be examined and if suspected of Chlamydia infection will be taken to a predesignated veterinarian/wildlife care facility for treatment prior to release – A procedure to guide koala interactions, including any translocations – Appropriate construction traffic speed limits will be established and managed to minimise vehicle strike risk – Incorporation of koala trees in landscape design and rehabilitation works, especially along existing corridors which are to be retained (e.g. riparian corridors).
		The following species-specific measures for Greater glider (*Petauroides volans volans*) will also be implemented: ■ Pre-clearing surveys to be undertaken of woodlands (and other relevant habitats) identified as potential habitat for the species (refer species habitat mapping in Appendix G) to identify whether individuals occur within disturbance footprint, including potential movement pathways, nest sites (i.e. hollow bearing trees) and feeder trees ■ Fauna fencing in accordance with ARTC guidelines and DTMR's Fauna Sensitive Road Design Manual (DTMR 2010). Fencing extent will be determined by the availability of suitable habitat adjacent to alignment. Also, where possible, avoid the use of barb wire particularly on the top strand, to prevent threatened species (particularly Greater glider, flying-foxes and microbats) from becoming entangled. Fauna friendly fencing must be used, whilst being in accordance with landowner and/or structural requirements. ■ The Flora and Fauna Sub-plan will include: – Pre-clearing surveys to identify and map out hollow bearing trees, feeder trees and potential movement pathways – Consultation with the project team and construction team to determine whether key microhabitats can be avoided – Where key microhabitats cannot be avoided developed protocols/procedures to manage these features, including inspecting and relocating hollow bearing trees into adjacent habitat and the use of nest boxes, tapping of hollows bearing trees or where possible by lowering trees slowly with a claw extension prior to clearing. This works would be done under the on consultation with a suitably qualifier ecologist and where necessary under the supervision of a spotter-catcher.
		The following species-specific measures for Grey-headed flying-fox (*Pteropus poliocephalus*) will also be implemented: ■ Pre-clearing surveys to be undertaken of riparian habitat identified as potential roost sites of species to identify whether camps occur within or near the disturbance footprint. It is noted a roost site that previously supported the species has been identified approximately 540 m from the Project near Toowoomba. The nearest known roost currently occupied by the species is located 5 km north of the Project (Highfields area) ■ Where possible, reduce the disturbance footprint in winter foraging species, including avoiding clearing for ancillary works

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Incorporate winter foraging species into the landscape design and Reinstatement and Rehabilitation Plan ■ Work with the design team and property team to incorporate fencing which minimises the risk of entanglement (e.g. avoid the use of barbed wire fencing with a high tensile wire strand as the top wire) ■ The Flora and Fauna Sub-plan will include measures to be implemented should a roost site be found to occur. These will incorporate the mitigation standards detailed in the *Commonwealth's Referral guideline for management actions in grey-headed and spectacled flying-fox camps* (DotE 2015a).
		For other MNES species included in the initial impact assessments for MNES flora and MNES fauna, review the outcome of additional flora and fauna surveys, and ensure the species-specific measures are appropriately implemented for survey, landscape design, the Reinstatement and Rehabilitation Plan or the Flora and Fauna Sub-plan.
		Develop a post-construction MNES monitoring plan. The MNES monitoring plan will be informed by the survey results and developed in consultation with relevant stakeholders. The MNES monitoring plan will define the TEC or other MNES habitat location, reference condition, assessment framework, infrastructure elements (e.g. erosion and sediment control devices, fauna crossing structures), corrective actions, completion criteria and monitoring timeframes.
		Project design to incorporate minimum lighting requirements feasible for Project safety.
	Surface water quality and erosion	The potential for Project works to impact MNES through erosion, soil loss, land degradation, sedimentation or decreased surface water or groundwater quality or availability will be managed through the following: ■ Soil surveys to further characterise soil conditions across the disturbance footprint at a suitable scale to inform detailed design, including appropriate design responses where reactive or problem soils are present or suspected ■ Contaminated land surveys to inform detailed design and subsequent contaminated land strategy ■ A Soil Management Plan will be developed to provide the framework for the stripping, storage, treatment and reuse of topsoil ■ An Erosion and Sediment Control Plan (ESCP) will be developed as part of the CEMP, in accordance with the International Erosion Control Association's *Best Practice Erosion and Sediment Control* (IECA 2008). It will include: – Soil/land conservation objectives for the Project – Management of problem soils – Temporary/permanent drainage, erosion and sediment control measures – Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material – Vehicle, machinery and imported fill hygiene protocols and documentation – Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction – Where practical and or in accordance with specific flora and fauna management plans, vegetation clearing and ground disturbing works will be staged sequentially across the Project to minimise areas exposed to erosion and sediment risk of receiving waterways and drainage lines in accordance with the general environmental duty of the *Environmental Protection Act 1994* (Qld) – Measures for minimising the exposure time of unprotected materials to prevent sedimentation of receiving waterways and subsequent impacts to ecological receptors

Delivery phase	Environmental value impacted	Mitigation and management measures
		– A process for site- and activity-specific preparation when forecast large or high-intensity wet weather events are predicted. This may include, but not be limited to, removing equipment out of riparian zones, stabilising/covering live work areas, additional application of soil binders/veneers and pre event treatment, and dewatering of sediment basins. – Process for the continuous review of effectiveness of erosion and sediment controls ■ Water quality monitoring requirements as defined in the Surface Water Sub-plan to assess the effectiveness of erosion and sediment controls and reinstatement and rehabilitation programs ■ The ESCP will align with the Reinstatement and Rehabilitation Plan and will include progressive stabilisation of earth materials and soil consolidation to prevent erosion and sedimentation in areas within the disturbance footprint that do not form part of the permanent works (e.g. temporary construction compounds, temporary waterway barrier works and laydown areas etc.) ■ A surface water monitoring framework, which will inform the development of the Surface Water Sub-plan and construction water quality monitoring program. It will identify monitoring locations including upstream, downstream and at the intersection of the Project disturbance footprint and watercourse. It will include the relevant water quality objectives, parameters, criteria and specific monitoring locations, frequency and duration identified in consultation with relevant regulators to reduce impacts to surface water quality. ■ The Surface Water Sub-plan will establish the construction water quality monitoring program which will include (as a minimum): – Analysis of the representative background monitoring dataset – Identification of Project works and activities during construction and operation, including runoff, emergencies and spill events, that have the potential to impact on surface water quality of potentially affected waterways and riparian land (via discharge points) – A risk management framework for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of impacts that trigger contingency and ameliorative measures. ■ Potential aquatic and terrestrial GDEs will be field-truthed to confirm presence ■ Further geotechnical investigations will be undertaken at deep cut sections to inform design and location-specific construction management of groundwater. ■ Risks associated with dewatering (i.e. water table lowering) and environmental management requirements during construction will be identified through appropriate baseline groundwater monitoring, modelling and analysis, and incorporated into the CEMP.
	Riparian vegetation and aquatic habitats	Project design minimises impacts to waterways, riparian vegetation and in-stream flora and habitats by: ■ Adopting a waterway crossing structure hierarchy: bridges/viaducts preferred to culverts, to maintain infrastructure permeability for fauna at identified habitat connectivity points, however local conditions and constructability impacts must be considered when determining the preferred environmental solution ■ Avoiding, then minimising the extent and duration of temporary waterway diversions. Where unavoidable, implement water quality, erosion and sediment control measures to minimise impacts to downstream environments and water users. ■ Continuing to refine Project design in response to hydraulic modelling outcomes. This includes addressing flood impact objectives which include consideration of peak water levels, flow distribution, velocities, and duration of inundation, and implications for fish passage. This will confirm bridge lengths, culvert sizing and numbers, localised scour and erosion protection measures for both rail, road and other permanent Project infrastructure.

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Avoiding, then minimising the extent of permanent waterway diversions. Where unavoidable, waterway diversion design to include simulation of natural features e.g. meanders, pools, riffles, shaded and open sections, deep and shallow sections and different types of sub-strata, depending on the pre-disturbance environmental values, as per requirements of relevant and applicable conditions of approval, legislation, regulations and industry guidelines. Maintenance activity locations, construction compounds and storage areas will be defined as part of Project detailed design and positioned away from waterways. ■ Stormwater controls, such as scour protection, are to be further developed and incorporated where necessary to achieve compliance with established water quality objectives. Temporary and permanent measures must be appropriate to the site conditions, responding to the erosion risk assessment, environmental receptors, climatic zone and seasonal factors. The ESCP will establish and specify the monitoring and performance objectives for handover to operational management on completion of construction. ■ Ensuring the disturbance footprint extents allow sufficient space for provision of the required temporary and permanent erosion and sediment control measures/pollution control measures defined during detailed design ■ Undertaking rehabilitation of temporary waterway crossings in accordance with the Reinstatement and Rehabilitation Plan ■ Developing ESCPs for implementation during pre-construction, construction and commissioning
	Water quality	■ A Surface Water and Hydrology Sub-plan will be developed as a component of the CEMP. The Sub-plan will provide a surface water monitoring framework for the Project that establishes: – Additional monitoring and sampling required to establish baseline water quality conditions, as a continuation of data collected during the EIS. Baseline water quality conditions will preferentially utilise water quality monitoring sites used within the EIS, with consideration of construction activities, seasonality and watercourse sensitivity. These will be monitored, at a minimum monthly, for a period of 12-24 months prior to construction to determine baseline conditions as a reference for monitoring of impact (as per QLD Water Quality Guidelines (QWQG)). – Watercourse-specific water quality criteria, based on baseline data, ANZECC/ARMCANZ, QWQG and relevant Water Quality Objectives (WQO) – Frequency and location of surface water sampling during construction of the Project, with consideration for: ■ Construction activities with potential to impact water quality ■ Seasonality ■ Sensitivity of receiving watercourses – A risk management framework will be prepared for evaluation of the risks to surface water quality and ecosystems in the receiving environment, including definition of instances (including accidental discharge of contaminants and sediments) that trigger contingency and ameliorative measures – In-situ water quality parameters will be tested (pH, Electrical Conductivity, dissolved oxygen, temperature, Oxidation-reduction Potential and Total Dissolved Solids) and laboratory analysis required for samples collected at each sampling location – QA/QC requirements for surface water sampling and analysis – Location specific impact thresholds – Responses to impact threshold exceedances (to be determined after the establishment of baseline water quality conditions) – Data management and reporting requirements.

Delivery phase	Environmental value impacted	Mitigation and management measures
	Fauna passage[1,2]	■ Refine fauna passage locations and associated rehabilitation areas in the design to maintain infrastructure permeability, particularly at the key locations identified as part of the EIS assessment process to maintain and/or re-establish habitat connectivity. ■ Design of fauna passage structures and associated rehabilitation areas will respond to local topographical and hydrological context, with consideration of safety requirements for the rail corridor and adjoining properties. ■ Design bridges and culverts to accommodate terrestrial fauna passage where assessed as appropriate, in addition to fish passage design requirements. ■ Fauna passage design will be consistent with the intent of DTMR's Fauna Sensitive Road Design Manual (DTMR 2010) and where applicable species specific requirements.
	Fauna fencing[1,2]	■ Fauna fencing opportunities will be further assessed and, where appropriate, developed during detailed design to limit fauna strike and fauna mortality risk and/or maintain habitat connectivity. This will include: – Assessment of the compatibility of each approach for the targeted local species with the general fencing principles at each proposed fencing location – Consideration of safety requirements for the rail corridor and adjoining properties – Consultation with adjoining landholders – Requirements for maintaining an appropriate clearance buffer between adjacent vegetation and fauna fences – Consideration for maintenance constraints and responsibilities that a fauna connectivity or fencing opportunity may introduce to operations. ■ Fauna fencing will be designed with reference to DTMR's Fauna Sensitive Road Design Manual (DTMR 2010). Additional expert guidance in relation to specific design features will be sought during the detailed design process. ■ The design will aim to maximise infrastructure permeability by connecting fauna fencing with safe crossing opportunities.
	Aquatic fauna	■ Design watercourse crossing structures (including culverts and bridges) to maintain fish passage where applicable in accordance with *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works. ■ The design will aim to minimise the need for ongoing maintenance and inspection to maintain fish passage. ■ Develop a dewatering strategy in accordance with the Biosecurity Act, providing reasonable measures to avoid the spread of pest species and in accordance with any required aquatic fauna species management plans and water quality objectives defined in the outline CEMP. ■ Where a temporary impoundment or diversion is required for construction purposes and the species is found to be present, the Flora and Fauna Sub-plan will include requirements for an appropriately qualified person to be consulted to make an assessment on the method of recovery, transport and release of fish. The Flora and Fauna Sub-plan will include requirements for the application of follow relevant State (DAF) fish salvage guidelines during construction activities. ■ The Biosecurity Management Plan will include measures to manage the risk of translocating non-endemic flora and fauna through dewatering and fish salvage activities.

Delivery phase	Environmental value impacted	Mitigation and management measures
	Flora and fauna (general)	Develop the Flora and Fauna Sub-plan to include appropriate criteria, directives and procedures in relation to: ■ Pre-clearing surveys, including terrestrial, aquatic and wetland habitats, protected plants, breeding habitats (including burrows and hollow bearing trees/logs, existing culverts and structures, riparian habitat identified as potential roost sites) for both threatened and non-threatened species by suitably qualified persons ■ Staged and sequential clearing protocols ■ Signage requirements for the delineation of no-go areas and clearing extents, including avoiding works above the tunnel as this area is a key corridor to maintain movement during construction and operation of the project ■ Animal handling protocols, including relocation and emergency care. For example, koalas subject to handling will be examined and if suspected of Chlamydia infection will be taken to a predesignated veterinarian/wildlife care facility for treatment prior to release ■ Works protocols to allow safe movement away from works area, should other fauna be observed within or adjacent to the works area ■ Requirements for inspections and corrective actions during construction and rehabilitation activities ■ Requirements for fauna and flora management actions to be undertaken by suitably qualified persons ■ Requirements for training, inspections, corrective actions, notification and classification of environmental incidents, record keeping, monitoring and performance objectives for handover on completion of construction ■ Where feasible and practicable, locate construction areas including compounds, stockpiles, fuel storage, laydown areas and staff parking outside the tree protection zone as defined in AS4970-2009 Protection of trees on development sites. ■ Where practical, existing tracks will be used and the design for new access tracks (permanent and temporary) will be undertaken with the aim of minimising disturbance of substrate and vegetation.
	Weeds and pests	Develop the Biosecurity Management Plan[1,2,3] to include: ■ Requirements for pre-clearing surveys in areas immediately adjacent to the Project disturbance footprint to determine the risk of environmental weeds and pests including prohibited and restricted matters prescribed under the Biosecurity Act and Biosecurity Regulation 2016 being present ■ Relevant guidelines to control potential deleterious pathogens including *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities both of which may impact Melaleuca and eucalypt species. ■ Revegetation species to be obtained from source certified free of *Phytophthora cinnamomi* ■ Mapping of the existing extent and severity of any weed infestation and weed management requirements in the disturbance footprint or on adjacent land, (restricted matters including Small-leaved privet, Opuntioid cactus, and Lantana species) ■ Pest animal management, including Red imported fire ants management within the Biosecurity Zones 1 and 2 as per current DAF advice ■ Weed surveillance and treatment during construction and rehabilitation activities ■ Vehicle and plant washdown protocols when traversing properties via temporary access tracks or if any high risk areas are identified during the Project construction ■ Requirements in relation to pesticide and herbicide use and documentation, recognising the *Agricultural Chemicals Distribution Control Act 1966* (Qld) requirements including any limitations on use, such as, restrictions on use in sensitive environmental areas, drainage lines that flow to waterways and aquatic habitats, and ensuring that broad scale use does not result in an increased erosion and sediment risk ■ Vehicle and plant equipment and imported fill hygiene protocols and documentation

Delivery phase	Environmental value impacted	Mitigation and management measures
		■ Erosion and sediment control risks associated with broad scale weed removal or treatment ■ Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material ■ Consideration of local government Biosecurity Plans (Toowoomba Region Biosecurity Plan (August 2020) ■ Dewatering and fish salvage requirements to manage the risk of translocating non-endemic flora and fauna ■ Requirements for monitoring the effectiveness of weed hygiene measures. ■ Develop the Community Engagement Sub-plan in the CEMP, to enable members of the public to assist with weed surveillance in the vicinity of Project works.
	Rehabilitation	Landscape design establishes the requirements for rehabilitation of disturbed areas for habitat re-creation, landscaping and stabilisation, including for riparian zones and informs the development of the Reinstatement and Rehabilitation Plan[1,3]. This will also include criteria for retrieval of potential habitat elements (loose surface rock, large fallen timber) during vegetation clearing for habitat recreation where appropriate. Develop a Reinstatement and Rehabilitation Plan for areas within the disturbance footprint that do not form part of the permanent works (e.g. construction compounds, laydown areas, temporary access tracks etc). The Plan will include and clearly identify: ■ Location of areas subject to rehabilitation and/or reinstatement/stabilisation, in accordance with the landscape and rehabilitation design developed during detailed design, including operational rail safety considerations ■ Objectives and timeframes for rehabilitation and/or reinstatement/stabilisation works (including biodiversity, vegetation establishment and erosion and sediment control outcomes to be achieved) ■ Where appropriate, the plan describes how the objectives align with relevant recovery plans, threat abatement plans, conservation advices or policy guidance for target species in areas identified for rehabilitation ■ Details of the actions and responsibilities to progressively rehabilitate, regenerate, and/or revegetate areas, consistent with the Reinstatement and Rehabilitation Plan objectives ■ Native flora species endemic to the Toowoomba region or other suitable species appropriate to the landscape context and nursery/seed stock sources. Where possible (i.e. propagated material is available) include MNES species (e.g. *Sophora fraseri*) in rehabilitation activities. ■ Incorporate koala trees in landscape design and rehabilitation works, especially along existing corridors which are to be retained (e.g. riparian corridors) ■ Procedures, timeframes, measurable performance objectives and responsibilities for monitoring the success of rehabilitation and/or reinstatement/stabilisation areas ■ Corrective actions if the outcomes of rehabilitation and/or reinstatement/stabilisation are not achieved ■ Post construction maintenance requirements, monitoring requirements and completion criteria.
	Offsets[1,2]	■ Restriction of the Project disturbance footprint through detailed design as far as practical to that required to safely and efficiently construct and operate the Project[1,2,3]. ■ Significant adverse residual impacts to habitat for MNES will be re-calculated to confirm the Project's offset obligations under Australian Government and State requirements based on the outcomes of the flora, fauna and MNES habitat surveys. ■ A Environmental Offset Delivery Plan will be developed to provide for the staged delivery of offsets, where appropriate, ahead of relevant clearing works being undertaken and finalised in consultation with relevant Australian Government and State regulatory agencies (refer Appendix I of this Report: Environmental Offset Delivery Strategy QLD).

Delivery phase	Environmental value impacted	Mitigation and management measures
Pre-construction	Flora and fauna	■ Implement the Flora and Fauna Sub-plan. ■ Undertake pre-clearing surveys in any areas to be cleared to enable pre-construction activities and confirm the species-specific works protocols to be implemented. ■ Document the area and type of vegetation cleared in a post clearance summary, including MNES for offsetting and compliance purposes.
	Landscape, rehabilitation and stabilisation	■ The Reinstatement and Rehabilitation Plan will guide the approach to rehabilitation and be implemented progressively during pre-construction and construction phase activities.
	Weeds and pests	■ Implement the Biosecurity Management Plan during pre-construction to reduce the potential for the spread of weeds and pests into the surrounding environments and land uses.
	Erosion and sediment control	■ Implement appropriate site stabilisation treatments, including seeding and planting requirements, in accordance with the ESCPs and Reinstatement and Rehabilitation Plan.
Construction	■ Flora and fauna (including MNES)	■ Project clearing extents are limited to that which is required to safely construct, operate and maintain the Project, in accordance with the approved disturbance footprint. ■ Locate temporary construction facilities compounds, stockpiles, fuel storage, laydown areas, temporary access roads and staff parking to minimise the extent of disturbance on existing habitat and significant vegetation (i.e. undertake micro-siting of these temporary activities and facilities). ■ Appropriate construction traffic speed limits will be established and managed to minimise vehicle strike risk. ■ Clearly define clearing boundaries associated with the construction disturbance footprint with flagging or marking tape, signage or other suitable means to delineate no go areas. Undertake this delineation and marking process in a manner that is consistent with the Project flagging/marking tape process and specifications, to ensure that it is consistent with the wider Project control processes and does not conflict or contradict any other demarcation practices. ■ Staged and sequential clearing where feasible to minimise the extent of exposed areas. Where possible, minimise loss of canopy vegetation and works that will lead to the proliferation of weed species[1]. ■ A qualified Fauna Spotter Catcher will undertake pre-clearance surveys of habitats and vegetation, including where applicable fauna reduction activities. The Fauna Spotter Catcher will supervise the subsequent clearing. The area and type of vegetation cleared will be documented where required for compliance with secondary approvals and offset purposes[1,2,3]. ■ Implement the post-construction MNES Monitoring Plan. Continue monitoring each nominated MNES against initial assessment values, until completion criteria are achieved. Corrective actions to be implemented where Project-associated impacts are identified. ■ Implement Air Quality Sub-plan to minimise dust impacts including dust monitoring and suppression methods.

Delivery phase	Environmental value impacted	Mitigation and management measures
	Riparian vegetation and aquatic habitats	■ Locate construction areas including compounds, stockpiles, fuel storage, laydown areas, temporary and permanent access roads within the disturbance footprint. ■ Undertake a flood/drainage assessment to inform the siting and scale of temporary construction areas (including stockpiles, construction compounds, fuel storage and laydown areas etc). Locate these areas on land that is not subject to flooding to the extent possible. ■ Siting of plant and equipment and refuelling facilities to be undertaken in accordance with *AS1940:2017 The storage and handling of flammable and combustible liquids*. ■ Implement the site-specific ESCPs. ■ Works within or adjacent to watercourses will be conducted in accordance with relevant secondary approvals including: – *Riverine protection permit exemption requirements* (WSS/2013/726) or conditions of a riverine protection permit issued for the Project – *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works. ■ Dewatering/extraction of water from artificial impoundments will be undertaken after consultation with relevant stakeholders. ■ Dewatering strategies will be required to comply with the Biosecurity Act to take reasonable measures to avoid the spread of pest species (with capacity to affect water quality) and in accordance with any required aquatic fauna species management plans. ■ The salvage and relocation of fish within isolated aquatic environments will be managed in accordance with DAF Guidelines for Fish Salvage. ■ An appropriately qualified person will be consulted to make an assessment on the method of recovery, transport and release of fish and other aquatic fauna, as required. As a minimum, the following will be implemented: – Relocation will be undertaken by a suitably qualified person – Dewatering pumps will have an intake screen – Records of all fish recovered, and the location of their release will be maintained. – In the event of a spill incident during construction, any impacted aquatic environments will be assessed for the presence of fauna. If necessary, salvage and recovery efforts will be undertaken[1].
	Flora	■ Minimise clearance of remnant vegetation to that necessary for safe and efficient construction and operation[1,2,3]. ■ Where practicable and feasible, locate construction areas including compounds, stockpiles, fuel storage, laydown areas, staff parking outside the tree protection zone as defined in *AS4970-2009 Protection of trees on development sites*. ■ Where possible, minimise loss of canopy vegetation and works that will lead to the proliferation of weed species. ■ Implement a Soil Management Plan as part of the CEMP, guiding the stripping, stockpiling and management of topsoil where it has the potential to contain seedbank or weed material. ■ Topsoil stockpiles will be managed to maintain the viability of soil seed banks for threatened flora ■ Plan and implement revegetation and rehabilitation works so that they do not create safety, maintenance or performance issues e.g. vegetation does not grow and obscure signals or impact longevity of rail infrastructure.

Delivery phase	Environmental value impacted	Mitigation and management measures
	Aquatic fauna	■ Construct temporary and permanent watercourse crossing structures in accordance with the detailed design and Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier. This is required to minimise impacts to aquatic fauna (i.e. fish passage) and hydrology during construction and operation.
	Fauna passage	■ Where incorporated in the final design, fauna movement opportunities will be constructed to reinstate safe fauna passage as soon as possible, in accordance with a fauna movement strategy which will be finalised and documented in the detailed design.
	Fauna fencing	■ Install fauna exclusion fencing in accordance with detailed design and fencing hierarchy especially in conjunction with the identified fauna passages/creek crossing locations for the Project to maintain permeability in the alignment[1,2].
	Weeds and pests	■ Implement the Biosecurity Management Plan during construction to reduce the potential for the spread of weeds and pests into the surrounding environments and land uses. ■ The effectiveness of weed hygiene measures will be monitored as a component of the environmental monitoring procedure for the Project. ■ Any vegetated material containing, or with the potential to contain, weed seed material will not be used for on-site mulching or erosion protection[1,2] ■ Implement the Community Engagement Sub-plan in the CEMP, to enable members of the public to assist with weed surveillance in the vicinity of Project works.
	Erosion and sediment control	■ Vegetation clearing and ground disturbing activities will be supplemented by the progressive installation of erosion and sediment controls including stabilisation works to minimise areas exposed to erosion and sediment risk. ■ Implement site stabilisation treatments in accordance with: – ESCP – Air Quality Sub-plan – Reinstatement and Rehabilitation Plan. ■ Assess the suitability of cleared vegetation for mulching/erosion protection on a case by case basis. Any vegetated material containing or with the potential to contain weed seed material will not be used for on-site mulching or erosion protection without prior treatment. For any unsuitable material i.e. noxious weeds etc, the cleared and grubbed material shall be removed from the site and disposed of in accordance with relevant statutory requirements and the Biosecurity Management Plan. ■ Re-use suitable mulch generated by construction of the Project within appropriate timeframes and manner as specified in the ESCP and the Reinstatement and Rehabilitation Plan.
	Landscape, rehabilitation and stabilisation	■ Construct landscaping treatments in accordance with the landscape design. ■ Implement the Soil Management Plan to protect MNES species (e.g. soil seedbanks and habitat). ■ Undertake progressive rehabilitation and reinstatement of disturbed areas in accordance with the Reinstatement and Rehabilitation Plan to minimise threatening process to MNES such as weed invasion.

Delivery phase	Environmental value impacted	Mitigation and management measures
Operation	Riparian vegetation and aquatic habitats	■ Undertake maintenance activities and refuelling facilities in accordance with *AS1940:2017 The storage and handling of flammable and combustible liquids.* ■ Maintenance activities within or adjacent to watercourses will be conducted in accordance with the intent of: – *Riverine protection permit exemption requirements* (WSS/2013/726) or conditions of a riverine protection permit issued for the Project – *Accepted development requirements for operational work that is constructing or raising waterway barrier works* (DAF 2018) or conditions of development approval for operational work that is constructing or raising waterway barrier works.
	Weeds and pests	■ Weed management protocols for the operational rail corridor and other ARTC facilities will be in accordance with the requirements of the Biosecurity Act and incorporated into the Operation EMP[1,2,3]. These protocols will include: – Site hygiene and waste management procedures to deter pest animals – Weed surveillance and treatment during operation and maintenance activities – Requirements in relation to pesticide and herbicide use, including any limitations on use. Restrictions may apply in proximity to watercourses, known areas of MNES habitat or land uses sensitive to spray-drift from the application of pesticides and herbicides. – Vehicle, machinery and imported fill hygiene protocols and documentation – Erosion and sediment control risks associated with broad scale weed removal or treatment – Corrective actions should the outcomes not achieve the adopted objectives ■ ARTC's Enviroline will be advertised for the Project to enable members of the public to notify ARTC of issues, including concerns regarding weeds and pests.
	Fauna passage	■ Where incorporated, fauna movement/passage infrastructure and surrounding vegetation will be inspected and maintained during operation to retain the integrity/viability of the fauna movement opportunities[1,2].
	Fauna fencing	■ Inspect and maintain fauna fencing in accordance with ARTC *Engineering (Track and Civil) Code of Practice – Section 17 Right of Way: Inspection and Assessment*[1,2]. ■ Fauna fencing will be maintained and where applicable monitored during the operational life of the Project (design life of 100-years). ■ Record vehicle strikes with Koalas and Greater gliders and investigate potential source of the issue Where applicable implement corrective measures (e.g. erect fauna friendly fencing, glider poles etc)

Table notes:

1 Mitigation measure successfully implemented as part of the Toowoomba Second Range Crossing Project.
2 Mitigation measure approved by the Commonwealth as part of the rail component for the Carmichael Coal Mine and Rail Project (EPBC 2013/6885) (refer measures within *Species Management Plans. Carmichael Rail Project* (CRN 2019)).
3 Mitigation measure commonly applied across other projects as approved by the Commonwealth in central and southern Queensland e.g. *Santos Significant Species Management Plan – GFD Project* (Santos 2016), *Anya Significant Species Management Plans* (Shell 2017), *Species Management Plans - Carmichael Rail Project* (CRN 2019).

5.3 Significant impact assessment

Potential flora and fauna impacts during construction, commissioning/reinstatement and operation have been assessed in accordance with the qualitative impact assessment methodology outlined in the EIS Chapter 4: Assessment methodology.

Potential impacts to environmental values due to construction of the Project are summarised in Section 5.3.2 and have been assessed in Sections 5.3.3, 5.3.4 and 5.3.5. For the purposes of impact assessment, the maximum potential direct disturbance to each MNES (i.e. areas identified using the predictive habitat mapping) have been used. This mapping assumes the presence of species if habitat has been identified as being present (i.e. habitat has been used as a proxy for species presence). This represents an application of the precautionary approach and represents a highly conservative estimate of Project impacts. Given the highly conservative approach adopted, impacts identified represent the maximum potential impact and assume a "worst-case" scenario in relation to the Project's disturbance.

The initial significance assessment is undertaken on the assumption that the design measures factored into the Project design (refer Section 5.2.1) have been implemented. The residual significance level of the potential impacts is reassessed taking into consideration the implementation of the proposed mitigation measures listed in Table 5.3. This has been split into consideration of the construction phase, the commissioning and reinstatement phase, and operations. Environmental offsets in response to residual impacts are discussed in Section 5.4.

5.3.1 Quantification of potential magnitude of impacts

Estimations of the potential magnitude of disturbance (i.e. clearing as a result of the Project) was undertaken for each MNES, using the total quantity of habitat as identified in Table 5.4. (i.e. combines the habitat categories to identify the maximum potential habitat loss). Note that the different habitat categories were considered in relation to the MNES significant impact criteria in Section 3.2.4.

The table also provides an estimate of the total extent of habitat within the MNES study area for each MNES and the per cent of this habitat being disturbed as a result of the Project.

Table 5.4 Estimation of potential magnitude of disturbance for each of the matters of national environmental significance identified for the Project

MNES	Total coverage of ecological receptor within the MNES study area (ha). Study area size = 7,827.39 ha	Total unmitigated potential disturbance area associated with the Project (ha). Project disturbance footprint = 456.81 ha	Percentage (%) disturbance to receptors within the MNES study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.6 for magnitude criteria)
TEC				
Lowland Rainforest of Subtropical Australia	1.5	0.00	0.00	Negligible
Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD	4.50	0.00	0.00	Negligible
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland – Critically Endangered.	100.30	0.00	0.00	Negligible
Threatened flora species habitat:				
Hairy-joint grass (*Arthraxon hispidus*)	382.32	9.18	2.40	Moderate
Bunya Mountains bluegrass (*Bothriochloa bunyensis*)	314.73	0.00	0.00	Negligible

MNES	Total coverage of ecological receptor within the MNES study area (ha). Study area size = 7,827.39 ha	Total unmitigated potential disturbance area associated with the Project (ha). Project disturbance footprint = 456.81 ha	Percentage (%) disturbance to receptors within the MNES study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.6 for magnitude criteria)
Miniature moss-orchid (*Bulbophyllum globuliforme*)	115.01	2.36	2.05	Moderate
Stream clematis (*Clematis fawcettii*)	0.71	0.00	0.00	Negligible
King blue-grass (*Dichanthium queenslandicum*)	294.33	0.67	0.23	Negligible
Bluegrass (*Dichanthium setosum*)	294.33	0.67	0.23	Negligible
Four-tailed grevillea (*Grevillea quadricauda*)	97.05	1.02	1.05	Low
Blunt-leaved Leionema (*Leionema obtusifolium*)	106.49	0.63	0.59	Negligible
Wandering pepper-cress (*Lepidium peregrinum*)	38.59	0.00	0.00	Negligible
Paspalidium grandispiculatum (A grass)	1,432.47	156.25	10.91	Moderate
Hawkweed (*Picris evae*)	1,657.52	31.88	1.92	Low
Austral cornflower *(Rhaponticum australe*)	721.36	63.02	8.74	Moderate
Waxy sarcochilus (*Sarcochilus hartmannii*)	88.55	0.00	0.00	Negligible
Blotched sarcochilus (*Sarcochilus weinthalii*)	414.82	3.14	0.76	Negligible
Brush sophora (*Sophora fraseri*)	605.22	31.05	5.13	Moderate
Austral toadflax (*Thesium australe*)	661.64	29.53	4.46	Moderate
Threatened fauna species habitat				
Birds				
Regent honeyeater (*Anthochaera phrygia*)	1,732.82	156.25	9.02	Moderate
Australasian bittern (*Botaurus poiciloptilus*)	272.32	8.90	3.27	Moderate
Curlew sandpiper (*Calidris ferruginea*)	272.32	8.90	3.27	Moderate
Red goshawk (*Erythrotriorchis radiatus*)	833.72	88.77	10.65	Moderate
Grey falcon (*Falco hypoleucos*)	3,322.29	211.69	6.37	Moderate
Painted honeyeater (*Grantiella picta*)	338.77	8.54	2.52	Moderate
White-throated needletail (*Hirundapus caudacutus*)	7,153.28	427.35	5.87	Moderate
Swift parrot (*Lathamus discolor*)	2,564.28	189.01	7.37	Moderate
Australian painted snipe (*Rostratula australis*)	272.32	8.9	3.27	Moderate
Black-breasted button-quail (*Turnix melanogaster*)	404.36	9.18	2.27	Moderate
Mammals				
Spotted-tail quoll (*Dasyurus maculatus maculatus*)	2,126.30	153.99	7.24	Moderate
Greater glider (*Petauroides volans*)	1,449.53	109.05	7.52	Moderate

MNES	Total coverage of ecological receptor within the MNES study area (ha). Study area size = 7,827.39 ha	Total unmitigated potential disturbance area associated with the Project (ha). Project disturbance footprint = 456.81 ha	Percentage (%) disturbance to receptors within the MNES study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.6 for magnitude criteria)
Brush-tailed rock-wallaby (*Petrogale penicillata*)	10.75	0.00	0.00	Negligible
Koala (*Phascolarctos cinereus*)	3,997.55	259.61	6.49	Moderate
Long-nosed potoroo (*Potorous tridactylus tridactylus*)	1,724.10	156.25	9.06	Moderate
New Holland mouse (*Pseudomys novaehollandiae*)	1,716.92	156.25	9.10	Moderate
Grey-headed flying-fox (*Pteropus poliocephalus*)	2,790.60	201.19	7.21	Moderate
Reptiles				
Five-clawed worm-skink (*Anomalopus mackayi*)	43.1	0.00	0.00	Negligible
Collared delma (*Delma torquata*)	2,376.80	197.41	8.31	Moderate
Dunmall's snake (*Furina dunmalli*)	0.00	0.00	0.00	Negligible
Condamine earless dragon (*Tympanocryptis condaminensis*)	371.37	16.22	4.37	Moderate
Fish				
Murray cod (*Maccullochella peelii*)	168.09	3.21	1.91	Low

Table note:

* There is potential for each of the receptor impacts to overlap spatially. As a result, addition of disturbance values presented in the above table would not represent a true reflection of the total Project disturbance footprint

5.3.2 Initial assessment of impacts and mitigation measures

Following the assessment of the sensitivity of MNES values, identification of the potential impacts to these values and the assessment of the magnitude of impact, an initial outline of the assessment of the impact of the Project on each MNES value was undertaken.

The magnitude of impacts presented in Table 5.4, takes into consideration direct impacts associated with the direct removal of habitat and also considers indirect impacts associated with air quality (refer EIS Chapter 12: Air Quality), surface water and hydrology (refer EIS Chapter 13: Surface Water and Hydrology), groundwater (refer EIS Chapter 14: Groundwater) and noise and vibration (refer EIS Chapter 15: Noise and Vibration). The initial assessment of potential impacts from the Project on MNES values is provided in the following section for TECs (refer Table 5.5), threatened flora (refer Table 5.6) and threatened fauna (refer Table 5.7). The assessments present an initial assessment significance of those impacts detailed in Section 5.1.2 considered appropriate to the MNES species or species groups assessed (i.e. application of mitigation measures already incorporated into the design), an outline of the mitigation measures detailed in Table 5.3 which are most appropriate to the species or species groups (further species-specific information is added where required), and an assessment of the reduction of impact following the application of Project's mitigation measures. The assessment provides a more targeted focus on those Project impacts most likely to affect individual MNES.

The initial assessment of impacts has taken a conservative approach and those MNES that returned an impact rating of Major, High, Moderate or Low are assessed using MNES Guidelines (refer Sections 5.3.3, 5.3.4 and 5.3.5).

Table 5.5 Initial impact assessment of the Project upon identified matters of national environmental significance – Threatened Ecological Communities

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland, Natural Grasslands and Lowland Rainforest TECs							
High	Pre-construction and Construction	Displacement of flora and fauna species from invasion of weed and pest species Dust impacts Erosion and sedimentation	Low	**Moderate**	None of these TECs are located within the Project disturbance footprint. The nearest mapped instance of each to Project works is as follows: ■ Lowland Rainforest TEC - 100 m from the Project disturbance footprint (confirmed) ■ White Box-Yellow Box-Blakely's Red Gum - 600 m from aboveground Project disturbance footprint (not confirmed as present) ■ Natural grasslands TEC - 1 km from the Project disturbance footprint (not confirmed as present) Flora and Fauna Sub-plan developed and in place prior to construction. Pre-construction surveys will be carried out to confirm whether TECs occur in the vicinity of the Project disturbance footprint. Where TECs are found to occur condition assessment will be carried (using Biocondition assessment) with regular monitoring against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified. Soil Management Plan developed and in place prior to construction. To include soil conservation measures and erosion and sediment controls with specific reference/controls to identified TEC areas Biosecurity Management Plan developed prior to construction. The MNES study area is already subject to significant weed invasion. The Plan will consider relevant guidelines to control potential deleterious pathogens including *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities both of which may impact Lowland Rainforest TEC. General measures to include: ■ Pre-construction weed assessment in TEC areas adjacent to construction footprint ■ Construction vehicle weed certification and wash down procedures in place	Negligible	**Low** (refer to Section 5.3.3 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					■ Contractor education on the requirements for site access regarding identified habitat (including procedures regarding clean clothing/footwear) ■ Weed monitoring within TEC in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified ■ Control protocols will be designed so as to reduce the risk of herbicides/chemicals entering the TEC Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods		
	Commissioning and reinstatement	Displacement of flora and fauna species from invasion of weed and pest species Erosion and sedimentation	Low	**Moderate**	■ Weeds and pests (pre-construction, construction and commissioning) ■ Erosion and sediment control (pre-construction, construction and commissioning) ■ Flora (detailed design, construction and commissioning) Soil Management Plan – continued maintenance of erosion and sediment controls with specific reference/controls to identified TEC areas Biosecurity Management Plan ongoing: ■ Construction vehicle weed certification and wash down procedures in place ■ Continued weed monitoring within TEC in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified In accordance with the MNES Monitoring Plan, regular monitoring and maintenance of erosion and sediment devices/infrastructure with specific reference/controls to identified TEC areas. Landscape, rehabilitation and stabilisation – rehabilitation of temporary construction areas.	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Operation	Displacement of flora and fauna species from invasion of weed and pest species Erosion and sedimentation	Negligible	**Low**	Soil Management Plan – ongoing regular monitoring and maintenance of erosion and sediment devices/infrastructure with specific reference/controls to identified TEC areas Biosecurity Management Plan ongoing: ■ Ongoing weed monitoring within TEC in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified ■ Annual TEC monitoring against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified.	Negligible	**Low**

Table notes:

1 Refer Table 3.8 for 'sensitivity' and 'magnitude' criteria.
2 Potential impacts to MNES in the above table are based upon those presented in Section 5.1.
3 The use of offsets has not been considered as a mitigation measure for the purposes of Project mitigation for the assessment of potential impacts. Refer Section 5.3.5 and Appendix I: Environmental Offsets Strategy for information relating to the use of offset to compensate Project related impacts that are not sufficiently reduced in the above table.

Table 5.6 Initial impact assessment of the Project upon identified matters of national environmental significance – threatened flora

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
***Paspalidium grandispiculatum* (a grass), Austral cornflower (*Rhaponticum australe*), Brush sophora (*Sophora fraseri*) and Austral toadflax (*Thesium australe*)**							
High	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora species from invasion of weed species Edge effects Dust impacts Erosion and sedimentation	High	**Major**	▪ MNES (detailed design), flora and fauna (pre-construction, construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) **Species-specific** All of these species are known to have populations which may occur within the Project disturbance footprint. Flora and Fauna Sub-plan developed and in place prior to construction. Pre-construction protected flora surveys as per DES guidelines (2020c) throughout identified habitat (refer species habitat mapping in Appendix G) within alignment to identify whether protected species occur. Particular focus on the following: ▪ Suitable habitat in and adjacent to vine forest/semi-evergreen vine thicket for Brush sophora ▪ Identified grassland/grassy woodland habitat for Austral toadflax ▪ Other identified threatened flora species occur on the dark clay soils in the western portion of the Project disturbance footprint. This includes assessing the condition and health of any identified population prior to construction and monitoring the population during construction to determine if any changes to the population occur as a result of the Project or due to natural attrition. Potential criteria may include recruitment and presence of fertile material, plus signs of water stress.	Moderate	**High** (refer to Section 5.3.4.2 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Where a threatened flora species is found to occur - pre-construction condition assessment of species habitat in vicinity of Project disturbance footprint (using Biocondition assessment) with regular monitoring against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified Where a threatened species population is detected and impacts from the Project are likely, specific measures will be developed in consultation with relevant specialists, the project team and the construction team. Vegetation clearing to include: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision ■ All workers will be briefed on the importance of threatened flora species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them Soil Management Plan developed and in place prior to construction. To include soil conservation measures and erosion and sediment controls with specific reference to identified habitat for threatened flora (where they are found to occur) Biosecurity Management Plan developed and in place prior to construction. To include: ■ Pre-construction weed assessment of threatened flora species habitat (where found to occur) in areas adjacent to construction footprint ■ Construction vehicle weed certification and wash down procedures in place ■ Weed monitoring within threatened flora habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods		
	Commissioning and reinstatement	Displacement of flora species from invasion of weed and pest species Erosion and sedimentation	Negligible	**Low**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) In accordance with the MNES Monitoring Plan, undertake regular monitoring and maintenance of erosion and sediment devices/infrastructure to identified threatened flora habitat areas. Biosecurity Management Plan ongoing: ▪ Construction vehicle weed certification and wash down procedures in place ▪ Continued weed monitoring within threatened flora habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified Where previously identified continued threatened flora habitat monitoring against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas Soil Management Plan – continued maintenance of erosion and sediment controls with specific reference/controls to identified threatened flora habitat areas	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Operation	Erosion and sedimentation	Negligible	**Low**	Soil Management Plan – ongoing regular monitoring and maintenance of erosion and sediment devices/infrastructure to identified threatened flora habitat areas Biosecurity Management Plan – ongoing annual weed monitoring within identified threatened flora habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified Annual monitoring of previously identified threatened flora habitat against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified	Negligible	**Low**
Hairy-joint grass (*Arthraxon hispidus*), Miniature moss-orchid (*Bulbophyllum globuliforme*), Stream clematis (*Clematis fawcettii*), King blue-grass (*Dichanthium queenslandicum*), Four-tailed grevillea (*Grevillea quadricauda*), Bluegrass (*Dichanthium setosum*), Blunt-leaved Leionema (*Leionema obtusifolium*), Wandering peppercress (*Lepidium peregrinum*) and Blotched sarcochilus (*Sarcochilus weinthalii*)							
High	Construction	Habitat loss from vegetation clearing/removal Reduction in biological viability of soil to support plant growth due to soil compaction Displacement of flora species from invasion of weed species Edge effects Dust impacts Erosion and sedimentation	Moderate	**High**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) **Species specific** These species are not known to occur within or near the Project disturbance footprint but have potential to occur based on predictive habitat mapping. Pre-construction protected flora surveys as per DES guidelines (2020c) targeting potential habitat within and adjacent the Project disturbance footprint (refer species habitat mapping in Appendix G).	Moderate	**Moderate** (refer to Section 5.3.4 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Where a species is detected, specific measures will be developed in consultation with relevant specialists, the project team and the construction team (e.g. micro-siting to avoid population or minimise impacts, ensuring ancillary works avoid these areas, collection of seed and other fertile material). Vegetation clearing to include at a minimum: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision ■ All workers will be briefed on the importance of threatened flora species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them Soil Management Plan developed and in place prior to construction. To include soil conservation measures and erosion and sediment controls with specific reference to identified habitat for threatened flora (where they are found to occur) Biosecurity Management Plan developed and in place prior to construction. To include: ■ Pre-construction weed assessment of threatened flora species habitat (where found to occur) in areas adjacent to construction footprint ■ Construction vehicle weed certification and wash down procedures in place ■ Weed monitoring within threatened flora habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods.		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Commissioning and reinstatement	Displacement of flora species from invasion of weed species Edge effects Erosion and sedimentation	Negligible	**Low**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Flora (detailed design, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) In accordance with the MNES monitoring plan, undertake regular monitoring and maintenance of erosion and sediment devices/infrastructure to identified threatened flora habitat areas. Biosecurity Management Plan ongoing: ▪ Construction vehicle weed certification and wash down procedures in place ▪ Continued weed monitoring within threatened flora habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified Where previously identified continued threatened flora habitat monitoring against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas Soil Management Plan – continued maintenance of erosion and sediment controls with specific reference/controls to identified threatened flora habitat areas.	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Operation	Displacement of flora species from invasion of weed and pest species Erosion and sedimentation	Negligible	**Low**	Soil Management Plan – ongoing regular monitoring and maintenance of erosion and sediment devices/infrastructure to identified threatened flora habitat areas Biosecurity Management Plan – ongoing annual weed monitoring within identified threatened flora habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified. Annual monitoring of previously identified threatened flora habitat against initial assessment values. Corrective actions to be implemented where Project-associated impacts are identified.	Negligible	**Low**

Table notes:

1 Refer Table 3.8 for 'sensitivity' and 'magnitude' criteria.
2 Potential impacts to MNES in the above table are based upon those presented in Section 5.1.
3 The use of offsets has not been considered as a mitigation measure for the purposes of Project mitigation for the assessment of potential impacts. Refer Section 5.3.5 and Appendix I: Environmental Offsets Strategy for information relating to the use of offset to compensate Project related impacts that are not sufficiently reduced in the above table.

Table 5.7 Initial impact assessment of the Project upon identified matters of national environmental significance – threatened fauna

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
Murray cod (*Maccullochella peelii*)							
High	Construction	Habitat loss from temporary waterway impoundment Displacement of fauna species from invasion of weed and pest species Barrier effects Dust impacts Aquatic habitat degradation Erosion and sedimentation	Moderate	**High**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Aquatic fauna (detailed design, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning) **Species-specific:** Murray cod is not known from Gowrie Creek but has some potential to occur. Detailed design – bridges and are proposed over Gowrie Creek where the species may occur, which will ensure fish passage is maintained. Pre-construction surveys of waterways identified as potential habitat of species (i.e. Gowrie Creek) to identify whether Murray cod occurs. Surveys will follow the *Survey guidelines for Australia's threatened fish* (DSEWPaC 2011a). Avoid clearing within and along major watercourses, in particular Gowrie Creek, through the use of bridge structures and the placement of pylons away from bed and banks.	Low	**Moderate** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Where a temporary impoundment or diversion is required for construction purposes and the species is found to be present, an appropriately qualified person will be consulted to make an assessment on the method of recovery, transport and release of fish and will follow relevant State (DAF) fish salvage guidelines during construction activities. Dewatering and fish salvage activities to include measures to manage the risk of translocating non-endemic flora and fauna (i.e. Biosecurity Management Plan) Maintain low flows during drought conditions and avoid fluctuations to water levels downstream during spawning period (i.e. Gowrie Creek) Biosecurity Management Plan developed and in place prior to construction. To include: ▪ Pre-construction aquatic and riparian weed and pest fish assessment of waterways identified as potential habitat of species ▪ Construction vehicle weed certification and wash down procedures in place ▪ Weed monitoring within identified waterways in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods Through final Project design considerations changes to hydrological conditions in the area are expected to be minor at worst, localised and transient (during flood events) and are unlikely to impact potential habitat for the species. Surface Water and Hydrology Sub-plan developed and in place prior to construction. To include at a minimum: ▪ Watercourse-specific water quality criteria based on baseline data ▪ A surface water quality sampling monitoring detailing water quality parameters and schedule		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					▪ Response framework where water quality impacts identified from Project activities Soil Management Plan developed and in place prior to construction. To include soil conservation measures and erosion and sediment controls with specific reference/controls to all waterways.		
	Commissioning and reinstatement	Displacement of fauna species from invasion of weed and pest species Aquatic habitat degradation Erosion and sedimentation	Low	**Moderate**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning) ▪ Aquatic fauna (detailed design, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) Where possible, instream habitat will be reinstated to pre-construction state (e.g. replacement of large woody debris and ensure no or limited change to instream flows and allow fish passage). Biosecurity Management Plan ongoing: ▪ Construction vehicle weed certification and wash down procedures in place ▪ Continued aquatic weed monitoring within waterways with required control protocols in place where weed invasion is identified Soil Management Plan – continued maintenance of erosion and sediment controls associated with all waterways	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas including instream and riparian habitat Surface Water and Hydrology Sub-plan monitoring and evaluation ongoing		
	Operation	Erosion and sedimentation	Negligible	**Low**	▪ Weeds and pests (operation) ▪ Fauna passage (operation) including ongoing maintenance of fish passage structures ▪ Riparian vegetation and aquatic habitats (operation) ▪ Soil Management Plan – ongoing regular monitoring and maintenance of erosion and sediment devices/infrastructure associated with all waterways.	Negligible	**Low**
Wetland birds: Australian painted snipe, Australasian bittern and Curlew sandpiper							
High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Edge effects Noise, dust, and light impacts Aquatic habitat degradation Erosion and sedimentation	Moderate	**High**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Fauna fencing (detailed design, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Aquatic fauna (detailed design, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) **Species specific** None of these species are known from the MNES study area and it is uncertain if suitable habitat is present within the Project disturbance footprint.	Low	**Moderate** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Flora and Fauna Sub-plan developed and in place prior to construction. Will detail pre-construction surveys of wetlands identified as potential habitat of species to identify whether habitat and/or any of these species occurs. Surveys will follow the *Survey guidelines for Australia's threatened birds* (DEWHA 2010a). Clearing/construction works in potential habitat areas will be timed where possible to avoid wet conditions where habitat is likely to be most suitable. Should species be found to occur Plan to include: ▪ Engagement of a qualified fauna spotter/ecologist for surveys and measures to ensure safe movement of species away from works area ▪ Restricted works measures in place should nesting of Australian painted snipe or Australasian bittern be detected Measures to minimise habitat loss during vegetation clearing to include: ▪ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ▪ Vegetation clearance will be approved and carried out under ecological supervision ▪ All workers will be briefed on the importance of threatened fauna species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them Biosecurity Management Plan developed and in place prior to construction. To include: ▪ Pre-construction wetland and riparian weed assessment of wetlands identified as potential habitat of species ▪ Construction vehicle weed certification and wash down procedures in place ▪ Weed monitoring within identified wetlands in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					▪ Measures to ensure pest predator fauna are not attracted to works areas or utilising Project area for shelter CEMP to include measures to minimise noise as much as feasible and Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods Project design to incorporate minimum lighting requirements feasible for Project safety Surface Water and Hydrology Sub-plan developed and in place prior to construction. To include: ▪ Wetland and watercourse-specific water quality criteria based on baseline data ▪ A surface water quality sampling monitoring detailing water quality parameters and schedule ▪ Response framework where water quality impacts identified from Project activities. Soil Management Plan developed and in place prior to construction. To include soil conservation measures and erosion and sediment controls with specific reference/controls to all waterways and wetland habitat.		
High	Commissioning and reinstatement	Displacement of fauna species from invasion of weed and pest species Edge effects Noise, dust, and light impacts Aquatic habitat degradation Erosion and sedimentation	Low	**Moderate**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ▪ Aquatic fauna (detailed design, construction and commissioning) ▪ Erosion and sediment control (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning)	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					In accordance with the MNES Monitoring Plan, undertake regular monitoring and maintenance of erosion and sediment devices/infrastructure associated with all waterways. Biosecurity Management Plan ongoing: ■ Construction vehicle weed certification and wash down procedures in place ■ Continued aquatic/wetland weed monitoring within waterways with required control protocols in place where weed invasion is identified ■ Continued monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Noise and Vibration Sub-plan and Air Quality Sub-plan measures ongoing Project design to incorporate minimum lighting requirements feasible for Project safety Soil Management Plan – continued maintenance of erosion and sediment controls associated with all waterways and wetland habitats Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas including riparian habitat Surface Water and Hydrology Sub-plan monitoring and evaluation ongoing.		
	Operation	Displacement of fauna species from invasion of weed and pest species Light impacts Erosion and sedimentation	Negligible	**Low**	Biosecurity Management Plan – ongoing annual weed monitoring within wetland habitat in vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified Project design to incorporate minimum lighting requirements feasible for Project safety Soil Management Plan – ongoing regular monitoring and maintenance of erosion and sediment devices/infrastructure associated with all waterways	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
Koala (*Phascolarctos cinereus*) and Collared delma (*delma torquata*)							
High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects Noise, dust, and light impacts	High	Major	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning) ▪ Fauna fencing (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) **Species-specific:** These species are known to occur within or close to the Project disturbance footprint. Flora and Fauna Sub-plan developed and in place prior to construction. Will detail pre-construction surveys of areas identified as potential habitat of Collared delma to identify to what extent the species occurs within or adjacent to Project disturbance footprint. Surveys will target those areas identified as potential habitat for the species as per species habitat mapping (refer Appendix G) and be carried out as per relevant MNES guidelines. Particular focus on the following: ▪ Searches of mapped habitat where required microhabitat features occur (e.g. loose surface rocks) within alignment (refer *Survey guidelines for Australia's threatened reptiles* (DSEWPaC 2011b) for survey methods) ▪ Koala may be assumed as potentially present throughout eucalypt woodlands in Project disturbance footprint. Flora and fauna Sub-plan to include: ▪ Vegetation clearing within the Project disturbance footprint in Koala habitat will be carried out in a manner to minimise stress on potential individuals as much as is practicably possible (e.g. sequential clearing and	Moderate	**High** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					minimising time of disturbance to animals). Where possible, clearing activities will take place outside the breeding season for Koala (October-May). ■ Restricted works measures in place should Koala be observed within Project disturbance footprint to allow safe movement safe away from works area ■ Measures to allow safe and responsible handling of fauna (where required) and repatriation in pre-identified appropriate habitat outside of Project disturbance footprint ■ Koalas subject to handling will be examined and if suspected of Chlamydia infection will be taken to a predesignated veterinarian/wildlife care facility for treatment prior to release ■ Measures to responsibly handle injured fauna ■ Measures to control vehicle speed limits onsite to no more than 40 km/hr ■ Fauna management and incident register Measures to minimise habitat loss during vegetation clearing to include at a minimum: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision ■ All workers will be briefed on the importance of threatened fauna species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them Biosecurity Management Plan developed prior to construction. Weed species are not considered to be more than a minor impact on these species. The MNES study area is already subject to significant weed invasion. The Plan will consider relevant guidelines to control potential deleterious pathogens including *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities both of which may impact eucalypt species and therefore Koala. General measures to include:		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					■ Pre-construction weed assessment of potential habitat of species ■ Construction vehicle weed certification and wash down procedures in place ■ Contractor education on the requirements for site access regarding identified habitat (including procedures regarding clean clothing/footwear) ■ Weed monitoring within in immediate vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified ■ Measures to ensure pest predator fauna are not attracted to works areas or utilising Project area for shelter The Project incorporates a number of raised viaducts in the Toowoomba Range allowing fauna passage underneath. Project design to consider further incorporating fauna crossing structures (e.g. underpasses for koalas) to allow fauna movement across alignment. The locations of the structures and supporting fencing will aim to complement similar structures on the Toowoomba Bypass, with further consultation between DTMR and ARTC warranted to confirm the location and effectiveness of the current treatments and discusses reinstatement and ongoing management strategies. Fauna passage and Koala-proof fencing design will also be considered to guide fauna to crossing structures and viaduct areas. Where used fauna crossings will be consistent with the intent of DTMR's *Fauna Sensitive Road Design Manual* (DTMR 2010) and where applicable species-specific requirements. Fencing extent will be determined by the availability of suitable habitat adjacent to alignment. Also, where possible, avoid the use of barb wire particularly on the top strand, to prevent threatened species (particularly Greater glider, flying-foxes and microbats) from becoming entangled. Fauna friendly fencing must be used, whilst being in accordance with landowner and/or structural requirements.		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					CEMP to include measures to minimise noise as much as feasible and Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas Project design to incorporate minimum lighting requirements feasible for Project safety		
	Commissioning and reinstatement	Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects Noise, dust, and light impacts	Low	Moderate	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning) ▪ Fauna fencing (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) Flora and Fauna Sub-plan activities ongoing: ▪ Measures to control vehicle speed limits onsite to no more than 40 km/hr ▪ Fauna management and incident register Biosecurity Management Plan ongoing: ▪ Construction vehicle weed certification and wash down procedures in place ▪ Continued weed monitoring with required control protocols in place where weed invasion is identified ▪ Continued monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Fauna crossing structures and fencing in place and completed Noise and Vibration and the Air Quality Management Sub-plan measures ongoing	Negligible	Low

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Project design to incorporate minimum lighting requirements feasible for Project safety Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas where woodland habitat has been cleared. Aligned with Biosecurity Management Plan revegetation plant species will be obtained from a reliable source that is certified free of pathogens.		
	Operation	Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects Light impacts	Negligible	Low	Flora and Fauna Sub-plan activities ongoing: ▪ Fauna management and incident register including observed collisions associated with rail operations ▪ Information on collisions used to inform potential for further measures to be applied to minimise/eliminate incidents Biosecurity Management Plan ongoing: ▪ Continued annual weed monitoring with required control protocols in place where weed invasion is identified ▪ Continued opportunistic monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Fauna fencing (operation) including ongoing maintenance of fauna passages and fencing during the operational life of the Project (i.e. 100 years) Project design to incorporate minimum lighting requirements feasible for Project safety.	Negligible	Low
Spotted-tail quoll (*Dasyurus maculatus maculatus*), Brush-tailed rock-wallaby (*Petrogale penicillata*), Long-nosed potoroo (*Potorous tridactylus tridactylus*), Greater glider (*Petauroides volans*) and **New Holland mouse (*Pseudomys novaehollandiae*)**							
High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality	Moderate	**High**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning)	Low	**Moderate** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
		Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects Noise, dust, and light impacts			▪ Fauna fencing (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) **Species-specific:** These species are not known to occur within or near the Project disturbance footprint but have potential to occur in woodland habitat based on predictive habitat mapping (refer Appendix G). Flora and Fauna Sub-plan developed and in place prior to construction. Flora and Fauna Sub-plan developed and in place prior to construction. Will detail pre-construction surveys of woodlands identified as potential habitat of species to identify whether individuals occur within Project disturbance footprint. Surveys will be species specific following the *Survey guidelines for Australia's threatened mammals* (DSEWPaC 2011c) and include the following: ▪ Identification of species-specific habitat and habitat features considered suitable for species presence (e.g. cliff faces/boulder piles for Brush-tailed rock-wallaby, and Spotted-tail quoll) ▪ Targeted surveys as per MNES guidelines where suitable habitat has been identified as per species habitat mapping (refer Appendix G) Flora and Fauna Sub-plan to include the following construction measures at a minimum: ▪ Engagement of a qualified fauna spotter/ecologist for pre-clearance surveys ▪ Measures to ensure safe retrieval of tree hollows during vegetation clearing and allow safe movement of species (e.g. Greater glider) away from works area ▪ Restricted works measures in place should larger species (Spotted-tail quoll and Brush-tailed rock-wallaby) be observed within or adjacent to Project disturbance footprint to allow safe movement safe away from works area		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					■ Measures to ensure retrieval of potential habitat elements (loose surface rock, large fallen timber) during vegetation clearing and placement in adjacent unimpacted habitat ■ Measures to allow safe handling of fauna (where required) and repatriation in suitable habitat away from site ■ Measures to responsibly handle injured fauna ■ Measures to control vehicle speed limits onsite to no more than 40 km/hr ■ Fauna management and incident register Measures to minimise habitat loss during vegetation clearing to include at a minimum: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision ■ All workers will be briefed on the importance of threatened fauna species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them. Weeds species are not considered a to be more than a minor impact on these species excepting Brush-tailed rock-wallaby (particularly *Lantana camara*). The MNES study area is already subject to significant weed invasion including *Lantana* species. Habitat degradation via *Phytophthora cinnamomi* and Myrtle rust is thought to be a potential threat to New Holland mouse and Long-nosed potoroo. Biosecurity Management Plan developed and in place prior to construction. General measures to include: ■ Pre-construction weed and *Phytophthora cinnamomi* assessment of potential habitat of species ■ Construction vehicle weed certification and wash down procedures in place		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					▪ Contractor education on the requirements for site access regarding identified habitat (including procedures regarding clean clothing/footwear) ▪ Weed monitoring within immediate vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified ▪ Measures to ensure pest predator fauna are not attracted to works areas or utilising Project disturbance footprint for shelter. The Project incorporates a number of raised viaducts in the Toowoomba Range allowing fauna passage underneath. Project design to consider further incorporating specific fauna crossing structures for gliders, noting that other ground-dwelling species will benefit from the retention of vegetation under the viaducts and potentially dedicated fauna culvert to allow fauna movement across alignment. Fauna passage and Koala-proof fencing design will also be considered to guide fauna to crossing structures and viaduct areas. Where used fauna crossings will be consistent with the intent of DTMR's *Fauna Sensitive Road Design Manual* (DTMR 2010) and where applicable species-specific requirements. Fencing extent will be determined by the availability of suitable habitat adjacent to alignment. Also, where possible, avoid the use of barb wire particularly on the top strand, to prevent threatened species (particularly Greater glider, flying-foxes and microbats) from becoming entangled. Fauna friendly fencing must be used, whilst being in accordance with landowner and/or structural requirements. CEMP to include measures to minimise noise as much as feasible and Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas Project design to incorporate minimum lighting requirements feasible for Project safety.		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Commissioning and reinstatement	Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects Noise, dust, and light impacts	Low	**Moderate**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Fauna passage (detailed design, construction and commissioning) ▪ Fauna fencing (detailed design, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) Flora and Fauna Sub-plan activities ongoing: ▪ Measures to control vehicle speed limits onsite to no more than 40 km/hr ▪ Fauna management and incident register Biosecurity Management Plan ongoing: ▪ Construction vehicle weed certification and wash down procedures in place ▪ Continued weed and *Phytophthora cinnamomi* monitoring and with required control protocols in place where weed invasion is identified ▪ Continued monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Fauna crossing structures and fencing in place and completed. Noise and Vibration and the Air Quality Sub-plan measures ongoing Project design to incorporate minimum lighting requirements feasible for Project safety Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas where woodland habitat has been cleared. Revegetation species to be obtained from source certified free of *Phytophthora cinnamomi.*	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Operation	Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects Light impacts	Low	**Moderate**	Flora and Fauna Sub-plan activities ongoing: ▪ Fauna management and incident register including observed collisions associated with rail operations Biosecurity Management Plan ongoing: ▪ Continued weed and *Phytophthora cinnamomi* monitoring and with required control protocols in place where weed invasion is identified ▪ Continued opportunistic monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Fauna crossing structures and fencing in place and monitoring of effectiveness of structures for fauna passage carried out for at least two consecutive years within two years of Project completion Project design to incorporate minimum lighting requirements feasible for Project safety.	Negligible	Low
Five-clawed worm-skink (*Anomalopus mackayi*) and Condamine earless dragon (*Tympanocryptis condaminensis*)							
High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Habitat fragmentation Barrier effects	Moderate	**High**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Landscape, rehabilitation and stabilisation (pre-construction, construction and commissioning) **Species-specific:** These species are not known to occur within or near the Project disturbance footprint but have potential to occur where the dark cracking clay soils occur within the Project disturbance footprint north of Toowoomba.	Moderate	**Moderate** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Flora and Fauna Sub-plan developed and in place prior to construction. Will detail pre-construction surveys of areas identified as potential habitat of species to identify whether individuals occur within or adjacent to Project disturbance footprint. Surveys will target those areas identified as potential habitat for the species as per species habitat mapping (refer Appendix I) and be carried out as per relevant MNES guidelines. Particular focus on the following: ■ Suitable habitat on dark clay soils in northern portion of the alignment for Condamine earless dragon and Five-clawed worm-skink (refer *Survey guidelines for Australia's threatened reptiles* (DSWEPaC 2011b) for survey methods) Flora and Fauna Sub-plan to include at a minimum: ■ Engagement of a qualified fauna spotter/ecologist for pre-clearance surveys for all species. Surveys will require appropriate ground surveys for Condamine earless dragon and Five-clawed worm-skink where pre-construction surveys have identified the species as occurring or likely to occur. ■ Measures to allow safe and responsible handling of fauna (where required) and repatriation in pre-identified appropriate habitat outside of Project disturbance footprint ■ Measures to responsibly handle injured fauna ■ Fauna management and incident register ■ Measures to prevent entrapment within trenches, with trenches to be regularly inspected to ensure the measures are effective Measures to minimise habitat loss during vegetation clearing to include at a minimum: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					▪ All workers will be briefed on the importance of threatened fauna species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them Weeds species are not considered a to be more than a minor impact on these species. Biosecurity Management Plan developed and in place prior to construction. General measures to include: ▪ Pre-construction weed assessment of potential habitat of species ▪ Construction vehicle weed certification and wash down procedures in place ▪ Weed monitoring within immediate vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified ▪ Measures to ensure pest predator fauna are not attracted to works areas or utilising Project area for shelter		
	Commissioning and reinstatement	Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Habitat fragmentation Barrier effects	Negligible	**Low**	Flora and Fauna Sub-plan activities ongoing: ▪ Measures to control vehicle speed limits onsite to no more than 40 km/hr ▪ Fauna management and incident register Biosecurity Management Plan ongoing: ▪ Construction vehicle weed certification and wash down procedures in place ▪ Continued weed monitoring with required control protocols in place where weed invasion is identified ▪ Continued monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas where identified habitat has been cleared	Negligible	**Low**

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Operation	Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Reduction in the connectivity of biodiversity corridors Habitat fragmentation Barrier effects	Negligible	**Low**	Flora and Fauna Sub-plan activities ongoing: ▪ Fauna management and incident register including observed collisions associated with rail operations Biosecurity Management Plan ongoing: ▪ Continued annual weed monitoring with required control protocols in place where weed invasion is identified ▪ Continued opportunistic monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter	Negligible	Low
Grey-headed flying-fox (*Pteropus poliocephalus*)							
High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Noise, dust, and light impacts Aquatic habitat degradation	High	**Major**	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, pre-construction, construction and commissioning) **Species specific:** Flora and Fauna Sub-plan developed and in place prior to construction. The Plan will detail pre-construction surveys of riparian habitat identified as potential roost sites of species to identify whether camps occur within or near the Project disturbance footprint. It is noted the nearest roost site is approximately 540 m south of the Project disturbance footprint (refer Figure 4.3) although there is no recent data indicating the site is still used. Should a roost site be found to occur management actions will incorporate the mitigation standards detailed in the Commonwealth's *Referral guideline for management actions in grey-headed and spectacled flying-fox camps* (DotE 2015c). Where possible, reduce the disturbance footprint in winter foraging habitat, including avoiding clearing for ancillary works.	Moderate	**High** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Incorporate winter foraging species into the rehabilitation/ revegetation plans for the Project. Work with the design team and property team to incorporate fencing which minimises the risk of entanglement (e.g. barbed wire fencing with a high tensile wire strand as the top wire). Measures to minimise habitat loss during vegetation clearing to include at a minimum: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision ■ All workers will be briefed on the importance of threatened fauna species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them CEMP to include measures to minimise noise as much as feasible and Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods Project design to incorporate minimum lighting requirements feasible for Project safety Surface Water and Hydrology Sub-plan developed and in place prior to construction. To include at a minimum: ■ Wetland and watercourse-specific water quality criteria based on baseline data ■ A surface water quality sampling monitoring detailing water quality parameters and schedule ■ Response framework where water quality impacts identified from Project activities		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
	Commissioning and reinstatement	Noise, dust, and light impacts Aquatic habitat degradation	Negligible	**Low**	▪ Riparian vegetation and aquatic habitats (detailed design, pre-construction, construction and commissioning) Noise and Vibration/Air Quality Sub-plan measures ongoing Project design to incorporate minimum lighting requirements feasible for Project safety.	Negligible	**Low**
	Operation	Light impacts	Negligible	**Low**	Project design to incorporate minimum lighting requirements feasible for Project safety. Use of barbwire in the top strand of fencing is to be avoided wherever feasible	Negligible	**Low**
Woodland birds: Swift parrot (*Lathamus discolor*), Regent honeyeater (*Anthochaera phrygia*), Painted honeyeater (*Grantiella picta*), Red goshawk (*Erythrotriorchis radiatus*), Grey falcon (*Falco hypoleucos*) and Black-breasted button-quail (*Turnix melanogaster*)							
High	Construction	Habitat loss from vegetation clearing/removal Fauna species injury or mortality Displacement of fauna species from invasion of weed and pest species Noise, dust, and light impacts Aquatic habitat degradation	High	Major	▪ Flora and fauna (detailed design, pre-construction, construction and commissioning) ▪ Weeds and pests (pre-construction, construction and commissioning) ▪ Riparian vegetation and aquatic habitats (detailed design, pre-construction, construction and commissioning) **Species specific:** Three of these species are generalist nectivores which are nomadic following flowering events. None of these species nest in the area. Red goshawk requires large areas of woodland habitat and may occur in the Toowoomba Range. Grey falcon is a bird of arid inland habitats that may occasionally utilise open habitats in the area. Black-breasted button-quail occurs in vine forest, semi-evergreen vine thickets and low scrub (including where *Lantana camara* occurs).	Moderate	**High** (refer to Section 5.3.5 for assessment against MNES Guidelines)

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					A Flora and Fauna Sub-plan developed and in place prior to construction. The Plan will detail pre-construction surveys of woodlands identified as habitat for Red goshawk (refer species habitat mapping in Appendix G) to identify whether individuals occur and potentially nest within the Project disturbance footprint. Surveys for nest sites within or adjacent to the disturbance footprint will be as per MNES guidelines where suitable nesting habitat (i.e. large emergent trees near water) is identified. Should an active Red goshawk nest site be identified, the Plan will incorporate restricted works measures during construction to allow nesting to continue undisturbed as determined by pre-clearance surveys (e.g. micrositing of works to avoid nests or maximise separation distance, 100 m buffer and signage around nests, no disturbance to nests until after breeding season (being until fledglings/offspring no longer use the nest/roost for habitat)). Some limited works may occur in the buffer zone during this period (e.g. cultural heritage surveys). The Plan will also detail pre-construction surveys for Black-breasted button-quail where predicted habitat has been identified (refer Appendix G). Measures to minimise habitat loss during vegetation clearing to include at a minimum: ■ All vegetation outside of construction footprint will be appropriately marked as a No-Go Zone to site workers ■ Vegetation clearance will be approved and carried out under ecological supervision ■ All workers will be briefed on the importance of threatened fauna species, their location (where they are found to occur within or near Project disturbance footprint), and procedures for working around them		

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
					Weeds species are not considered as an impact on these species. The MNES study area is already subject to significant weed invasion including *Lantana* species. Biosecurity Management Plan developed and in place prior to construction. General measures to include: ■ Pre-construction weed assessment of potential habitat of species ■ Construction vehicle weed certification and wash down procedures in place ■ Weed monitoring within immediate vicinity of Project disturbance footprint with required control protocols in place where weed invasion is identified ■ Measures to ensure pest predator fauna are not attracted to works areas or utilising Project area for shelter CEMP to include measures to minimise noise as much as feasible and Air Quality Sub-plan will include measures to minimise dust impacts including dust monitoring and suppression methods Project design to incorporate minimum lighting requirements feasible for Project safety Surface Water and Hydrology Sub-plan developed and in place prior to construction. To include at a minimum: ■ Wetland and watercourse-specific water quality criteria based on baseline data ■ A surface water quality sampling monitoring detailing water quality parameters and schedule ■ Response framework where water quality impacts identified from Project activities		
	Commissioning and reinstatement	Displacement of fauna species from invasion of weed and pest species Noise, dust, and light impacts	Low	Moderate	■ Flora and fauna (detailed design, pre-construction, construction and commissioning) ■ Weeds and pests (pre-construction, construction and commissioning) ■ Riparian vegetation and aquatic habitats (detailed design, pre-construction, construction and commissioning)	Negligible	Low

Sensitivity[1]	Phase	Potential impacts[2]	Initial impact significance (application of initial mitigation measures) presented in Section 5.2.1		Application of proposed mitigation measures presented in Table 5.3	Residual impact significance following the application of Project mitigation measures presented in Table 5.3[3]	
			Magnitude[1]	Significance		Magnitude	Significance
		Aquatic habitat degradation			Biosecurity Management Plan ongoing: ■ Construction vehicle weed certification and wash down procedures in place ■ Continued weed monitoring with required control protocols in place where weed invasion is identified ■ Continued monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Noise and Vibration/Air Quality Sub-plan measures ongoing Project design to incorporate minimum lighting requirements feasible for Project safety Reinstatement and Rehabilitation Plan will include rehabilitation of temporary construction areas where woodland habitat has been cleared Surface Water and Hydrology Sub-plan monitoring and evaluation ongoing		
	Operation	Displacement of fauna species from invasion of weed and pest species Noise and light impacts	Negligible	Low	Biosecurity Management Plan ongoing: ■ Continued annual weed monitoring with required control protocols in place where weed invasion is identified ■ Continued opportunistic monitoring to ensure pest predator fauna are not utilising Project infrastructure for shelter Project design to incorporate minimum lighting requirements feasible for Project safety.	Negligible	Low

Table notes:

1 Refer Table 3.8 for 'sensitivity' and 'magnitude' criteria.
2 Potential impacts to MNES in the above table are based upon those presented in Section 5.1.
3 The use of offsets has not been considered as a mitigation measure for the purposes of Project mitigation for the assessment of potential impacts. Refer Section 5.3.5 and Appendix I: Environmental Offsets Strategy for information relating to the use of offset to compensate Project related impacts that are not sufficiently reduced in the above table.

5.3.3 Significant residual impact assessment for threatened ecological communities

Of the six TECs identified from the desktop assessment, three TECs were confirmed b within the MNES study area (No TECs were identified from within the Project disturbance footprint. (refer Section 4.4.1.3):

- Lowland Rainforest of Subtropical Australia – Critically Endangered
- Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD – Critically Endangered
- White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland – Critically Endangered.

Assessment of the significance of impact in accordance with the criteria contained within the MNES Guidelines has been undertaken for this TEC. In accordance with the guidelines, an action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:

- Reduce the extent of an ecological community
- Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines
- Adversely affect habitat critical to the survival of an ecological community
- Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns
- Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting
- Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to:
  - Assisting invasive species, that are harmful to the listed ecological community, to become established, or
  - Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community
- Interfere with the recovery of an ecological community.

A range of mitigation measures have been proposed to ameliorate potential impacts to occurrences of TEC wherever possible (refer Section 5.2 and specific measures in Table 5.3). These include measures considered as effective in addressing the recognised threats to TECs as recognised in the approved conservation advice, and DAWE-adopted threat abatement plans including but not restricted to:

- Ensuring that ancillary works are planned to avoid known TECs
- Identify the extent of any occurrence of TEC within the vicinity of the Project including area outside of the Project disturbance footprint. Provide these outcomes to relevant agencies to inform their mapping and understanding of this community.
- MNES Monitoring Plan will incorporate monitoring strategies including detailed pre-construction site surveys and operational monitoring to ensure degradation to adjacent occurrences of TEC is not occurring as a result of the Project
- Biosecurity Management Plan to protect flora habitats adjacent to the Project from deleterious impacts including weed invasion, pest fauna and invasion by introduced pathogens (such as Myrtle rust and *Phytophthora cinnamomi*)

- Erosion and Sediment Control Plan and Surface Water Sub-plan to protect water quality values associated with wetlands and waterways
- Air Quality Sub-plan includes measures to minimise dust impacts on vegetation/habitats including dust monitoring and suppression methods
- Reinstatement and Rehabilitation Plan to detail rehabilitation of temporary construction areas not required for Project operation.

The assessment of significant impacts on the identified MNES flora species from the Project is based on:

- Habitat modelling based on ecological surveys and TEC descriptions (refer Section 4.4.1.3)
- The design and layout of the Project (refer Section 1.9)
- Information on potential impacts of Project during construction and operation (refer Section 5.1)
- Proposed Project mitigation measures (refer Section 5.2 and Table 5.5)

To assess the potential for the occurrence of a significant residual impact upon the identified TECs the significant impact criteria was applied to each TEC. Assessment against the significant impact criteria for each TEC is presented in the following tables:

- Table 5.8 (Lowland Rainforest of Subtropical Australia)
- Table 5.9 (Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD)
- Table 5.10 (White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland).

Table 5.8 Assessment of the Lowland Rainforest of Subtropical Australia TEC against the EPBC Act matters of national environmental significance significant impact criteria for Critically Endangered Threatened Ecological Communities

Significant impact criteria	Lowland Rainforest of Subtropical Australia TEC
Reduce the extent of an ecological community	**No** – Clearing is a major threat to this community. However, the Project does not require any clearing of any instances of this TEC and will not clear within a 100 m of the TEC (i.e. the patch is located 100 m from the edge of the Project disturbance footprint) (refer Figure 4.5).
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	**No** – Although the Project is linear in nature, no instances of this TEC will be impacted by clearing and no further fragmentation will result. This is based on RE mapping, including pre-clear mapping for the area, site investigations, other studies in the area, aerial interrogation and that the Project is located above 300 m asl.
Adversely affect habitat critical to the survival of an ecological community	**No** – the Project does not require any clearing of any instances of this TEC. The nearest occurrence is located 100 m from the Project disturbance footprint. The Project will not adversely impact habitat critical to the survival of an ecological community.
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	**No** – There is little potential for the Project to destroy abiotic factors essential to the survival of the TEC. For the most part the impacts will be localised to the Project disturbance footprint. The hydrology modelling indicates minor changes to the local flow paths upgradient and downgradient of the alignment. However, these changes are not considered to be substantial with the Project flooding indicating no change to the hydrology in the area of mapped TEC (near Oaky Creek in the Toowoomba Range). Groundwater modelling also indicates no impacts from groundwater drawdown are predicted on the occurrence of the TEC. Refer EIS Chapter 13: Surface water and hydrology, EIS Chapter 14: Groundwater.

Significant impact criteria	Lowland Rainforest of Subtropical Australia TEC
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	**No** – Invasive WoNS such as Lantana (*Lantana camara*) and Asparagus fern (*Asparagus africanus*) were noted as already present in the area. Management of weeds will be undertaken as part of the Project mitigation measures. In addition, a construction buffer will be applied to this TEC which will reduce edge related impacts. It is expected that these activities will reduce the likelihood of significant alterations to species diversity associated with the TEC.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: ▪ Assisting invasive species, that are harmful to the listed ecological community, to become established, or ▪ Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community	**No** – *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi* (DotEE 2018) is applicable to this species. Myrtle rust is also thought to be a threat to the community (DSEWPaC 2011d). These threats will be managed under the Biosecurity Management Plan. The Plan will consider relevant guidelines to control *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities. This will include at a minimum vehicle washdown procedures and contractor education (including procedures regarding cleaning clothing). This will be particularly important during any revegetation activities in the vicinity of this TEC. Revegetation plant species will be obtained from a reliable source that is certified free of these pathogens. The nearest occurrence of the TEC to the Project is 100 m away. Management of pests and weeds will be undertaken as part of the Project mitigation measures. In addition, management measures will be in place to reduce the risk of herbicides, chemicals, run-off and sediment entering the TEC. These control measures are likely to remove any chance of a substantial reduction in the quality or integrity of an occurrence of an ecological community.
Interfere with the recovery of an ecological community	**No** – Any removal of this TEC will affect the recovery of the ecological community, however the Project will not impact any instance of this TEC. The Project will not interfere with the recovery of this community.
Assessment of potential for significant residual impacts	Under the seven-part test detailed above, there is unlikely to be a 'significant residual impact' on Lowland Rainforest of Subtropical Australia TEC as a result of the Project.

Table 5.9 Assessment of the Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD TEC against the EPBC Act matters of national environmental significance significant impact criteria for Critically Endangered Threatened Ecological Communities

Significant impact criteria	Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD TEC
Reduce the extent of an ecological community	**No** – Although this community is mapped as occurring within the MNES study area (4.5 ha) no areas of this TEC are mapped as occurring within the Project disturbance footprint or will be removed as part of the proposed works. The only potential occurrence of this community is located 1 km from the Project disturbance footprint. The Project will not reduce the extent of an occurrence of this community (refer Figure 4.5). This is based on RE mapping, including pre-clear mapping for the area, site investigations, other studies in the area and aerial interrogation.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	**No** – The Project will not impact an occurrence of this TEC and therefore will not fragment or increase fragmentation of the TEC
Adversely affect habitat critical to the survival of an ecological community	**No** – There are no areas of land comprising this TEC that will be used to construct the Project

Significant impact criteria	Natural grassland on basalt and fine-textured alluvial plains of northern NSW and southern QLD TEC
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	**No** – The only potential occurrence of this community is located 1 km from the Project disturbance footprint. The Project will not modify abiotic factors essential to the survival of an occurrence of the TEC. The hydrology modelling indicates minor changes to the local flow paths upgradient and downgradient of the alignment. However, these changes are not considered to be substantial with the Project flooding indicating no change to the hydrology in the area of mapped TEC (near Gowrie Creek in the Toowoomba Range). Groundwater modelling also indicates no impacts from groundwater drawdown are predicted on the occurrence of the TEC. Refer EIS Chapter 13: Surface water and hydrology, EIS Chapter 14: Groundwater.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	**No** – The potential occurrence of this TEC is over 1 km from Project activities and is unlikely to be affected by Project activities
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: ▪ Assisting invasive species, that are harmful to the listed ecological community, to become established, or ▪ Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community	**No** –The potential occurrence of this TEC is over 1 km from Project activities and is unlikely to be affected by Project activities. A number of invasive species are already established in the area and there is a risk that the Project will result in new infestations or the proliferation of existing invasive species along or adjacent the Project footprint (refer Section 4.4.1.1). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders. The Project will not cause a substantial reduction in the quality or integrity of an occurrence of an ecological community.
Interfere with the recovery of an ecological community	**No** – The Project is not likely to result in the removal of this TEC, nor are there indirect impacts that could threaten the recovery of the ecological community
Assessment of potential for significant residual impacts	Under the seven-part test detailed above, there is unlikely to be a 'significant residual impact' on Natural Grasslands TEC as a result of the Project.

Table 5.10 Assessment of the White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC against the EPBC Act matters of national environmental significance significant impact criteria for Critically Endangered Threatened Ecological Communities

Significant impact criteria	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC
Reduce the extent of an ecological community	**No** – Although this community is mapped as occurring within the MNES study area (193.63 ha) no areas of this TEC are mapped as occurring within the Project disturbance footprint or will be removed as part of the proposed works. The nearest potential occurrence of this community is located 450 m from aboveground works within the Project disturbance footprint (associated with the tunnel infrastructure). The community has not been confirmed as present. The Project will not reduce the extent of an occurrence of this community.

Significant impact criteria	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland TEC
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	**No** – The Project will not impact an occurrence of this TEC and therefore will not fragment or increase fragmentation of the TEC
Adversely affect habitat critical to the survival of an ecological community	**No** – There are no areas of land comprising this TEC that will be used to construct the Project
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	**No** – The Project will not modify abiotic factors essential to the survival of an occurrence of the TEC. The hydrology modelling indicates minor changes to the local flow paths upgradient and downgradient of the alignment. However, these changes are not considered to be substantial with the Project flooding indicating no or very minor change to the hydrology in areas of mapped TEC near Gowrie Creek in the Toowoomba Range area. Groundwater modelling indicates no impacts from groundwater drawdown are predicted on an occurrence of the TEC. Refer EIS Chapter 13: Surface water and hydrology, EIS Chapter 14: Groundwater.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	**No** – Rehabilitation and management of weeds will be undertaken as part of the Project mitigation measures to ensure that the extant flora species diversity is maintained. Application of mitigation measure to reduce the likelihood of ecosystem changing events (e.g. Fire, harvesting) will ensure that little likelihood of any potential substantial alterations to species diversity associated with the TEC
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: ▪ Assisting invasive species, that are harmful to the listed ecological community, to become established, or ▪ Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community	**No** –This TEC is not in close proximity to the Project activities and is unlikely to be affected by Project activities. A number of invasive species are already established in the area and there is a risk that the Project will result in new infestations or the proliferation of existing invasive species along or adjacent the Project footprint (refer Section 4.4.1.1). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders. The Project will not cause a substantial reduction in the quality or integrity of an occurrence of an ecological community
Interfere with the recovery of an ecological community	**No** – The Project is not likely to result in the removal of this TEC, nor are there indirect impacts that could threaten the recovery of the ecological community
Assessment of potential for significant residual impacts	Under the seven-part test detailed above, there is unlikely to be a 'significant residual impact' on White Box-Yellow Box-Blakely's Red Gum Grassy Woodland TEC as a result of the Project.

In consideration of the preceding assessments significant adverse residual impacts **are not likely to occur** to any TECs within the MNES study area (refer Section 4.4.1.3).

ARTC are committed to undertaking additional surveys throughout the Project disturbance footprint to further verify and delineate the vegetation communities present within and surrounding the Project disturbance footprint, including TECs and their relevant thresholds and diagnostic characteristics. As an outcome of the surveys the habitat mapping (and subsequent constraints mapping) and the above assumptions will be reassessed and appropriate mitigation measures developed with regard to the recovery plans and conservation advices, including changes to offset requirements and disturbance limits.

5.3.4 Significant residual impact for threatened flora

This section assesses the potential for significant residual impacts from the Project on each threatened flora species identified as potentially occurring within the Project disturbance footprint using the relevant criteria outlined in the MNES Guidelines. Within the MNES Guidelines there are specific criteria depending on whether the species is listed as critically endangered or endangered compare to a species listed as vulnerable. Key terms relevant to the assessment include:

- A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area. In relation to critically endangered, endangered or vulnerable species, occurrences include but are not limited to:
  - A geographically distinct regional population, or collection of local populations, or
  - A population, or collection of local populations, that occurs within a particular bioregion.
- An 'invasive species' is an introduced species, including an introduced (translocated) native species, which out-competes native species for space and resources or which is a predator of native species. Introducing an invasive species into an area may result in that species becoming established. An invasive species may harm listed threatened species or ecological communities by direct competition, modification of habitat or predation.
- 'Habitat critical to the survival of a species or ecological community' refers to areas that are necessary:
  - For activities such as foraging, breeding, roosting, or dispersal
  - For long-term maintenance of the species or ecological community (including the maintenance of species essential to the survival of the species or ecological community, such as pollinators)
  - To maintain genetic diversity and long-term evolutionary development
  - For the reintroduction of populations or recovery of the species or ecological community.

Such habitats may include, but are not limited to; habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the register of Critical Habitat maintained by the minister under the EPBC Act.

There are 16 threatened flora species listed as MNES relevant to the MNES study area including 14 species listed as vulnerable and two species listed as endangered. The ecology, life history and distribution of these species are summarised in Appendix B. Relevant Commonwealth documents applicable to each species including threat abatement plans, Approved Conservation Advice, and recovery plans are also summarised in Appendix B.

As noted in Section 4.4.1.2, only one species, Brush sophora (*Sophora fraseri*) was confirmed as occurring within the Project disturbance footprint.

Key impacts to terrestrial threatened flora are considered to be restricted to direct clearing of individuals/populations. Given the degraded nature of the habitats within the Project disturbance footprint (due to vegetation clearance, previous tree thinning and weed invasion) indirect impacts such as edge effects (such as dust deposition) are considered to be suitably mitigated under the Project's mitigation measures and restricted to the construction period.

A range of mitigation measures have been proposed to ameliorate these impacts wherever possible (refer Section 5.2 and species-specific measures in Table 5.3). These include measures considered as effective in addressing the recognised threats for each species as recognised in recovery plans, approved conservation advice, and DAWE-adopted threat abatement plans (as identified in the following sections for each species) including but not restricted to:

- Flora and Fauna Management Sub-plan will incorporate species-specific monitoring strategies including detailed pre-construction site surveys and operational monitoring to ensure degradation to adjacent habitats is not occurring as a result of the Project – applicable to all species

- Biosecurity Management Plan to protect flora habitats adjacent to the Project from deleterious impacts including weed invasion, pest fauna (such as feral pigs and European rabbit) and invasion by introduced pathogens (such as Myrtle rust and *Phytophthora cinnamomi*) – applicable to all species
- Erosion and Sediment Control Plan and Surface Water Sub-plan to protect water quality values associated with wetlands and waterways – applicable to aquatic species
- Air Quality Sub-plan includes measures to minimise dust impacts on vegetation/habitats including dust monitoring and suppression methods – applicable to all species
- Reinstatement and Rehabilitation Plan to detail rehabilitation of temporary construction areas not required for Project operation – applicable to all species

The assessment of significant impacts on the identified MNES flora species from the Project is based on:

- Currently knowledge of the species, including local populations and habitat requirements (refer Appendix B)
- Predictive habitat modelling for each species (refer Table 5.4) based on the habitat assumptions associated with each species, along with the findings of ecological surveys (refer Appendix A)
- The design and layout of the Project (refer Section 1.9)
- Information on potential impacts of Project during construction and operation (refer Section 5.1)
- Proposed Project mitigation measures (refer Section 5.2 and Table 5.6).

In addition, it is noted that targeted surveys for threatened flora species have not been carried out throughout the entirety of the Project disturbance footprint. Where protected plant surveys have been undertaken including in areas of *potential habitat* for the species listed in Table 5.11, only one species was detected (Brush sophora (*Sophora fraseri*)) indicating that predicted habitat mapping overestimates the extent of habitat present for these flora species.

ARTC are committed to undertaking additional protected plants surveys in accordance with the Protected Plant Flora Survey Guidelines throughout the Project footprint with the aim to verify and further refine the habitat mapping, and address in limitations associated with the initial works (e.g. sections of the alignment have changed as a result of design development). The outcomes of the surveys will also inform relevant approvals and management plans (e.g. new mitigation measures may be developed or the design/construction activity alerted to avoid a certain area), along with offset requirements and disturbance limits.

A summary of the findings of the significant residual impact assessment for threatened flora is provided in Table 5.11, Section 5.3.4.1 provides significant impact assessments for critically endangered and endangered species, and Section 5.3.4.2 provides the significant impact assessment for vulnerable species.

Table 5.11 Summary of the results of the significant impact assessment for matters of national environmental significance flora species

Flora species	EPBC Act status	Results of assessment	Table containing assessment against MNES Guidelines
Hairy-joint grass (*Arthraxon hispidus*)	V	No significant residual impact from the Project anticipated— no important populations or critical have been identified for this species within the Project disturbance footprint	Table 5.14
Bunya Mountains bluegrass (*Bothriochloa bunyensis*)	V	No significant residual impact from the Project anticipated— no potential habitat within Project disturbance footprint	Table 5.14
Miniature moss-orchid (*Bulbophyllum globuliforme*)	V	No significant residual impact from the Project anticipated—no potential habitat within Project disturbance footprint	Table 5.14

Flora species	EPBC Act status	Results of assessment	Table containing assessment against MNES Guidelines
Stream clematis (*Clematis fawcettii*)	V	No significant residual impact from the Project anticipated— no potential habitat within Project disturbance footprint	Table 5.14
King bluegrass (*Dichanthium queenslandicum*)	E	No significant residual impact from the Project anticipated—no potential habitat within Project disturbance footprint	Table 5.12
Bluegrass (*Dichanthium setosum*)	V	No significant residual impact from the Project anticipated— no important populations or critical have been identified for this species within the Project disturbance footprint	Table 5.14
Four-tailed grevillea (*Grevillea quadricauda*)	V	Potential for a significant residual impact as a result of the Project	Table 5.15
Blunt-leaved leionema (*Leionema obtusifolium*)	V	No significant residual impact from the Project anticipated—no potential habitat within Project disturbance footprint	Table 5.16
Wandering pepper-cress (*Lepidium peregrinum*)	E	No significant residual impact – no potential habitat within Project disturbance footprint	Table 5.13
Paspalidium grandispiculatum	V	Potential for significant residual impact as a result of the Project	Table 5.17
Hawkweed (*Picris evae*)	V	Potential for significant residual impact as a result of the Project	Table 5.18
Austral cornflower (*Rhaponticum australe*)	V	Potential for significant residual impact as a result of the Project	Table 5.19
Waxy sarcochilus (*Sarcochilus hartmannii*)	V	No significant residual impact –from the Project anticipated— no potential habitat within Project disturbance footprint	Table 5.14
Blotched sarcochilus (*Sarcochilus weinthalii*)	V	Potential for significant residual impact as a result of the Project	Table 5.20
Brush sophora (*Sophora fraseri*)	V	Project is likely to cause 'significant residual impacts' on an important population of Brush sophora	Table 5.21
Austral toadflax (*Thesium australe*)	V	No significant residual impact — from the Project anticipated— no important populations or critical have been identified for this species within the Project disturbance footprint	Table 5.14

5.3.4.1 Critically endangered/endangered flora species

Under the MNES Guidelines an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of a population
- Reduce the area of occupancy of the species
- Fragment an existing population into two or more populations
- Adversely affect habitat critical to the survival of the species
- Disrupt the breeding cycle of a population
- Modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline
- Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat

- Introduce disease that may cause the species to decline
- Interfere with the recovery of the species.

All populations of critically endangered and endangered flora species are considered important populations.

The following sections assess the potential for significant residual impacts on the two endangered flora species identified as potentially occurring within the Project area using the criteria set out in the Guidelines.

King blue-grass (*Dichanthium queenslandicum*) - endangered

Ecology and distribution

King blue-grass is endemic to central and southern QLD. This species occurs on black cracking clay in tussock grasslands mainly in association with other species of Bluegrass (*Dichanthium* spp. and *Bothriochloa* spp.*)* but also with other grasses restricted to this soil type. It is mostly confined to natural bluegrass grasslands of central and southern QLD, including the endangered EPBC ecological community: Natural Grasslands on Basalt and Fine-textured Alluvial Plains of northern NSW and southern QLD.

King blue-grass is endemic to central and southern QLD where it occurs in three disjunct populations; Hughenden district; Nebo to Monto and west to Clermont and Rolleston; and Dalby district, Darling Downs. The extent of the species occurrence is thought to be reduced from 1,100 square kilometres (km^2) to 245 km^2 (Accad et al. 2008; DAWE 2020).

King blue-grass occurs within the SEQ, Brigalow Belt South, Brigalow Belt North, Central Mackay Coast, Desert Uplands, Mitchell Grass Downs and Einasleigh Uplands Bioregions; and the SEQ, Condamine, Border Rivers Maranoa-Balonne, Burnett Mary, Fitzroy, Burdekin, Mackay Whitsunday, Southern Gulf and Desert Channels Natural Resource Management regions (DAWE 2020).

Distribution in context to the Project

This species was not identified during any Project-associated field surveys or for the nearby B2G and TSRC projects. There are no database records (AoLA) within or near the MNES study area. The nearest records from within a 50 km buffer of the alignment occur to the southwest at Pittsworth (30 km from the Project) and to the northwest between Oakey and Dalby (35 km from the Project) (refer Figure 1.21 in Appendix B).

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan applicable to this species. The following threat abatement plan has been identified as relevant to this species:

- *Threat abatement plan for competition and land degradation by rabbits* (DotEE 2016)

The DAWE Approved Conservation advice (Threatened Species Scientific Committee (TSSC) 2013) notes the following potentially threatening processes identified for Queensland blue-grass:

- Loss of habit through agricultural and mining activities, road construction and other infrastructure developments
- Agricultural (cropping) and grazing associated activities. The species is susceptible to continuous heavy grazing regimes.
- Invasion from weeds including Parthenium (*Parthenium hysterophorus*) and Parkinsonia (*Parkinsonia aculeata*).

Habitat critical to the survival of the species

No critical habitat for this species has been noted in published information. In the absence of a definition for critical habitat for the species this assessment has applied a 1 km buffer on known records (less than 30 years old) that intersect ‘potential habitat’ (refer Appendix A for methodology).

Predictive mapping indicates the MNES impact study area incorporates 0.67 ha of potential habitat, for this species (refer Table 5.4). This habitat occurs on the cracking clay soils in the Gowrie area (refer habitat figure in Appendix G). This area has been heavily modified and is largely subject to agriculture and grazing land use. Impacts and mitigation measures associated with this species are identified within Table 5.6. Assessment against the significant impact criteria for endangered species is shown in Table 5.12.

Table 5.12 Assessment against the significant impact criteria: King blue-grass (*Dichanthium queenslandicum*)

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	The western portion of the Project disturbance footprint occurs on the eastern edge of the species distribution. The species was not observed during Project-associated surveys, along with surveys in adjacent areas such as the B2G and TSRC projects. The nearest records are from the Pittsworth area approximately 30 km from the Project disturbance footprint. All other records of the species are from much further north and west of the Project. Predictive modelling indicates 0.67 ha of potential habitat may occur within the Project disturbance footprint in the Gowrie area where suitable heavy clay soils occur. Despite this the species is not known from the area. There is no evidence that the Project will result in a long-term decrease in the size of a population.
Reduce the area of occupancy for the species	The species was not observed during Project-associated surveys, along with surveys in adjacent areas such as the B2G and TSRC projects. The nearest records are from the Pittsworth area approximately 30 km from the Project disturbance footprint. Predictive modelling indicates 0.67 ha of potential habitat may occur within the Project disturbance footprint in the Gowrie area. The local landscape has been subject to extensive habitat modification and degradation. The Project is not considered likely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	The species was not observed during Project-associated surveys and the nearest records are from the Pittsworth area approximately 30 km from the Project disturbance footprint. Potential habitat within the Project disturbance footprint is restricted 0.67 ha. The Project is considered unlikely to fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of the species	This species is largely associated with native grasslands on dark clay soils which have been heavily impacted by previous land use in the local region. Predictive mapping indicates 0.67 ha of potential habitat for the species occurs. No Habitat critical to the survival of the species (for the purposes of this assessment) occurs within the Project disturbance footprint. That is the grasslands present in the Project disturbance footprint (refer Section 4.4.4.5) do not support the species and are not considered important for the dispersal and long-term maintenance of the species, along with the maintenance of genetic diversity, The communities would also not be appropriate for the reintroduction of populations. As such, the Project will not adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	This species has been recorded flowering all year round, particularly in March. The species is not known to occur within or near the Project disturbance footprint. Predictive mapping indicates 0.67 ha of potential habitat for the species occurs. The Project is considered unlikely to disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The main threats to the species relevant to the Project include loss of habitat and weed invasion. Uncontrolled fires may also be a threat associated with the Project. However, the species was not observed during Project-associated surveys, along with surveys in adjacent areas such as the B2G and TSRC projects. The nearest records are from the Pittsworth area approximately 30 km from the Project disturbance footprint. Predictive modelling indicates 0.67 ha of potential habitat may occur within the Project disturbance footprint. Given the relatively small area the Project occupies on the edge of this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	Weed invasion, particularly by *Parthenium hysterophorus* and *Parkinsonia aculeata* is a potential threat to the species (TSSC 2013). Whilst one of these species (i.e. Parthenium) is known from the area, its abundance was relatively low. Project-associated surveys have recorded 10 weed species listed as Weeds of national Significance (refer Section 4.4.1.1). Grasslands in the area are already subject to invasion by introduced pastoral grass species. ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	There are no identified introduced diseases associated with this species. The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice (TSSC 2013) for the species identifies research priorities and regional priority actions including: ▪ Design and implement a monitoring program on known populations, to identify threats, management program success and identify high conservation priority areas ▪ More precisely assess population size, distribution, ecological requirements and the relative impacts of threatening processes. ▪ Undertake survey work in suitable habitat and potential habitat to locate any additional populations/occurrences/remnants. ▪ Investigate management options including optimal fire regimes for regeneration and grazing management practices ▪ Ensure there is no disturbance in areas where King blue-grass occurs, excluding necessary actions to manage the conservation of the species/ecological community ▪ Manage any other known, potential or emerging threats, including mining practices, grazing, weed invasion and climate change. Should the species be found to occur within the Project footprint the Project may conflict with priority actions ensuring no disturbance occurs where the species occurs but will add to information known about the distribution of the species in the area. Nevertheless, the Project footprint occupies a very minor area within the overall distribution of the species and is considered unlikely to substantially interfere with the recovery of the species. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, it is unlikely the Project will cause 'significant residual impacts' on a population of King bluegrass

Wandering pepper-cress (*Lepidium peregrinum*) - endangered

Ecology and distribution

Wandering pepper-cress (*Lepidium peregrinum*) is a perennial plant that grows to 10 to 80 cm tall, sometimes ascending to 2 m in surrounding vegetation. The species has been recorded growing in riparian open forest dominated by *Eucalyptus camaldulensis* and *Casuarina cunninghamiana* with variably dense shrubby understorey. The species was most abundant in the tussock grassland fridge of the riparian open forest, with some plants reaching a height of 2 m in thickets of *Hymenanthera*. It has also been recorded in shade under shrubs close to the creek bank, in which cases most plants have been small, approximately 30 cm in height. Herbarium records and observations in the wild suggest this species responds to disturbance events, due to observations along walking tracks, native pine plantations and car parks, and therefore population densities may fluctuate as a response to such events (Scarlett 2000; Office of Environment and Heritage (OEH) 2018a; DAWE 2020).

Wandering pepper-cress occurs from the Bunya Mountains, SEQ, to near Tenterfield, in northern NSW. This species occurs within the New England Tableland and SEQ Bioregions and the SEQ, Condamine and Border-Rivers Maranoa-Balonne Natural Resource Management regions (OEH 2018a; DAWE 2020).

Distribution in context to the Project

This species was not identified during any Project-associated field surveys or for the nearby B2G and TSRC projects. Database records (AoLA) indicate that there are no records of *Lepidium peregrinum* within the MNES study area. The closest records are located approximately 6 km north of the Project disturbance footprint at Highfields Falls Bushland Reserve and are dated 2007. The next closest records are located approximately 8 km south of the alignment immediately east of Toowoomba and are dated 2007. A number of other records are located within a 50 km buffer of the Project disturbance footprint. These are concentrated near Ravensbourne National Park (19 km northeast of the Project) (refer Figure 1.45 in Appendix B).

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species. The following threat abatement plan has been identified as relevant to this species:

- *Threat abatement plan for competition and land degradation by rabbits* (DotEE 2016)

The DAWE Approved Conservation advice (TSSC 2014) notes the following potentially threatening processes identified for Wandering pepper-cress

- Loss of habit through agricultural activities
- Grazing from livestock and rabbits
- Invasion from weeds.

Habitat critical to the survival of the species

No Habitat critical to the survival of the species has been noted in published information such as the approved conservation advice for the species. In the absence of a definition for Habitat critical to the survival of the species this assessment has applied a 1 km buffer on known records (less than 30 years old) that intersect ‘potential habitat’ (refer Appendix A for methodology).

Although there is 38.59 ha of potential habitat within the overall MNES study area there is no potential habitat in which this species is likely to occur within the Project disturbance footprint (refer Table 5.4). Impacts and mitigation measures associated with this species are identified within Table 5.6. Assessment against the significant impact criteria for endangered species is shown in Table 5.13.

Table 5.13 Assessment against the significant impact criteria: Wandering pepper-cress (*Lepidium peregrinum*)

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	No historical records exist within or near the MNES study area and no individuals were observed during field investigations. Predictive mapping indicates no potential habitat for the species within the Project disturbance footprint. It is uncertain if any individuals occur in the local area within or surrounding the Project disturbance footprint. No historical records exist within or near the MNES study area. There is no evidence that the Project will result in a long-term decrease in the size of a population.
Reduce the area of occupancy for the species	No individuals were observed during field investigations. No historical records exist within or close to the MNES study area. Predictive mapping indicates no potential habitat for the species within the Project disturbance footprint. It is uncertain if any individuals occur within the local area surrounding the Project disturbance footprint. The species occurs across a wide area to the north and south of the Project. The Project is considered unlikely to reduce the area of occupancy for the species.
Fragment an existing population into two or more populations	No records have been found to occur within or near the Project disturbance footprint. The nearest database records are located at least 6 km north of the Project disturbance footprint. Predictive mapping indicates no potential habitat for the species within the Project disturbance footprint. There is no evidence the Project would fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species occurs in riparian open forest particularly on the fringes of tussock grasslands and under shrubs along creek banks. Predictive mapping indicates no *Habitat critical to the survival of the species* or *Potential habitat* within the Project disturbance area. The species occurs across a wide area from Bunya Mountains south to Tenterfield. The species is not known to occur within or near the Project disturbance footprint. As such, it is considered unlikely that the Project will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	There is little information available regarding the species reproductive cycle. Nevertheless, the species has not been recorded within, or near the Project disturbance footprint. Predictive mapping indicates no potential habitat for the species within the Project disturbance footprint. The Project is considered unlikely to disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Predictive mapping indicates no potential habitat occurs within the Project disturbance area. The species occurs across a wide area from Bunya Mountains south to Tenterfield. Nevertheless, the species has not been recorded within, or near the Project disturbance footprint. The Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	Weed invasion is a potential threat to the species (TSSC 2014). Project-associated surveys have recorded 10 weed species listed as Weeds of national Significance (refer Section 4.4.1.1). Riparian and adjacent areas within the MNES study area were noted as often comprising heavy infestations of Lantana (*Lantana camara*). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.

Criterion	Assessment against significance criteria
Interfere with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice (TSSC 2014) for the species identifies research priorities and regional priority actions including: ■ Monitor known populations to identify key threats, identify high priority populations and manage current or potential threats. ■ Monitor the progress of recovery, including the effectiveness of management actions and the need to adapt them if necessary. ■ Ensure there is no inappropriate disturbance in areas where Wandering pepper-cress occurs, excluding necessary actions to manage the conservation of the species. The Project is considered unlikely to interfere with the recovery strategies listed above and is unlikely to interfere with the recovery of the species.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, it is considered unlikely the Project could cause 'significant residual impacts' on a population of Wandering pepper-cress.

5.3.4.2 Vulnerable flora species populations

In accordance with the MNES Guidelines, an action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

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

As evident the criteria, the impact is only applicable if the population is important. An 'important population' as defined within the MNES Guidelines (DotE 2013a) is:

'*An important population is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:*

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

Given above, an initial assessment was undertaken to determine whether an 'important population' is present in the MNES study area. Where an 'important population' is considered not to be present an assessment against the above criteria was not undertaken.

Given the specificity of the above definition and the scarcity of information and records available for most listed species and populations in the region (and Australia), it is difficult to determine: 1) attributes such as breeding and dispersal behaviour and whether the population is a 'key source' and 2) the genetic diversity of individuals inhabiting a population or sub-population. It is noted the Project is linear and is not expected to impact the potential distribution of local pollinators for most (if not all) plant species and as such is not considered likely to impact dispersal or genetic exchange within a plant population.

Given the paucity of information available, significance of impacts to threatened species has been based on experience of the assessment team and the latest available information.

Impacts and mitigation measures associated with this species are identified within Table 5.6 and Table 5.14 provides an evaluation of the populations of vulnerable flora species considered as potentially associated with the MNES study area.

Table 5.14 Assessment of status of vulnerable flora species population against matters of national environmental significance Guidelines criteria

Common name	Species name	Project area population evaluation
Hairy-joint grass	*Arthraxon hispidus*	This species was not identified during any Project-associated field surveys or for the nearby B2G and TSRC projects. The nearest cluster of database records (AoLA 2020) are located approximately 4 km south of the Project disturbance footprint (refer Figure 1.17 in Appendix B). All of these records are located within Toowoomba LGA. Recent records are associated with parkland areas. There are no other records within 50 km of the Project. DAWE (2020) mapping indicates the species or species habitat as likely to occur within Project disturbance footprint in the Toowoomba Range. The species occurs from Port Douglas (north Queensland) south to Kempsey in NSW (DEWHA 2008a). The bulk of the population occurs in coastal areas south of Noosa (DAWE 2020). The MNES study area is not located near the limit of the species range. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008a) has not revealed any important populations or *Habitat critical to the survival of the species*. No populations that are important for the long-term survival and recovery of the species have been identified. The species can be found in a variety of habitats including edges of rainforest, wet eucalypt forest, woodland, creek banks and beds, shaded gullies and mound springs (DEWHA 2008a). Recent studies of the species in New South Wales indicate a preference for native dominated freshwater wetlands, drainage lines, and groundwater seepages with little canopy cover (White et al. 2019). As such, no habitat can be identified as critical in the absence of the species presence. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect 'potential habitat' (refer Appendix A for methodology). The Project is linear and located near existing linear infrastructure and is not expected to impact dispersal or breeding capacity. Predictive habitat mapping indicates there is 9.18 ha potential habitat for this species within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G), however it is to be noted that wetlands are generally limited in the area. The species has not been recorded within or nearby to the Project. No important populations or *Habitat critical to the survival of the species* have been identified for this species in relation to the Project and the species occurs across a wide area. The predicted impact area is minor and will not conceivably impact the species such that it is likely to decline or impact recovery of the species. Therefore, the Project is unlikely to significantly impact this species and it is not considered further.
Bunya Mountains bluegrass	*Bothriochloa bunyensis*	This species was not identified during any Project-associated field surveys or for the nearby TSRC project. Database records (i.e. AoLA & WildNet) indicate this species occurs within the MNES study area at Blue Mountain Heights dated 2004 (2.2 km from aboveground disturbance associated with the Project). The next closest record occurs 5 km to the south in Toowoomba dated 2005. Other records from within a 50 km buffer of the Project disturbance footprint occur in the Lockyer Forest Reserves (1985) to the north (10km north of the Project) and at Main Range National Park over 35 km to the south-east (refer Figure 1.13 in Appendix B). Other records outside of a 50 km buffer of the Project disturbance footprint occur at Bunya Mountains National Park. DAWE (2020) mapping indicates the species as may occur in the Toowoomba Range area including habitat intersected by the Project disturbance footprint. Bunya Mountains bluegrass is endemic to SEQ where populations occur on Bunya Mountains north of Dalby, near Toowoomba, Crows Nest and the Main Range (Mt Mistake Plateau). The species occurs on relatively fertile (dark brown) soils derived from basalt on upper slopes and hill crests at higher altitudes, in grassland or woodland with a grassy understorey (Halford 1998).

Common name	Species name	Project area population evaluation
		There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008b) has not revealed any important populations or critical habitat for the species. No populations that are important for the long-term survival and recovery of the species have been identified. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect 'potential habitat' (refer Appendix A for methodology). The Project is linear and located near existing linear infrastructure and is not expected to impact dispersal or breeding capacity. Predictive habitat mapping indicates there is no *Habitat critical to the survival of the species* or *potential habitat* within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). This is largely the result of the location of the tunnel through preferred habitat areas (i.e where there is no aboveground disturbance) and the heavily modified lands occurring at the top of, and west of the Toowoomba Range. The Project is not predicted to impact any habitat for the species and therefore, is unlikely to significantly impact the species and it is not considered further.
Miniature moss-orchid	*Bulbophyllum globuliforme*	This species was not identified during any Project-associated field surveys or for the nearby TSRC project. There are no records close to the MNES study area (refer Figure 1.27 in Appendix B). The nearest database records are located approximately 120 km from the Project in Lamington and Border Ranges National Parks to the south-east (AoLA 2020). These records are located a considerable distance from other records within the species' range. Nevertheless, there is potential habitat for the species. The species occurs on the bark of Hoop pines (*Araucaria cunninghamiana*) colonising the upper branches in upland rainforest (Harrison 2002). It is noted that few Hoop pines, growing under natural conditions were identified within the MNES study area. The species distribution within QLD ranges from Paluma in northeast QLD south to the McPherson Range along the QLD/NSW border. Miniature moss-orchid are conserved in Noosa National Park, Lamington National Park and Bunya Mountains National Park, QLD, and the Border Ranges National Park, NSW (DAWE 2020). The Project area is isolated from the species' known distribution. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008c) has not revealed any important populations or *Habitat critical to the survival of the species*. No populations that are important for the long-term survival and recovery of the species have been identified. If the species was found to occur within the Project area it would be an isolated population and therefore potentially an important population. Nevertheless, there are no records within 120 km of the Project. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). Predictive habitat mapping has taken a conservative approach and indicates there is 2.36 ha of *potential habitat* (comprising Hoop Pine) for this species within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). The species has not been recorded within 120 km of the Project. The predicted impact area is minor and will not conceivably impact the species such that it is likely to decline or impact recovery of the species. The Project will not impact *Habitat critical to the survival of the species*. Therefore, the Project is unlikely to significantly impact this species and it is not considered further.
Stream clematis	*Clematis fawcettii*	This species was not identified during any Project-associated field surveys or for the nearby B22G and TSRC projects. The nearest database records are located approximately 9 km south of the Project disturbance footprint to the east of Toowoomba at Mount Davidson with two records from 1990 (AoLA 2020). Two records exist approximately 25 km northwest of the Project disturbance footprint at Gumbungee dated 1987. Two more recent records (2011) occur at Irongate Conservation Park approximately 45 km southwest of the Project disturbance footprint (refer Figure 1.40 in Appendix B). The species distribution within QLD extends from the Bunya Mountains to the NSW border. This species is conserved within Lamington, Mount Barney and Main Range National Parks (DAWE 2020). Stream clematis is a perennial climbing vine found in drier rainforests near streams. Invasion by Lantana (*Lantana camara*) is considered a threat to the species (DEWHA 2008d). Lantana was found to be common in the MNES study area with heavy infestations observed in riparian areas.

Common name	Species name	Project area population evaluation
		There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008d) has not revealed any important populations or *Habitat critical to the survival of the species*. No populations that are important for the long-term survival and recovery of the species have been identified. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology). Predictive habitat mapping indicates there is only 0.71 ha of potential habitat within the MNES study area and no *potential habitat* for this species within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). The Project is not predicted to impact habitat for the species and therefore, is unlikely to significantly impact the species and it is not considered further.
Bluegrass	*Dichanthium setosum*	This species was not identified during any Project-associated field surveys or for the nearby B2G and TSRC projects. Database records (AoLA) from 1996 occur within 5 km to the north of the alignment (west of Murphys Creek). Records from 2009 occur a similar distance to the south of the Project disturbance footprint to the east of Toowoomba. Scattered records for this species occur throughout the Toowoomba Range from Crows Nest in the north to Hodgson Vale in the south (refer Figure 1.8 in Appendix B). DAWE (2020) mapping indicates the species or species habitat as likely to occur within Project disturbance footprint. Bluegrass occurs sparsely on the north western slopes, central western slopes and north western plains of NSW, extending west to Narrabri. In QLD, it has been documented to occur from the Leichhardt, Morton, North Kennedy and Port Curtis regions. It occurs around Carnarvon National Park and scattered locations as far north as southern Cape York Peninsula. The MNES study area is not on the edge of the species distribution. Bluegrass is a warm season perennial grass, that commences growing in spring, flowers in summer and becomes dormant in late autumn (DotEE 2019). It is associated with associated with heavy basaltic black soils and stony red-brown hardsetting loam with clay subsoil (DEWHA 2008h). There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008e) has not revealed any important populations or *Habitat critical to the survival of the species*. No populations that are important for the long-term survival and recovery of the species have been identified. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). The Project is linear and located near existing linear infrastructure and is not expected to impact dispersal or breeding capacity. Predictive habitat mapping indicates there is 0.67 ha of *potential habitat* for this species within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). Likely habitat within the vicinity of the Project is largely avoided as a result of the Toowoomba Range Tunnel (i.e. no aboveground disturbance). The species has not been recorded within or nearby to the Project. No important populations or *Habitat critical to the survival of the species* have been identified for this species in relation to the Project and the species occurs across a wide area. The predicted impact area is very minor and will not conceivably impact the species such that it is likely to decline or impact recovery of the species. Therefore, the Project is unlikely to significantly impact this species and it is not considered further.
Four-tailed grevillea	*Grevillea quadricauda*	This species was not identified during any Project-associated field surveys or for the nearby H2C and TSRC projects. Database records indicate this species has been detected/recorded within approximately 2 km to the north of the eastern section of the Project disturbance footprint to the south of the Lockyer Forest Reserves area dated 2017. There are a number of records further north and east of this record within the Lockyer Forest Reserves area. Several records occur to the east of the Project disturbance footprint at Helidon approximately 3 km from the alignment. A cluster of records occur to the east of Toowoomba approximately 10 km south of the Project disturbance footprint. In QLD this species occurs near Toowoomba from Helidon Hills in the Murphys Creek area. This species also occurs in NSW however these populations are largely geographically isolated from one another (DAWE 2020).

Common name	Species name	Project area population evaluation
		There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008f) has not revealed any important populations or Habitat critical to the survival of the species. However, given there are database records in close proximity to the Project disturbance footprint and the species has a narrow range of occurrence there is potential for an 'important population' to be impacted by the Project. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). Predictive habitat mapping indicates that the Project may disturb 1.02 ha of *potential habitat* for this species (refer Table 5.4 and habitat figure in Appendix G). Under the MNES Guidelines there may be an 'important population' of the species in the area and there is potential for the Project to impact the species. The potential for significant residual impacts on an important population of *Grevillea quadricauda* is assessed under the Guidelines in Table 5.14.
Blunt-leaved leionema	*Leionema obtusifolium*	This species was not identified during any Project-associated field surveys or for the nearby H2C and TSRC projects. Two older database records (AoLA) occur 2 km to the east of the Project disturbance footprint near Helidon dated 1964 and 1978. Almost all other historical records for this species exist to the northeast within the Lockyer Forest Reserves area with the most recent dated from 2016 and located 6.6 km northeast of the Project. This species only occurs in a small area of SEQ from Helidon to Ravensbourne. A number of other records exist to the north associated with the Lockyer Forest Reserves. The species is only known from the Helidon-Ravensbourne area (and mapping produced by DAWE indicates the species as likely to occur in the Helidon Hills adjacent to the north of the Project disturbance footprint. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008g) has not revealed any important populations or *Habitat critical to the survival of the species*. However, given there are database records in close proximity to the Project disturbance footprint and the species has a narrow range of occurrence there is potential for an 'important population' to be impacted by the Project. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology). Predictive habitat mapping indicates that the project may disturb 0.63 ha of *potential habitat* for this species (refer Table 5.4 and habitat figure in Appendix G). Under the MNES Guidelines there may be an 'important population' of the species in the area and there is potential for the Project to impact the species. The potential for significant residual impacts on an important population of *Leionema obtusifolium* is assessed under the Guidelines in Table 5.16.
A grass	*Paspalidium grandispiculatum*	This species was not identified during any Project-associated field surveys or for the nearby H2C and TSRC projects. Nevertheless, there are a number of records to the northeast of the Project disturbance footprint. The closest is within approximately 4 km of the Project disturbance footprint and is dated 1997. Other records occur throughout the Lockyer Forest Reserves with the most recent record dated from 2016. There are further records to the north near Crows Nest. In QLD the species occurs in a band from Kingaroy to Beaudesert. There are also scattered records in the Grafton area of northern NSW (DAWE 2020) and mapping indicates the species as likely to occur in the Helidon Hills area including habitat intersected by the Project disturbance footprint. A review of the available literature has not revealed any important populations or definition of *Habitat critical to the survival of the species* including the approved conservation advice for the species (DEWHA 2008h). However, given there are database records in close proximity to the Project disturbance footprint and the species has a narrow range of occurrence there is potential for an 'important population' to be impacted by the Project. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology). It is estimated that the Project may impact 156.25 ha of *potential habitat* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). Under the MNES Guidelines there may be an 'important population' of the species in the area and there is potential for the Project to impact the species. The potential for significant residual impacts on an important population of *Paspalidium grandispiculatum* is assessed under the Guidelines in Table 5.17.

Common name	Species name	Project area population evaluation
A hawkweed	*Picris evae*	This species was not identified during any Project-associated field surveys but has been recorded during surveys for the nearby TSRC project and there are records from the Gowrie Creek floodplain (refer Section 4.3.1.1). This species has been recorded between 2008 to 2019 within the MNES study area to the north and south of the Project disturbance footprint near Cranley to the north of Toowoomba. A record from 2015 occurs near Gowrie Mountain approximately 3 km southwest of the western section of the alignment. Other records from within a 50 km buffer of the Project disturbance footprint occur to the south, southwest, west and northwest of the Project disturbance footprint. A single record exists to the east near Esk from 2001 approximately 40 km from the Project disturbance footprint (AoLA 2020). This species occurs in the Darling Downs and Moreton pastoral districts in SEQ from across 30 sites (DAWE 2020). The species occurs on the Darling Downs in QLD and around Inverell in NSW. There is no Commonwealth adopted recovery plan for the species. The approved conservation advice for the species does not identify important populations or *Habitat critical to the survival of the species* (DEWHA 2008i). The overall population is relatively restricted in occurrence and local occurrences within the Project disturbance footprint may therefore be considered as part of an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). It is estimated that the project is likely to impact 31.88 ha of *potential habitat* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). Given individuals potentially occurring within the Project disturbance footprint could be considered part of an important population the Project has the potential to significantly impact this species and is assessed further in Table 5.18.
Austral cornflower	*Rhaponticum australe*	This species was not identified during any Project-associated field surveys but has been recorded during surveys for the nearby TSRC project and there are records from the Gowrie Creek floodplain (refer Section 4.3.1.1). This species has been recorded (AoLA) from 1999 within the Project disturbance footprint towards the western section of the alignment north of Cotswold Hills. Another record from 1999 occurs within the MNES study area within a few hundred metres north of this record. The next closest records occur to the northwest at Kingsthorpe dated 2011 approximately 5 km from the Project disturbance footprint and a similar distance to the southwest at Gowrie Mountain dated 1984. No recovery plan exists for this species. DAWE state the most significant population of this species occurs in the Toowoomba-Aubigny region which the Project disturbance footprint intersects. The overall population is relatively restricted in occurrence and local occurrences within the Project disturbance footprint may therefore be considered as part of an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). It is estimated that the project is likely to impact 73.98 ha of *potential habitat* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). Given individuals potentially occurring within the Project disturbance footprint could be considered part of an important population the Project has the potential to significantly impact this species and is assessed further in Table 5.19.
Waxy sarcochilus	*Sarcochilus hartmannii*	This species was not identified during any Project-associated field surveys or for the nearby TSRC project. Waxy sarcochilus is an epilithic orchid (i.e. grows on rocks and cliff faces) in sclerophyll forests, edges of rainforest and open areas from 500 m to 1,000 m altitude (DEWHA 2008j). A single record exists within a 50 km buffer of the Project disturbance footprint located approximately 15 km south of the alignment near Barry Griffith Park (refer Figure 1.47 in Appendix B). The collection date for this record is between 1850 to 1890 and has a high degree of spatial uncertainty possibly to protect the exact location as a major threat to this species is excessive illegal collecting. Given the date and high degree of spatial uncertainty this record is not reliable. The nearest records outside of a 50 km buffer of the Project disturbance footprint occur approximately 75 km southeast of the alignment at Main Range National Park (AoLA 2020). The species has been identified as being conserved in Lamington National Park, Main Range National Park, Tamborine Mountain National Park, Mount Warning National Park and Nightcap National Park. These locations could be considered important for the long-term survival of the species. Toowoomba Range is at the northern limit of the species range.

Common name	Species name	Project area population evaluation
		No recovery plan exists for this species. There is no Commonwealth adopted recovery plan for the species. The approved conservation advice for the species does not identify important populations or *Habitat critical to the survival of the species* (DEWHA 2008j). No populations that are important for the long-term survival and recovery of the species have been identified. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology). Predictive habitat mapping indicates there is 88.55 ha within the MNES study area but no *potential habitat* for this species within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). There is no suitable rocky habitat within the Project disturbance footprint. The Project is not predicted to impact habitat for the species and therefore, is unlikely to significantly impact the species and it is not considered further.
Blotched sarcochilus	*Sarcochilus weinthalii*	This species was not identified during any Project-associated field surveys or for the nearby TSRC project. Database records (AoLA) for the species have been generalised to protect the location of the species, likely from specialist collectors. As such, database records may not reflect the actual location of the record. There are two very old records (1882 and 1957) located 2 km north of the Project disturbance footprint. There are eight records to the east of Toowoomba located 8.5 km south of the Project, the most recent of which is from 2015. To the south-east of Toowoomba are three very old records (103 to 1909) located 11 km south. The species occurs in rainforest, dry rainforest and dry scrubs on sub-coastal ranges. In QLD this species occurs from the NSW border to the Bunya Mountains and the Gallangowan area (DAWE 2020). There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature has not revealed any important populations or *Habitat critical to the survival of the species* (DotE 2014b). No populations that are important for the long-term survival and recovery of the species have been identified. The species has a scattered distribution of isolated populations and occurs in the Toowoomba Range. As such, a local population may be considered as an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology). It is predicted the project may impact 3.14 ha of *potential habitat* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). Given individuals potentially occurring within the Project disturbance footprint could be considered part of an important population the Project has the potential to significantly impact this species and is assessed further in Table 5.20.
Brush sophora	*Sophora fraseri*	This species was recorded within the Project disturbance footprint (near the eastern tunnel portal during Project surveys (refer Figure 4.4). This species has been recorded recently (2018) within the Project disturbance footprint east of Mount Kynoch in the Toowoomba area. The next closest records dated 1997 occur to the west of the Project disturbance footprint at Kingsthorpe with two records at this location (AoLA). The species distribution extends from Casino in northern NSW north to the Sunshine Coast hinterland. The Project may be on the western edge of the species range. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature has not revealed any important populations (DEWHA 2008k). No populations that are important for the long-term survival and recovery of the species have been identified. The species occurs in moist habitats on the edges of rainforest and in canopy gaps in closed forest communities (DEWHA 2008k). In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). It is predicted the project may impact 28.69 ha of *potential habitat* and 2.36 ha of *Habitat critical to the survival of the species* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). Under the MNES Guidelines the Project may impact an important population and *Habitat critical to the survival of the species* (as adopted for this assessment). The potential for significant residual impacts on an important population of Brush sophora is assessed under the MNES Guidelines in Table 5.21.

Common name	Species name	Project area population evaluation
Austral toadflax	*Thesium australe*	This species was not identified during any Project-associated field surveys but has been recorded during surveys for the nearby TSRC project. The location of this record cannot be ascertained at this time due to probity issues associated with the project. There are two database records (AoLA) to the east of Toowoomba from 1989 and 2009 located approximately 6 km south of the Project. To the southwest of Toowoomba there is a 2000 and 2004 record located approximately 11 km south. There are a number of records further south of Toowoomba. To the north there are many records from 2012 in Pechey State Forest (20 km north of the Project). To the east there are older records (1985) near Forest Hill (22 km from the Project) and to the west there is a 2000 record at Bowenville (refer Figure 1.4 in Appendix B). DAWE (2020b) mapping indicates the species or species habitat as likely to occur in the Project disturbance footprint. The species occurs from Carnarvon National Park (southern QLD) east to the coast and south through NSW and Victoria (DotE 2013b). The MNES study area is not located near the limit of the species range. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature has not revealed any important populations or *Habitat critical to the survival of the species* when referring to the Approved conservation advice for the species (DotE 2013b). No populations that are important for the long-term survival and recovery of the species have been identified. The species can be found in a number of habitats including grassland, shrubland and woodland in a variety of climates and altitudes (subtropical, temperate and alpine) and on varying soils (DAWE 2020). As such, no habitat can be identified as *Habitat critical to the survival of the species* in the absence of the species presence. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology). The Project is linear and is not expected to impact dispersal or breeding capacity. Predictive habitat mapping indicates that the Project may disturb 29.53 ha of *potential habitat* for this species (refer Table 5.4 and habitat figure in Appendix G). However, the modelling has been carried out in a conservative manner which includes non-remnant communities in road reserves and is a likely overestimate. No important populations or *Habitat critical to the survival of the species* have been identified for this species in relation to the Project, the species occurs across a wide area and is not on the edge of the species distribution. The Project will not conceivably impact the species such that it is likely to decline or impact recovery of the species. Therefore, the Project is unlikely to significantly impact this species and it is not considered further.

5.3.4.3 Significant impact assessment – Vulnerable flora

Four-tailed grevillea (*Grevillea quadricauda*)

Ecology and distribution

Four-tailed grevillea is a dense shrub growing up to 2 m high. The species occurs on gravelly loam soils or in sandy soils. It inhabits the understorey of dry sclerophyll forest or eucalypt woodland, usually along creeks or drainage lines. Associated plant communities include creek line forest dominated by Turpentine (*Syncarpia glomulifera*) and Brush-box (*Lophostemon confertus*) (Makinson 2000; NSW National Parks and Wildlife Service 2005; Olde and Marriott 1995). Flowering in this species occurs between August to September (DAWE 2020).

Four-tailed grevillea occurs in north-east NSW and near Toowoomba, in SEQ, where the species has been recorded from the Helidon Hills and in the Murphy's Creek area. The species occurs in the Northern Rivers (NSW) and Condamine (QLD) Natural Resource Management regions (DAWE 2020).

Distribution in context to the Project

This species was not identified within any Project-associated field surveys including protected plant surveys within the alignment. Database records indicate this species has been detected/recorded within approximately 2 km to the north of the eastern section of the Project disturbance footprint to the south of the Lockyer Forest Reserves area dated 2017. There are a number of records further north and east of this record within the Lockyer Forest Reserves area. Several records occur to the east of the Project disturbance footprint at Helidon approximately 3 km from the alignment. A cluster of records occur to the east of Toowoomba approximately 10 km south of the Project disturbance footprint (refer Figure 1.5 in Appendix B). In QLD this species occurs near Toowoomba from Helidon Hills in the Murphys Creek area. This species also occurs in NSW however these populations are largely geographically isolated from one another (DAWE 2020). DAWE habitat mapping (2020) indicates the species or species habitat as likely to occur only in the eastern portion of the alignment associated with the Helidon Hills. The species is not considered to occur to the west of this area.

Recovery plan/threat abatement plans

No recovery plan or threat abatement plans have been adopted for this species. The Approved conservation advice for the species (DEWHA 2008f) identifies the following threats:

- Clearing and habitat fragmentation for urban and rural development
- Inappropriate fire regimes
- Road maintenance activities
- Timber harvesting
- Within the Lockyer Resource Reserves the population has been impacted by extractive industry (quarries).

Important population and Habitat critical to the survival of the species

There are no important populations or definitions of habitat critical to the survival of Four-tailed grevillea identified in published information. Nevertheless, given the restricted area of occurrence of the species it may be inferred that the population occurring in the Lockyer Forest Reserves could be considered on the edge of the species range. As such, for the purposes of this assessment the habitat adjacent to this area which is intersected by the eastern extent of the Project is considered as potentially comprising individuals within an 'important population'. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology).

Impacts and mitigation measures associated with this species are identified within Table 5.4. Predictive habitat mapping indicates the Project may impact 1.02 ha of *potential habitat* for this species as identified under the predictive mapping approach used for this assessment (refer Table 5.4 and habitat figure in Appendix G). It is noted there is no *potential habitat* located within the Project disturbance footprint within 1 km of the nearby database records referred to above and as such no *Habitat critical to the survival of the species* has been identified. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.15.

Table 5.15 Assessment against the significant impact criteria - *Grevillea quadricauda*

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species has a restricted range encompassing habitat within the western extent of the Project area (adjacent to the Lockyer Forest Reserves. No individuals have been identified within the Project footprint during Project-associated surveys. Nevertheless, an 'important population' has been identified as potentially occurring in the area. Recent database records (2017) indicate the species is known to occur 2 km north of the Project disturbance footprint in the Helidon area, although most records are located further north and northeast. Modelling indicates 1.02 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. As part of the Flora and Fauna Sub-plan additional protected plant surveys targeting this species will be undertaken prior to vegetation clearing to confirm whether the species occurs (refer Table 5.6). Given the minor area of *potential habitat* within the Project disturbance footprint the Project is unlikely to cause a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	An 'important population' has been identified as potentially occurring in the eastern portion of the Project disturbance footprint, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. Predictive habitat modelling indicates 1.02 ha of potential habitat is predicted to occur within the Project disturbance footprint. Should the species be found to occur within the Project disturbance footprint the Project has a potential to reduce the area of occupancy of an 'important population' for the species although this impact will be minor at worst.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the eastern portion of the Project disturbance footprint, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby (potentially to the north and south) and suitable habitat is predicted to occur within the Project disturbance footprint. Nevertheless, the local area is already highly fragmented in the Helidon area. There is existing linear disturbance running parallel to the Project in this area (the QR West Moreton System rail corridor). The Project is considered unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species occurs in dry sclerophyll or eucalypt forests usually along drainage lines (DEWHA 2008f) which is widespread to the north-east of the Project. Predictive mapping indicates no habitat considered as *Habitat critical to the survival of the species* (for the purposes of this assessment) occurs within the Project disturbance footprint, although 1.02 ha of *potential habitat* occurs. As such, the Project is not considered likely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. Flowering occurs from August to September. The Project may disturb individuals (should they be present) but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. Predictive mapping indicates 1.02 ha of *potential habitat* occurs within the Project disturbance area. Nevertheless, there is extensive suitable habitat located north-east of the Project in the Lockyer Forest Reserves where the bulk of the population occurs. It is noted the Project may be a point source for bushfires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event. Given the very minor area the Project occupies within this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion is not identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. *Lantana* species (including *L. camara* and *L. montevidensis*) were common throughout the MNES study area with severe infestations at some sites. Other dominant invasive flora included Climbing asparagus fern (*Asparagus africanus*) and Small-leaved privet (*Ligustrum lucidum*). Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019b). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DEWHA 2008f) identifies research priorities and regional priority actions including: ■ Monitoring known populations and identifying high conservation value populations ■ Limiting the impact of disturbance from adjacent land use and activities associated with road maintenance and upgrading ■ Manage any changes to hydrology that may adversely impact the species ■ Identifying and controlling problem weed species including *Lantana camara* ■ Developing a fire management strategy for the species The Project is considered unlikely to interfere with the recovery strategies listed above. The Project will necessarily reduce known threats such as through weed controls under the Biosecurity Management Plan. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, there is a very minor potential for the Project to cause 'significant residual impacts' on *an important population* of Four-tailed grevillea through a reduction in the occupancy of the population should the species be found to occur within the Project disturbance footprint.

Blunt-leaved leionema (*Leionema obtusifolium*)

Ecology and distribution

Blunt-leaved leionema (*Leionema obtusifolium*) is a shrub growing to approximately 1 m high. It is known to inhabit eucalypt forest, often with White mahogany (*Eucalyptus acmenoides*) and Brown bloodwood (*Corymbia trachyphloia*), on sandstone substrates in the Helidon Hills and White Mountain State Forest areas, and on granite at Crows Nest National Park (DAWE 2020). Little is known about the biology and reproduction of Blunt-leaved leionema, apart from the species is known to flower in spring (Stanley and Ross 1983).

The species is known to occur in a small area of SEQ, in the Helidon and Ravensbourne areas (Stanley and Ross 1983). It has been collected at sites near Crows Nest in the upper reaches of Alice Creek, from the Helidon Hills, and White Mountain State Forest, northeast of Murphy's Creek (DAWE 2020a).

Distribution in context to the Project

This species was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs or for the nearby TSRC project. Database records (AoLA) describe two older records located approximately 2.7 km southeast of the eastern section of the MNES study area dated 1964 and 1978 in what is now cleared habitat. The majority of records for this species occur within the Lockyer Resource Reserve to the north and northeast of the eastern section of the Project (between 6 km and 12 km from the Project disturbance footprint) including old and recent records dated 1970 to 2016. The nearest recent record (2016) is located 6.5 km northeast of the Project. The closest record is from 1989 and located 6.1 km from the Project. A single record from 1963 is located 5.5 km south of the eastern extent of the alignment, although this record has a high degree of spatial uncertainty. Another group of records exist at Crows Nest located approximately 30 km north of the Project (refer Figure 1.23 in Appendix B). Dawe habitat mapping (2020) indicates the species is not considered to occur within the Project disturbance footprint.

Recovery plan/threat abatement plans

No recovery plan or threat abatement plans have been adopted for this species. The Approved conservation advice for the species (DEWHA 2008g) identifies the following threats:

- Habitat loss and fragmentation
- Too frequent fires resulting inappropriate prescribed burning regimes and grazing management may deplete the soil seed bank
- Habitat degradation resulting from forestry activities and grazing activity (Boyes 2004).

Important population and Habitat critical to the survival of the species

There are no important populations or *Habitat critical to the survival* of Blunt-leaved leionema identified in published information. Nevertheless, given there are database records in relatively close proximity to the Project disturbance footprint and the species has a narrow range of occurrence there is potential for an 'important population' to be impacted by the Project. As such, for the purposes of this assessment the habitat which is intersected by the Project is considered as an 'important population'. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology).

Impacts and mitigation measures associated with this species are identified within Table 5.6. Predictive habitat mapping indicates the Project may impact 0.63 ha of *potential habitat* for this species (refer Table 5.4 and habitat figure in Appendix G). Assessment against the significant impact criteria for vulnerable species is shown in Table 5.16.

Table 5.16 Assessment against the significant impact criteria – Blunt-leaved leionema

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species has a restricted range encompassing habitat within the eastern extent of the Project area (adjacent to the Lockyer Forest Reserves. No individuals have been identified within the Project disturbance footprint during Project-associated surveys. Nevertheless, an 'important population' has been identified as potentially occurring in the eastern portion of the MNES study area. Recent database records indicate the species is only known to occur northeast of the Project. The nearest records are older and located 2.7 km from the Project disturbance footprint in what is now cleared habitat. There are no recent records within 6 km of the Project. Predictive mapping indicates 0.63 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. Nevertheless, there is abundant suitable habitat in which the species is known to occur to the northeast of the Project in the Lockyer Forest Reserves area. Predictive mapping indicates there is 106.49 ha of *potential habitat* for the species within the overall MNES study area. It is noted the Project may be a point source for bushfires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event.

Criterion	Assessment against significance criteria
	As part of the Flora and Fauna Sub-plan additional protected plant surveys targeting this species will be undertaken prior to vegetation clearing to confirm whether the species occurs (refer Table 5.6). Given the Project is located southwest of the known population and the *potential habitat* within the Project disturbance footprint is very minor given the extent of available habitat in the wider area, it is considered unlikely the Project will result in a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	An 'important population' has been identified as potentially occurring in the eastern portion of the MNES study area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. All local recent records occur to the northeast of the Project. Predictive mapping indicates 0.63 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. Nevertheless, there is abundant suitable habitat in which the species is known to occur to the north of the Project in the Lockyer Forest Reserves area. Predictive mapping indicates there is 106.49 ha of *potential habitat* for the species within the overall MNES study area. Given the distance recent records of the species occur from the Project disturbance footprint and the very minor area of predicted impact the Project is considered unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the eastern portion of the MNES study area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby, and suitable habitat is predicted to occur within the disturbance area. Nevertheless, all recent records occur to the northeast of the Project. The Project is linear, but the species pollination is thought to be wind-associated and as such is unlikely to impact the population (should individuals be found to occur south of the Project disturbance footprint). Nevertheless, the local area is already highly fragmented in the Helidon area. There is existing linear disturbance running parallel to the Project in this area (the QR West Moreton System rail corridor). It is considered unlikely the Project will fragment an existing important population into two populations.
Adversely affect habitat critical to the survival of the species	The species occurs in mixed eucalypt forest communities and modified pasture, both of which is a widespread vegetation type in the local area. Predictive mapping indicates no habitat considered as Habitat critical to the survival of the species (for the purposes of this assessment) occurs within the Project disturbance area, although 0.63 ha of *potential habitat* may occur. It is not known if the species occurs within the Project disturbance footprint. As such, the Project is considered unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the eastern portion of the MNES study area, although it is unknown at this stage if any individuals occur within or south of the Project disturbance footprint. The flowering and fruiting period is from January to May. The Project is linear, but the species pollination is thought to be wind-associated and as such is unlikely to impact the population (should individuals be found to occur south of the Project disturbance footprint). The Project may disturb individuals, but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the eastern portion of the MNES study area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby. Predictive mapping indicates 0.63 ha of *potential habitat* occurs within the Project disturbance area. Nevertheless, all local records occur to the north of the Project. There is abundant suitable habitat to the north and northeast of the Project in which the species is known to occur. Given the very minor area the Project occupies within this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion is not identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. *Lantana* species (including *L. camara* and *L. montevidensis*) were common throughout the MNES study area with severe infestations at some sites. Other dominant invasive flora included Climbing asparagus fern (*Asparagus africanus*) and Small-leaved privet (*Ligustrum lucidum*). Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a).

Criterion	Assessment against significance criteria
	ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DEWHA 2008g) identifies research priorities and regional priority actions including: ■ Monitoring known populations and identifying high conservation value populations ■ Limiting the impact of disturbance from adjacent land use and activities including road widening and maintenance activities ■ Manage any changes to hydrology that may adversely impact the species ■ Identifying and controlling problem weed species including *Lantana camara* ■ Developing fire management and stock (grazing) management strategies for the species The Project is considered unlikely to interfere with the recovery strategies listed above. The Project will necessarily reduce known threats such as grazing by livestock (on land within the Project footprint) and through weed controls under the Biosecurity Management Plan. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	The Project is predicted to impact 0.67 ha of *potential habitat* for the species although is located 6 km southwest of all known recent records. The nine-part test detailed above has been undertaken in a conservative manner. The Project is considered unlikely to cause significant residual impacts on an important population of Blunt-leaved leionema.

Paspalidium grandispiculatum

Ecology and distribution

Paspalidium grandispiculatum is a perennial, tufted grass growing to 1.5 m tall. In QLD the species occurs in mixed forest with *Corymbia citriodora*, on sub-coastal, old loamy and sandy plains (RE 12.5.1) and mixed open forest often with *Corymbia trachyphloia*, *Corymbia citriodora, Eucalyptus crebra*, and *Eucalyptus fibrosa* (RE 12.9-10.5). Records also exist from native pastures and open-forest communities. The soil type where *P. grandispiculatum* is generally found are shallow with a sandy texture, dark in colour, well drained and derived from sandstone rocks (DEWHA 2008h; Halford 1998). The species is a perennial grass which is assumed to be wind-pollinated. The flowering and fruiting period is from January to May for QLD populations (DAWE 2020a).

Paspalidium grandispiculatum occurs in SEQ in a band from Canungra to Kingaroy, over a range of approximately 100 km. It occurs in mixed Eucalypt forest, mixed open forest, and native pasture occurring as a result of land clearing for agriculture. One population has been recorded in the Crows Nest Falls National Park, the remaining known populations occur in either State forest or on private land (Halford 1998; Boyes 2001; DEWHA 2008h).

Distribution in context to the Project

This species was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs or for the nearby TSRC project. Database records (i.e. AoLA) indicate this species occurs to the northeast of the eastern end of the Project disturbance footprint in the Lockyer Forest Reserves area. The nearest records dated 1997 and 1999 are located 2.25 km north and 3.9 km northeast (respectively) from the Project disturbance footprint. A 2016 record is located 4.4 km northeast of the Project. All other records (from 1980 to 2013) in the vicinity of the Project occur further north throughout the Lockyer Forest Reserves and Crows Nest area (refer Figure 1.33 in Appendix B). Dawe habitat mapping (2020) indicates the species or species habitat as likely to occur only in the eastern portion of the alignment associated with the Helidon Hills. The species is not considered to occur to the west of this area.

Recovery plan/threat abatement plans

No recovery plan or threat abatement plans have been adopted for this species. The approved conservation advice for the species (DEWHA 2008h) identifies the following threats:

- Habitat clearing and inappropriate grazing pressure (on private and State lands)
- Habitat disturbance caused by timber harvesting
- Inappropriate fire regimes.

Important population and Habitat critical to the survival of the species

There are no important populations or *Habitat critical to the survival* of *Paspalidium grandispiculatum* identified in published information. Nevertheless, given the small area of occurrence of the species it may be inferred that a population in the Lockyer Forest Reserves could be considered as on the edge of the species range. As such, for the purposes of this assessment the local population within the Lockyer Forest Reserves, the southern edge of which is intersected by the Project is considered as an 'important population'. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology).

Impacts and mitigation measures associated with this species are identified within Table 5.6. Predictive habitat mapping indicates the Project may impact 156.25 ha of *potential habitat* for this species (refer Table 5.4 and habitat figure in Appendix G) This is a conservative figure which includes suitable vegetation communities that occur in the Toowoomba Range area (where the species is not currently known to occur) and is likely a substantial overestimate. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.17.

Table 5.17 Assessment against the significant impact criteria – *Paspalidium grandispiculatum*

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species has a restricted range encompassing habitat within the eastern extent of the Project area (adjacent to the Lockyer Forest Reserves). No individuals have been identified within the Project disturbance footprint during Project-associated surveys. Nevertheless, an 'important population' has been identified as potentially occurring in the area. Recent database records indicate the species is only known to occur northeast of the Project with the nearest record located 2.25 km from the Project disturbance footprint. Predictive mapping indicates 156.25 ha of *potential habitat* is predicted to occur within the Project disturbance footprint, although this is likely a substantial overestimate given it encompasses habitat in the Toowoomba Range west of the species known occurrence. Nevertheless, there is abundant suitable habitat in which the species is known to occur to the north of the Project in the Lockyer Forest Reserves area. Predictive mapping indicates there is 1,432 ha of *potential habitat* for the species within the overall MNES study area. It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event.

Criterion	Assessment against significance criteria
	As part of the Flora and Fauna Sub-plan additional protected plant surveys targeting this species will be undertaken prior to vegetation clearing to confirm whether the species occurs (refer Table 5.6). Given the Project is located southwest of the known population and the *potential habitat* within the Project disturbance footprint is relatively minor given the extent of available habitat in the wider area, it is considered unlikely the Project will result in a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	An 'important population' has been identified as potentially occurring in the area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. All local records occur to the north of the Project. Predictive mapping indicates 156.25 ha of potential habitat is predicted to occur within the Project disturbance footprint, although this is likely a substantial overestimate given it encompasses habitat in the Toowoomba Range west of the species known occurrence. Nevertheless, there is abundant suitable habitat in which the species is known to occur to the northeast of the Project in the Lockyer Forest Reserves area. Predictive mapping indicates there is 1,432 ha of potential habitat for the species within the overall MNES study area. Should the species occur within the Project disturbance footprint there is potential to reduce the area of occupancy of an 'important population' of the species.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby, and *Potential habitat* is predicted to occur within the disturbance area. Nevertheless, all local records occur to the northeast of the Project. The Project is linear, but the species pollination is thought to be wind-associated and as such is unlikely to impact the population (should individuals be found to occur south of the Project disturbance footprint). Nevertheless, the local area is already highly fragmented. There is existing linear disturbance running roughly parallel to the Project throughout the alignment (the QR West Moreton System rail corridor and the Toowoomba Bypass). It is considered unlikely the Project will fragment an existing important population into two populations.
Adversely affect habitat critical to the survival of the species	The species occurs in mixed eucalypt forest communities and modified pasture, both of which is a widespread vegetation type in the local area. Predictive mapping indicates no habitat considered as Habitat critical to the survival of the species (for the purposes of this assessment) occurs within the Project disturbance area, although 156.25 ha of *potential habitat* may occur, although this is likely a substantial overestimate given it encompasses habitat in the Toowoomba Range west of the species known occurrence. It is not known if the species occurs within the Project disturbance footprint. As such, the Project is considered unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the area, although it is unknown at this stage if any individuals occur within or south of the Project disturbance footprint. The flowering and fruiting period is from January to May. The Project is linear, but the species pollination is thought to be wind-associated and as such is unlikely to impact the population (should individuals be found to occur south of the Project disturbance footprint). The Project may disturb individuals, but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the area, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby. Predictive mapping indicates 156.25 ha of *potential habitat* occurs within the Project disturbance area, although this is likely a substantial overestimate given it encompasses habitat in the Toowoomba Range west of the species known occurrence. Nevertheless, all local records occur to the north of the Project. There is abundant suitable habitat to the northeast of the Project in which the species is known to occur. Given the relatively small area the Project occupies within this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion is not identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. *Lantana* species (including *L. camara* and *L. montevidensis*) were common throughout the MNES study area with severe infestations at some sites. Other dominant invasive flora included Climbing asparagus fern (*Asparagus africanus*) and Small-leaved privet (*Ligustrum lucidum*). Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DEWHA 2008h) identifies research priorities and regional priority actions including: ■ Monitoring and managing known populations and identifying high conservation value populations ■ Limiting the impact of disturbance from adjacent land use and activities associated with road maintenance and upgrading ■ Develop a stock management plan for public lands and manage grazing practises at known sites ■ Developing a fire management strategy for the species The Project is considered unlikely to interfere with the recovery strategies listed above. The Project will necessarily reduce known threats such as grazing by livestock (on land within the Project footprint). While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	The Project is predicted to impact 156.25 ha of *potential habitat*, although this is likely a substantial overestimate given it encompasses habitat in the Toowoomba Range west of the species known occurrence. The Project is also located south of all known records. The nine-part test detailed above has been undertaken in a conservative manner. The Project has a minor potential to cause 'significant residual impacts' on *an important population* of *Paspalidium grandispiculatum* through a reduction in the occupancy should the species be found to occur within the Project disturbance footprint.

Hawkweed (*Picris evae*)

Ecology and distribution

Hawkweed (*Picris evae*) is a soft-stemmed annual plant, up to 130 cm tall. The species typically occurs in eucalypt open woodlands with a grassy understorey, characteristically represented by *Dichanthium* spp. Canopy species include *Eucalyptus melliodora*, *E. crebra*, *E. populnea*, *E. albens*, *Angophora subvelutina*, *Allocasuarina torulosa*, and *Casuarina cunninghamiana*. This species has been collected along roadsides, and in cultivated areas (i.e. paddocks), on black, dark grey or red-brown soils, reddish clay-loam or medium clay soils (Holzapfel 1994; DEWHA 2008l).

Hawkweed is known to occur in two distinct areas: northern NSW (e.g. Inverell, Elsmore, Tamworth); and the Darling Downs and Moreton pastoral districts in SEQ (Bostock and Holland 2007).

Distribution in context to the Project

Hawkweed was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs, but has been recorded in the area for surveys carried out for the nearby TSRC project. The location of these records cannot be ascertained at this time due to probity issues associated with the project. This species has been recorded between 2008 to 2019 within the MNES study area to the north and south of the Project disturbance footprint near Cranley to the north of Toowoomba (refer Figure 4.2). The nearest record is recent from 2019 and is located 550 m to the north of the Project disturbance footprint east of the Wetalla Water Reclamation Facility. The record occurs between Gowrie Creek and Goombungee Road. Another record is from 2010 and occurs 800 m east of the Project disturbance footprint at Goombungee Road. Several records occur nearby and are all within 1 km of the Project disturbance footprint and are all recent. A record from 2015 occurs near Gowrie Mountain approximately 3 km southwest of the western section of the alignment. The nearest record outside of the MNES study area occurs at Toowoomba approximately 7.5 km south of the Project and is dated from 2001. Other records within a 50 km radius of the Project are scattered occurring to the northwest near to New Acland Coal Mine through to the south of Toowoomba with only one record to the northeast at Mount Hallen (refer Figure 1.19 in Appendix B). DAWE habitat mapping (2020) indicates the species or species habitat as likely to occur within the Project footprint in the Highfields area in the location of the tunnel (i.e. where no surface disturbance is proposed). The species is not considered to occur elsewhere in the Project disturbance footprint.

Recovery plans/threat abatement plans

This species has not been recognised as requiring a recovery plan, nor has a threat abatement plan been identified as being relevant for this species. The approved conservation advice for the species (DEWHA 2008i) identifies the following threats:

- Habitat loss and fragmentation due to agricultural and grazing development
- Inappropriate fire regimes
- Overgrazing by livestock
- Weed invasion.

Important populations and habitat critical to the survival of the species

The approved conservation advice for the species does not identify important populations or *habitat critical for the species* (DEWHA 2008i). The overall population is relatively restricted in occurrence and local occurrences within the Project disturbance footprint may therefore be considered as part of an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology).

Predictive modelling estimates the Project is likely to impact 31.88 ha of *potential habitat* in which this species is predicted to occur (refer Table 4.4). It is noted although database records are located within 1 km of the alignment this is the area above the proposed tunnel and as such there will be no aboveground impacts. As such no *Habitat critical to the survival of the species* will be impacted (under the approach for this assessment). The predictive mapping has taken a conservative approach and includes habitat where relevant REs once occurred but have been subject to vegetation clearing and as such may overestimate the likely occurrence of the species.

Impacts and mitigation measures associated with this species are identified within Table 5.6. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.22.

Table 5.18 Assessment against the significant impact criteria – Hawkweed

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species range extends along the Toowoomba Range from the Project south and at the eastern Western Darling Downs region. The species was not detected during Project-associated surveys but was recorded during surveys for the nearby TSRC project). Recent database records indicate the species is known to occur to the north and south with the nearest record located 550 m from the Project disturbance footprint (tunnel area). Therefore an 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint where suitable black clay soils occur. Predictive mapping indicated 31.88 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. Nevertheless, there is abundant suitable habitat in which the species is known to occur to the south of the Project along Toowoomba Range. It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event. The species may occur in highly disturbed habitats and there are local records in the area. Predictive mapping indicates there is 1,678 ha of *potential habitat* for the species within the overall MNES study area. Given the relatively small area of potential habitat impacted by the Project it is considered unlikely to result in a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. Modelling indicates 31.88 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. Should the species be found to occur within the Project disturbance footprint the Project has potential to reduce the area of occupancy of an 'important population' for the species.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby (within the MNES study area) and suitable habitat is predicted to occur within the Project disturbance footprint. Nevertheless, the local area is already highly fragmented in the Cranley area where database records occur. There is substantial existing linear disturbance running parallel to the Project to the south including the Toowoomba Bypass and the QR West Moreton System rail corridor. The species has been detected in roadside vegetation and cultivated areas. The Project is considered unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species occurs in eucalypt open woodlands with a grassy understorey and has been collected along roadsides, and in cultivated areas, both of which occur within the local area. Predictive mapping indicates no habitat considered as Habitat critical to the survival of the species (for the purposes of this assessment) occurs within the Project disturbance area, although 31.88 ha of potential habitat may occur. There is abundant suitable habitat in which the species is known to occur to the south of the Project along Toowoomba Range. Predictive mapping indicates there is 1,678 ha of potential habitat for the species within the overall MNES study area. As such, the Project is considered unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint, although it is unknown at this stage if any individuals occur within or north of the Project disturbance footprint. The flowering and fruiting period occur during October to January. The Project is linear and may disturb individuals, but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint, although it is unknown at this stage if any individuals occur within the Project disturbance footprint. The species is known to occur nearby. Predictive mapping indicates 31.88 ha of *potential habitat* occurs within the Project disturbance area. there is abundant suitable habitat in which the species is known to occur to the south of the Project along Toowoomba Range. Predictive mapping indicates there is 1,678 ha of *potential habitat* for the species within the overall MNES study area. Given the relatively small area the Project occupies within this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion has been identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. Lantana species (*Lantana camara*), Climbing asparagus fern (*Asparagus africanus*) and Small leaf privet (*Ligustrum lucidum*) were common throughout the MNES study area at sites where the species may occur in the western portion of the MNES study area. Project-associated surveys have recorded 10 weed species listed under as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DEWHA 2008i) identifies research priorities and regional priority actions including: ▪ Monitoring and managing known populations and identifying high conservation value populations ▪ Limiting the impact of disturbance from adjacent land use and activities associated with road maintenance and upgrading ▪ Develop a stock management plan for public lands and manage grazing practises at known sites ▪ Developing a fire management strategy for the species The Project is considered unlikely to interfere with the recovery strategies listed above. The Project will necessarily reduce known threats such as grazing by livestock (on land within the Project footprint) and through weed controls under the Biosecurity Management Plan. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	The Project is predicted to impact 31.88 ha of *potential habitat* for the species. The nine-part test detailed above has been undertaken in a conservative manner. The Project has the potential to cause 'significant residual impacts' on *an important population* of *Picris evae* through the reduction in occupancy should the species be found to occur.

Austral cornflower (*Rhaponticum australe*)

Ecology and distribution

Austral cornflower (*Rhaponticum australe)* is an erect perennial herb that grows to 60 cm in height. The species typically grows in eucalypt open forests, with grassy understory. This species often occurs on roadsides and on road reserves alongside Rhodes grass *(Chloris gayana*), Spear thistle *(Cirsium vulgare*), Queensland blue gum *(Eucalyptus tereticornis*) and Rough-barked apple *(Angophora floribunda*) on black clay soil derived from basalt. This species is considered to be a poor competitor and prefers habitat where grass competition has been reduced by fire, or other forms of disturbance. However, Austral cornflower is unlikely to benefit from disturbance that allows the development of a dense cover of exotic grasses (DAWE 2020).

Austral cornflower is currently confined to QLD. The species was known to previously occur in NSW and Victoria but is now presumed extinct in those states. The current distribution extends from Allora (north of Warwick) to Callide (northwest of Biloela), QLD (DEWHA 2008l).

Distribution in context to the Project

Austral cornflower was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs, but has been recorded in the area for surveys carried out for the nearby TSRC project. The location of these records cannot be ascertained at this time due to probity issues associated with the project. Database records (AoLA) indicate this species has occurred within and adjacent to the Project to the west of the tunnel (refer Figure 4.2). There is a somewhat recent from 1999 located to the north of Morris Road east of Gowrie. The nearest record outside of the Project footprint is from 2016 occurring approximately 20 m to the north between Draper Road and Gowrie Creek between Kingsthorpe and Gowrie Junction. Two records occur near the western tunnel portal. Both records are dated from 1999 and are located approximately 85 m from the Project disturbance footprint between East Paulsens Road and Gowrie Creek. Other nearby database records within a 50 km radius of the Project occur at Kingsthorpe, Gowrie Mountain and Puzzling Gully. Database records extend from Jondaryan to the northwest of the Project disturbance footprint, to Pittsworth and Allora to the southwest and south and Laidley east of the Project (refer Figure 1.2 in Appendix B). DAWE species habitat mapping (2020) indicates the species or species habitat as likely to occur within the Project footprint in the Toowoomba Range and west.

Recovery plans/threat abatement plans

This species has not been recognised as requiring a recovery plan, nor has a threat abatement plan been identified as being relevant for this species. The approved conservation advice for the species (DEWHA 2008l) identifies the following threats:

- Habitat loss and fragmentation due to broad-scale land clearing
- Road construction and widening
- Overgrazing by livestock
- Weed invasion.

Important populations and habitat critical to the survival of the species

The approved conservation advice does not identify important populations or *Habitat critical to the survival of the species*. The most significant population of this species occurs in the Toowoomba-Aubigny region which the Project disturbance footprint intersects at its northern extent (DAWE 2020). The overall population is relatively restricted in occurrence and local occurrences within the Project disturbance footprint may therefore be considered as part of an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology).

It is estimated that the project is likely to impact 63.02 ha of *potential habitat* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). The predictive mapping has taken a conservative approach and includes habitat where relevant REs once occurred but have been subject to vegetation clearing and as such, is likely to be an overestimate of the likely occurrence of the species. It is noted although database records are located within 1 km of the alignment in the western portion of the Project the habitat within this area is highly impacted and does not represent *potential habitat* for the species, and as such no *Habitat critical to the survival of the species* has been identified.

Impacts and mitigation measures associated with this species are identified within Table 5.6. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.19.

Table 5.19 Assessment against the significant impact criteria – Austral cornflower

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species range extends along the Toowoomba Range, the eastern Darling Downs region and the Lockyer Valley. The species was not detected during Project-associated surveys however suitable habitat for the species was identified during surveys for the nearby TSRC project. Database records occur within the Project disturbance footprint and the MNES study area. An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint where suitable black clay soils occur. Recent database records indicate the species is known to occur to the west, south and east of the Project disturbance footprint. Predictive mapping indicated 63.02 ha of *potential habitat* is predicted to occur within the Project disturbance footprint, although this is likely an overestimate. Nevertheless, there is abundant suitable habitat in which the species is known to occur to the west, south and east of the Project. The species may occur in highly disturbed habitats. Predictive mapping indicates there is 1,060 ha of *potential habitat* for the species within the overall MNES study area. Given the relatively small area of potential habitat impacted by the Project it is considered unlikely to result in a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint. Database records indicate the potential for individuals to occur within the Project disturbance footprint. The species is considered extinct in Victoria and NSW and is thought to only occur in QLD. Modelling indicates 63.02 ha of potential habitat is predicted to occur within the Project disturbance footprint, although this is likely an overestimate. Given that relatively recent specimen backed records occur within the Project disturbance footprint the Project has potential have a direct impact and to reduce the area of occupancy of an 'important population' for the species.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the western portion of the Project disturbance footprint Database records indicate the potential for individuals to occur within the Project disturbance footprint. Database records (within the Project disturbance footprint and MNES study area) indicate the presence of the species and suitable habitat is predicted to occur within the Project disturbance footprint. Nevertheless, the local area is already highly fragmented in the Cranley area where database records occur. There is substantial existing linear disturbance running parallel to the Project including the Toowoomba Bypass and the QR West Moreton System rail corridor. The species has been detected in roadside vegetation and cultivated areas amongst exotic flora. The Project is considered unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species occurs in eucalypt open woodlands with a grassy understorey and has been collected along roadsides, and in cultivated areas, both of which occur within the local area. Predictive mapping indicates no habitat considered as *Habitat critical to the survival of the species* (for the purposes of this assessment) occurs within the Project disturbance area, although 63.02 ha of *potential habitat* may occur. It is not known if the species occurs within the Project disturbance footprint. As such, the Project is considered unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the area, although it is known from database records individuals may occur within and north of the Project disturbance footprint. The flowering and fruiting period occur from Spring through to Autumn. The Project is linear and may disturb individuals, but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the area, it is likely individuals occur within the Project disturbance footprint. Predictive mapping indicates 63.02 ha of *potential habitat* occurs within the Project disturbance area, although this is likely an overestimate. Local records occur to the north and south of the Project. There is abundant suitable habitat to the west, south and southwest of the Project in which the species is known to occur. The project will modify, destroy, remove or isolate or decrease the availability or quality of habitat. It is possible that the quantum of impacts may be sufficient that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion has been identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. Lantana species (*Lantana camara*), Climbing asparagus fern (*Asparagus africanus*) and Small leaf privet (*Ligustrum lucidum*) were common throughout the MNES study area at sites where the species may occur in the western portion of the MNES study area. Project-associated surveys have recorded 17 restricted flora species listed under the Biosecurity Act and/or as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders. Furthermore, the species is known to persist in disturbance areas in conjunction with exotic flora. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DEWHA 2008l) identifies research priorities and regional priority actions including: ■ Monitoring and managing known populations and identifying high conservation value populations ■ Limiting the impact of disturbance from adjacent land use and activities associated with road maintenance and upgrading ■ Develop a stock management plan for public lands and manage grazing practises at known sites ■ Developing a fire management strategy for the species The Project will necessarily reduce known threats such as grazing by livestock (on land within the Project footprint) and through weed controls under the Biosecurity Management Plan. The Project is considered unlikely to substantially interfere with the recovery of the species. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	The Project is predicted to impact 63.02 ha of *potential habitat* for the species. The nine-part test detailed above has been undertaken in a conservative manner. The Project has a minor potential to cause 'significant residual impacts' on *an important population* of Austral cornflower through the reduction in occupancy should the species be found to occur.

Blotched sarcochilus (*Sarcochilus weinthalii*)

Ecology and distribution

Blotched sarcochilus (*Sarcochilus weinthalii*) is an epiphyte orchid that grows on rainforest trees, either projecting or hanging from the trunk, or grows on rock surfaces. Blotched sarcochilus grows on trees in rainforest, dry rainforest and drier scrubs of sub-coastal ranges and associated foothills inland from the coast at altitudes of 400 to 700 m above sea level (Barker & Borsboom 1997). In SEQ, the Blotched sarcochilus has been recorded growing in a number of microphyll and notophyll rainforest types and also occurs in patches of isolated scrub (Halford 1998). Blotched sarcochilus flowers from June to October and fruits persist for 6 to 8 months after fertilisation (DotE 2014b).

Blotched sarcochilus has been recorded in northern NSW and SEQ. The species occurs north from the Richmond River to the Bunya Mountains and the Gallangowan area (DAWE 2020).

Distribution in context to the Project

This species was not identified during any Project-associated field surveys or for the nearby TSRC project. Database records (AoLA) for the species have been generalised to protect the location of the species, likely from specialist collectors. As such, database records may not reflect the actual location of the record. There are two very old records (1882 and 1957) located 2 km north of the Project disturbance footprint. There are eight records to the east of Toowoomba located 8.5 km south of the Project, the most recent of which is from 2015. To the southeast of Toowoomba are three historical records (1903 to 1909) located 11 km south. The only other record within 50 km of the Project is located 32 km northeast near Esk National Park and is dated 1986 (refer Figure 1.6 in Appendix B). DAWE species habitat mapping (2020) indicates the species or species habitat as likely to occur within the Project footprint in the Toowoomba Range.

Recovery plans/threat abatement plans

This species has not been recognised as requiring a recovery plan, nor has a threat abatement plan been identified as being relevant for this species. The approved conservation advice for the species (DotE 2014b) identifies the following threats:

- Habitat loss and fragmentation land clearing and forestry activities
- Inappropriate fire regimes
- Illegal collecting from the wild by specialist collectors.

Important populations and habitat critical to the survival of the species

There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature has not revealed any important populations or *Habitat critical to the survival of the species* (DotE 2014b). No populations that are important for the long-term survival and recovery of the species have been identified. The species has a scattered distribution of isolated populations and occurs in the Toowoomba Range. The assessment has taken a conservative approach and as such, given suitable habitat is present, should the species occur a local population may be considered as part of an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). It is predicted the project may impact 3.14 ha of *potential habitat* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G).

Impacts and mitigation measures associated with this species are identified within Table 5.6. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.20.

Table 5.20 Assessment against the significant impact criteria – Blotched sarcochilus

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species was not detected during Project-associated surveys however suitable habitat for the species was identified during surveys within the MNES study area. The species is known to occur in the Toowoomba Range including a recent record (2018) located to the south of the Project. The species occurs as isolated populations and an 'important population' has been identified as potentially occurring in the area. Predictive mapping indicated 3.14 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event. As part of the Flora and Fauna Sub-plan additional protected plant surveys targeting this species will be undertaken prior to vegetation clearing to confirm whether the species occurs (refer Table 5.6). Nevertheless, there is considerable suitable habitat in which the species may occur north and south of the Project in the Toowoomba Range. Predictive mapping indicates there is 414 ha of *potential habitat* for the species within the overall MNES study area. The Project is considered unlikely to result in a long-term decrease in the size of an important population.

Criterion	Assessment against significance criteria
Reduce the area of occupancy of an important population	An 'important population' has been identified as potentially occurring in the area. Database records and the presence of suitable habitat indicate the potential for individuals to occur within the Project disturbance footprint. Modelling indicates 3.14 ha of *potential habitat* is predicted to occur within the Project disturbance footprint. Should the species be found to occur the Project has potential to reduce the area of occupancy of an 'important population' for the species, although only to a minor extent.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the area. Database records and the presence of suitable habitat indicate the potential for individuals to occur within the Project disturbance footprint. Nevertheless, the Project runs roughly parallel with the adjacent Toowoomba Bypass which already has fragmented habitat within the Toowoomba Range. The Project is considered unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species occurs in notophyll rainforest which occurs within the Project disturbance footprint. Predictive mapping indicates no habitat considered as Habitat critical to the survival of the species (for the purposes of this assessment) occurs within the MNES study area, although 3.14 ha of *potential habitat* may occur. It is not known if the species occurs within the Project disturbance footprint. As such, the Project is considered unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the area, although it is unknown if the species occurs within the Project disturbance footprint. The flowering period occurs from June to October. The Project is linear and may disturb individuals, but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the area, although it is unknown if the species occurs within the Project disturbance footprint. Predictive mapping indicates 3.14 ha of *potential habitat* occurs within the Project disturbance area. Nevertheless, there is considerable suitable habitat in which the species may occur north and south of the Project in the Toowoomba Range. Predictive mapping indicates there is 414 ha of *potential habitat* for the species within the overall MNES study area. Given the relatively small area the Project occupies within this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion has not been identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. Lantana (*Lantana camara*) and Climbing asparagus fern (*Asparagus africanus*) were observed as present within suitable habitat for the species (semi-evergreen vine thicket and vine forest) during the surveys. Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	There are no known diseases which pose a risk to the species, however there are a number of pathogens which may indirectly impact the species. For example. *Phytophthora cinnamomi* a soil-borne organism, can cause dieback amongst some or all species of vegetation in the rainforest which are a feature of the vegetation communities/habitats in the Lockyer Valley and known habitat for this species. Thought it should be noted that myrtle rust is already widespread along the east coast of Australia. The CEMP and Operation EMP will incorporate, in the form of a biosecurity management plan, management measures for biosecurity matters, which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation.

Criterion	Assessment against significance criteria
	The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DotE 2014b) identifies research priorities and regional priority actions including: ■ Identifying high conservation value populations and ensuring no disturbance in areas where the species occurs ■ Developing a fire management strategy for the species and species habitat ■ Minimise adverse impacts from land use at known sites, particularly the impacts resulting from road maintenance and forestry operations The Project is considered unlikely to interfere with the recovery strategies listed above. The Project will necessarily reduce known threats through weed controls under the Biosecurity Management Plan. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	The Project is predicted to impact 3.14 ha of *potential habitat* for the species. The nine-part test detailed above has been undertaken in a conservative manner. The Project has a minor potential to cause 'significant residual impacts' on *an important population* of Blotched sarcochilus through the reduction in occupancy should the species be found to occur.

Brush sophora (*Sophora fraseri*)

Ecology and distribution

Brush sophora is a sparsely branched leguminous shrub that grows to 1 m to 2 m high. The species normally grows in wet sclerophyll forest and a range of rainforest types. It has been reported growing in hilly terrain on hillslopes at altitudes at altitudes from 60 m to 660 m, in mostly shallow stony to shaly soils, of loam to clay texture derived from sandstone or basalt rocks. The shrub appears to prefer growing along rainforest margins, in eucalypt forests in the vicinity of rainforests or in large canopy gaps in closed forest communities (Barker and Borsboom 1997). Flowering of Brush sophora has been recorded in April and from late August to mid-November. Fruiting has been recorded in January, April, July, August and November (Barker and Borsboom 1997).

Brush sophora is found north of Casino in northern NSW, where it is very rare, and into SEQ north to the Sunshine Coast hinterland, where it is widespread but not common. Brush sophora is conserved in Lamington National Park and Mount Mistake National Park (Briggs and Leigh 1995).

Distribution in context to the Project

This species was recorded within the Project disturbance footprint during Project surveys near the eastern entrance of the proposed tunnel in the Toowoomba Range (refer Figure 4.4). Two individuals were located within eucalypt open forest adjacent to a vine forest community. There is a recent database record (AoLA) from 2018 within the Project disturbance footprint east of Mount Kynoch in the same area as the Project survey records (refer Figure 4.2). There are 1997 and 2011 records from the Kingsthorpe area 2 km west of the Project disturbance footprint. There is also a very old record (1930) located 5 km south of the eastern extent of the Project. There are scattered records in the wider area to the northwest and southeast (refer Figure 1.10 in Appendix B). There is a concentration of records further to the northeast in the D'Aguilar Range. DAWE species habitat mapping the species or species habitat is likely to occur in the far western extent of the Project footprint in the Kingsthorpe area. The mapping also indicates the species or species habitat may occur in the Highlands area.

Recovery plans/threat abatement plans

This species has not been recognised as requiring a recovery plan, nor has a threat abatement plan been identified as being relevant for this species. The approved conservation advice for the species (DEWHA 2008k) identifies the following threats:

- Habitat loss and fragmentation due to agriculture and other development
- Timber harvesting activities
- Inappropriate fire regimes
- Degradation of habitat from grazing by livestock
- Weed invasion such as *Lantana camara.*

Important populations and habitat critical to the survival of the species

The approved conservation advice for the species does not identify important populations or *Habitat critical to the survival of the species (*DEWHA 2008k). The Project disturbance footprint may be on the western edge of the species range and therefore may be considered as part of an important population. In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat'* (refer Appendix A for methodology).

It is estimated that the project is likely to impact 28.69 ha of *potential habitat* and 2.36 ha of *Habitat critical to the survival of the species* in which this species is predicted to occur (refer Table 5.4 and habitat figure in Appendix G). Impacts and mitigation measures associated with this species are identified within Table 5.6. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.21.

Table 5.21 Assessment against the significant impact criteria – Brush sophora

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	The species was recorded within the Project disturbance footprint during Project surveys. Database records indicate the species occurs sparsely in the wider area (refer Section 4.3.1.1). The species may be on the western edge of the species distribution and therefore may be considered part of an 'important population' potentially occurring in the area. Predictive mapping estimates 28.69 ha of *potential habitat* and 2.36 ha of *Habitat critical to the survival of the species* occurs within the Project disturbance footprint. It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event.
Reduce the area of occupancy of an important population	The species is known to occur and an 'important population' has been identified as potentially occurring in the area. The species occurs across a limited area from northern NSW to SEQ occur in QLD. Modelling indicates 28.69 ha of *potential habitat* and 2.36 ha of *Habitat critical to the survival of the species* occurs within the Project disturbance footprint. Given that survey records occur within the Project disturbance footprint the Project has potential to reduce the area of occupancy of an 'important population' for the species.
Fragment an existing important population into two or more populations	An 'important population' has been identified as potentially occurring in the area. Database records and the presence of suitable habitat indicate the potential for individuals to occur within the Project disturbance footprint. Nevertheless, Project runs roughly parallel with the adjacent Toowoomba Bypass which already has fragmented habitat within the Toowoomba Range. The Project is considered unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species occurs in notophyll rainforest and adjacent eucalypt habitat which occurs within the Project disturbance footprint. Predictive mapping indicates 2.36 ha of *Habitat critical to the survival of the species* occurs within the Project disturbance footprint, as well as an additional 28.69 ha of *potential habitat*. As such, the Project will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	An 'important population' has been identified as potentially occurring in the area, and the species is known to occur within the Project disturbance footprint. Flowering is known to occur in April and from August to November occurs. The Project is linear and may disturb individuals, but it is considered unlikely impacts will be to the extent that the breeding cycle of the population would be disrupted.

Criterion	Assessment against significance criteria
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	An 'important population' has been identified as potentially occurring in the area, and the species is known to occur within the Project disturbance footprint. Predictive mapping indicates 28.69 ha of *potential habitat* and 2.36 ha of *Habitat critical to the survival of the species* occurs within the Project disturbance area. Nevertheless, there is considerable suitable habitat in which the species may occur north and south of the Project in the Toowoomba Range. Predictive mapping indicates there is 605 ha of *potential habitat* for the species within the overall MNES study area. Given the relatively small area the Project occupies within this area the Project is not considered to impact habitat suitable for the species to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Weed invasion has not been identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. Lantana (*Lantana camara*) and Climbing asparagus fern (*Asparagus africanus*) were observed as present within suitable habitat for the species (semi-evergreen vine thicket and vine forest) during the surveys. Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). ARTC will comply with the general biosecurity obligations under the Biosecurity Act through the implementation of biosecurity management plans. The plans will aim to mitigate the impacts of invasive species on the local ecosystems and species assemblages during the construction and operation of the Project, including measures to control, eradicate and monitor biosecurity matters. The plans will include measures around the management of invasive flora species, pathogens and animal species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	There are no known diseases which pose a risk to the species, however there are a number of pathogens which may indirectly impact the species. For example. Myrtle rust is a fungal disease which affects many plants in the Myrtaceae family, such as gum trees (Eucalyptus) which are a dominant feature of the vegetation communities/habitats in the Lockyer Valley and known habitat for this species. Thought it should be noted that myrtle rust is already widespread along the east coast of Australia. The CEMP and Operation EMP will incorporate, in the form of a biosecurity management plan, management measures for biosecurity matters, which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	There is no recovery plan for the species. The Approved Conservation Advice for the species (DEWHA 2008k) identifies research priorities and regional priority actions including: ■ Monitoring known populations, identifying additional populations and assess the population size, ecological requirements and threats to the species ■ Limiting the impact of disturbance from adjacent land use and activities associated with road maintenance and upgrading ■ Ensure forestry activities manage Brush sophora habitat ■ Develop a stock management plan for public lands and manage grazing practises at known sites ■ Manage weed invasion at known sites ■ Manage livestock grazing pressure where the species occurs ■ Developing a fire management strategy for the species.

Criterion	Assessment against significance criteria
	The Project is considered unlikely to interfere with the recovery strategies listed above. The Project will necessarily reduce known threats such as grazing by livestock (on land within the Project footprint) and through weed controls under the Biosecurity Management Plan. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The additional protected plant surveys will also align with the priority actions for the species, including additional survey work in suitable and potential habitat, and if encountered present an opportunity to understand population size, distribution, ecological requirements and the relative impacts of threatening processes.
Assessment of potential for significant residual impacts	The Project is predicted to impact 28.69 ha of *potential habitat* and 2.36 ha of *Habitat critical to the survival of the species*. The nine-part test detailed above has been undertaken in a conservative manner. The Project is likely to cause 'significant residual impacts' on *an important population* of Bush sophora through a reduction in the occupancy of an important population and impacts to critical habitat.

5.3.5 Significant impact assessment for threatened fauna

There are 21 threatened fauna species listed as MNES relevant to the MNES study area including 14 species listed as vulnerable and a further seven species listed as endangered or critically endangered (refer Table 5.4). The ecology, life history and distribution of these species are summarised in Appendix B – Species and Community Profiles. Relevant Commonwealth documents applicable to each species including threat abatement plans, approved conservation advice, and recovery plans are also summarised in Appendix B. Two of these species will not be impacted by the Project and are not considered further in this assessment:

- White-throated needletail (*Hirundapus caudacutus*) is an aerial foraging bird species that rarely, if ever, lands in Australia and may occur over heavily disturbed areas (such as urban) as well as natural habitats
- Dunmall's snake (*Furina dunmalli*) does not have habitat modelled within the MNES study area and as such is very unlikely to be impacted.

This section of the MNES report assesses the potential for significant residual impacts from the Project using the MNES Guidelines.

Key impacts to threatened fauna are considered to include the following:

- Direct clearing of species habitats
- Injury/mortality to individuals during vegetation clearing in the construction period (arboreal fauna and terrestrial fauna)
- Ongoing collisions with trains during operation of the rail line (larger arboreal and terrestrial mammal fauna)
- Potential fragmentation of suitable habitats/populations due to the linear nature of the Project (largely in the Toowoomba Range).

A range of mitigation measures have been proposed to ameliorate these impacts wherever possible (refer Section 5.2.2 and species-specific measures in Table 5.7). These include measures considered as effective in addressing the recognised threats for each species as recognised in recovery plans, approved conservation advice, and DAWE-adopted threat abatement plans (as identified in the following sections for each species) including but not restricted to:

- Flora and Fauna Management Sub-plan will incorporate species-specific monitoring strategies including detailed pre-construction site surveys and operational monitoring to ensure degradation to adjacent habitats is not occurring as a result of the Project – applicable to all species
- Biosecurity Management Plan to protect fauna habitats adjacent to the Project from deleterious impacts including weed invasion, proliferation of pest predators and invasion by introduced pathogens (such as Myrtle rust and *Phytophthora cinnamomi*) – applicable to all species

- Erosion and Sediment Control Plan and Surface Water Sub-plan to protect water quality values associated with wetlands and waterways – applicable to aquatic species/wetland birds
- Air Quality Sub-plan includes measures to minimise dust impacts on vegetation/habitats including dust monitoring and suppression methods – applicable to all species
- Fauna crossing structures and associated fencing and site-specific (crossing) vegetation rehabilitation to allow continued landscape connectivity for fauna across the alignment – applicable to terrestrial fauna
- Reinstatement and Rehabilitation Plan to detail rehabilitation of temporary construction areas not required for Project operation – applicable to all species.

Given the degraded nature of the majority of the woodlands within the Project disturbance footprint (due to vegetation clearance, previous tree thinning and weed invasion) indirect impacts such as edge effects (such as dust deposition) are considered to be suitably mitigated under the Projects mitigation measures and restricted to the construction period.

Impacts to aquatic species (i.e. Murray cod) include temporary barrier works in waterways, impacts to riparian and instream habitat, and surface water quality (refer Table 5.7). These impacts are likely to be restricted to Gowrie Creek (relative to the distribution of the species), expected to be temporary and during Project construction (i.e. sporadic maintenance works may be required at sites during the Project operation). There are no predicted impacts to downstream habitats (refer EIS Chapter 13: Surface water and Hydrology).

The assessment of significant impacts on the identified MNES species from the Project is based on:

- The design and layout of the Project (refer Section 1.9)
- Currently known information about the MNES affected (refer Appendix B)
- Predictive habitat modelling for MNES species (refer Table 5.4) based on the habitat assumptions associated with each species (refer Appendix A)
- Information on potential impacts of Project construction and operation (refer Section 5.1)
- Proposed Project mitigation measures (refer Section 5.2 and Table 5.7).

In addition, it is noted that targeted surveys for most fauna species have not been carried out thus far as part of Project ecology surveys. ARTC are committed to undertaking additional pre-clearing surveys in accordance with relevant State and Commonwealth guidelines throughout the Project disturbance footprint and where any of these species are encountered (or any additional threatened species) or habitat critical for the survival of the species is identified the habitat mapping and the above assumptions will be reassessed and appropriate mitigation measures developed with regard to the recovery plans and conservation advices, including changes to offset requirements and disturbance limits.

A summary of the findings of the assessment of the significant residual impact assessment for threatened fauna is provided in Table 5.22. Section 5.3.5.1 provides the significant impact assessment for Critically endangered and endangered species, and Section 5.3.5.3 provides the significant impact assessment for vulnerable species with potential to be impacted by the Project.

Table 5.22 Summary of the results of the significant impact assessment for matters of national environmental significance fauna species

Fauna species	EPBC Act status*	Results of assessment	Table containing assessment against MNES Guidelines
Five-clawed worm-skink (*Anomalopus mackayi*)	V	No significant residual impact as a result of the Project anticipated—*no potential habitat* within Project disturbance footprint	Table 5.30
Regent honeyeater (*Anthochaera phrygia*)	E	No significant residual impact from the Project anticipated—in part due to the absence of *habitat critical to the survival of the species*	Table 5.23

Fauna species	EPBC Act status*	Results of assessment	Table containing assessment against MNES Guidelines
Australasian bittern (*Botaurus poiciloptilus*)	E	No significant residual impact from the Project anticipated—in part due to the absence of *habitat critical to the survival of the species*	Table 5.24
Curlew sandpiper (*Calidris ferruginea*)	CE	No significant residual impact from the Project anticipated—in part due to the absence of *habitat critical to the survival of the species*	Table 5.25
Spotted-tail quoll (*Dasyurus maculatus maculatus*)	E	The Project is anticipated to have a significant residual impact on this species - *loss of habitat critical to the survival the species* fragmentation, barrier effects	Table 5.28
Swift parrot (*Lathamus discolor*)	CE	The Project is anticipated to have a significant residual impact on this species —*loss of habitat critical to the survival of the species*	Table 5.26
Australian painted snipe (*Rostratula australis*)	E	The Project is anticipated to have a significant residual impact on this species —*loss of habitat critical to the survival of the species*	Table 5.27
Collared delma (*Delma torquata*)	V	The Project is anticipated to have a significant residual impact on this species —*loss of important habitat* and *impacts to an important population*	Table 5.31
Red goshawk (*Erythrotriorchis radiatus*)	V	The Project is anticipated to have a significant residual impact on this species —*loss of habitat critical to the survival of the species*	Table 5.32
Grey falcon (*Falco hypoleucos*)	V	No significant residual impact as a result of the Project anticipated—habitat for the critical of the species Is predicted to occur; however, the species is considered to be a vagrant to the area	Table 5.33
Painted honeyeater (*Grantiella picta*)	V	No significant residual impact as a result of the Project anticipated—no important populations or *habitat critical to the survival of the species* has been identified for this species	Table 5.30
Murray cod (*Maccullochella peelii*)	V	No significant residual impact from the Project anticipated—the Project will involve a bridge structure over Gowrie Creek, which has been mapped as habitat critical to the survival of the species	Table 5.34
Greater glider (*Petauroides volans*)	V	No significant residual impact as a result of the Project anticipated—*no important populations* or *habitat critical to the survival of the species* has been identified for this species	Table 5.35
Brush-tailed rock-wallaby (*Petrogale penicillata*)	V	No significant residual impact as a result of the Project anticipated—no potential habitat within Project disturbance footprint	Table 5.30
Koala (*Phascolarctos cinereus*)	V	The Project is anticipated to have a significant residual impact on this species —loss of habitat critical to the survival of the species, fragmentation, barrier effects	Table 5.37

Fauna species	EPBC Act status*	Results of assessment	Table containing assessment against MNES Guidelines
Long-nosed potoroo (*Potorous tridactylus tridactylus*)	V	Potential for the Project to have a significant residual impact—*fragmentation and barrier effects* and *potentially the loss of habitat*	Table 5.38
New Holland mouse (*Pseudomys novaehollandiae*)	V	Potential for the Project to have a significant residual impact—*fragmentation and barrier effects* and *potentially the loss of habitat*	Table 5.39
Grey-headed flying-fox (*Pteropus poliocephalus*)	V	The Project is anticipated to have a significant residual impact on this species—*loss of habitat critical to the survival of the species*	Table 5.40
Black-breasted button-quail (*Turnix melanogaster*)	V	The Project is anticipated to have a significant residual impact on this species—*loss of habitat critical to the survival of the species*	Table 5.41
Condamine earless dragon (*Tympanocryptis condaminensis*)	E	Potential for the Project to have a significant residual impact—*fragmentation and barrier effects* and *potentially the loss of habitat*	Table 5.29

Table notes:

* CE = Critically endangered, E = Endangered, V = Vulnerable

5.3.5.1 Critically endangered and endangered fauna species

Under the Guidelines an action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

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

A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area. In relation to critically endangered, endangered or vulnerable species, occurrences include but are not limited to:

- A geographically distinct regional population, or collection of local populations
- A population, or collection of local populations, that occurs within a particular bioregion.

An 'invasive species' is an introduced species, including an introduced (translocated) native species, which out-competes native species for space and resources or which is a predator of native species. Introducing an invasive species into an area may result in that species becoming established. An invasive species may harm listed threatened species or ecological communities by direct competition, modification of habitat or predation.

‘Habitat critical to the survival of a species or ecological community’ refers to areas that are necessary:

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

Such habitats may be, but are not limited to: habitat identified in a recovery plan for the species or ecological community as habitat critical for that species or ecological community; and/or habitat listed on the register of Critical Habitat maintained by the Minister under the EPBC Act.

Impacts and mitigation measures associated with these species are identified within Table 5.7. The following sections assess the potential for significant residual impacts on the eight endangered or critically endangered fauna species identified as potentially occurring within the Project disturbance footprint using the criteria set out in the Guidelines.

Regent honeyeater (*Anthochaera phrygia*) – critically endangered

Ecology and distribution

Regent honeyeater is largely known to occur in box-ironbark eucalypt woodlands. The preferred habitat is wet areas containing fertile soils that provide reliable nectar seasonally in areas of creek flats, river valleys and lower slopes. They are also found in dry eucalypt woodland and open forest in both rural and urban environments with mature eucalypts (DES 2017b). The Regent honeyeater’s diet consists of nectar from key species such as Yellow box (*Eucalyptus melliodora*), White box (*Eucalyptus albens*) and Mugga ironbark (*Eucalyptus sideroxylon*) as well as sugary exudates. It also forages in Swamp mahogany (*Eucalyptus robusta*) and Spotted gum (*Corymbia maculata*) close to the coast. The species is also known to consume insects particularly when breeding (Birdlife International 2016a). The species prefers mature large trees that produce more flowers, particularly those on fertile soils and in riparian areas (DotE 2016). The species breeds as individual pairs or sometimes in loose colonies with the female honeyeater incubating eggs whilst both parents feed the young.

Breeding

The Regent honeyeater is endemic to south-east Australia, ranging from SEQ to central Victoria. In SEQ, the Regent honeyeater’s distribution ranges from the Cooloola Plains in the north to inland areas such as Dalby, and further south into areas such as Narrabri (NSW). Regent honeyeater is known to breed in small numbers regularly to the west of Warwick in Durikai State Forest (75 km south of the Project). The species is considered to comprise one population with some movements of individuals between regularly used areas (Garnett et al 2011).

Distribution in context to the Project

The species was not recorded during any Project-associated surveys or surveys for the adjacent TSRC project. Regent honeyeater is transient in the Toowoomba/Lockyer Valley area, being sporadically recorded in the winter months. Database records (i.e. AoLA) indicate that no records of Regent honeyeater exist within the MNES study area. It is noted AoLA records of the species have been generalised to protect the species and so may not reflect the actual occurrence location. The closest record is located approximately 3 km north of the eastern extent of the Project disturbance footprint, north of Helidon, and is an older record (<1976). The next closest record is located approximately 15 km north of the Project disturbance footprint near Mount Lawson and is also an older record (<1976). The only other record (from 2000) within a 50 km buffer of the Project disturbance footprint is in main Range National Park (38 km south of the Project) (refer Figure 5.23 in Appendix B). The nearest recent records are from Ipswich (over 60 km east) and the Durikai State Forest area (over 75 km south).

Recovery plans/threat abatement plans

The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016a) has been adopted by DAWE and has been in effect since May 2016. The Plan identifies the following threatening processes as applicable to the species:

- Small population size
- Habitat loss, fragmentation and degradation
- Competition with other nectivorous bird species as well as European honeybees (*Apis mellifera*)

Other identified threats include:

- Suppression of natural regeneration of overstorey tree species and shrub species as a result of overgrazing
- Disturbance to nesting sites leading to abandonment (DES 2017a).

The following threat abatement plan has been identified has been adopted as relevant to this species:

- *Threat abatement plan for competition and land degradation by rabbits* (DotEE 2016).

Important populations and habitat critical to the survival of the species

There are no important populations identified for this species. The overall population is difficult to define due to fluctuating numbers between years but is estimated at 350 to 400 mature individuals. The species is considered to occur as single widespread inter-breeding population (Garnett et al 2011). The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016a) identifies the following as habitat critical to the survival of the Regent honeyeater:

- Any breeding or foraging area where the species is likely to occur
- Any newly discovered breeding or foraging areas

Three known key breeding regions include:

- North-east Victoria (Chiltern-Albury)
- Capertee Valley NSW
- Bundarra-Barraba region NSW (DotE 2016a).

The nearest breeding site to the Project is the Durikai area approximately 75 km south of the Project. The species may sporadically occur as foraging individuals/pairs within the Project disturbance footprint during flowering events but it is not considered 'likely to occur'. There is no evidence the species occurs regularly/seasonally anywhere within the MNES study area or surrounds. The species forages widely and may as easily occur in modified urban environments as well as natural woodlands. This assessment has defined Habitat critical to the survival of the species by applying a 1 km buffer on known records that intersect '*potential habitat'* for the species (refer Appendix A for methodology). As such, the Project disturbance footprint is not considered to comprise *Habitat critical to the survival of the species*.

Impacts and mitigation measures associated with this species are identified within Table 5.7. Impact assessment for this species predicts that 156.25 ha of *potential habitat* used for foraging may be impacted under the current disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). It should be noted while this may represent available foraging habitat for the species it is not an indication of the species presence in the area. Assessment against the significant impact criteria for critically endangered species is shown in Table 5.23.

Table 5.23 Assessment against the significant impact criteria – Regent honeyeater

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	As noted above there are no identified important breeding locations or habitat critical to the survival of the species as identified in the *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016) which are within or near the MNES study area. The nearest known breeding location is Durikai State Forest which is over 80 km south-west of the Project. However, the species now rarely visits the Durikai (Gore-Karara) region (National Environmental Science Program Threatened Species Research Hub (NESPTSRH) 2019). Key breeding regions include: ■ North-east Victoria (Chiltern-Albury) ■ Capertee Valley NSW ■ Bundarra-Barraba region NSW (DotE 2016). The species is considered to occur as a single interbreeding population across its range. The species is only likely to occur in the MNES study area transiently (in winter during flowering events) in small numbers, if the species occurs in the area at all. No individuals have been observed during field investigations associated with the Project. The opening up of corridors within tracts of habitat may have potential to lead to an increase in aggressive/competitive honeyeater species accessing previously undisturbed woodlands. Nevertheless, this is not expected to be an impact from the Project. The western portion of the Project occurs largely in heavily disturbed lands. The proposed tunnel will leave a substantial area of vegetation in the Toowoomba Range undisturbed. The species has not been observed during field investigations associated with the Project or for the adjacent Inland Rail projects or the TSRC project. The nearest database records (AoLA) are few and old (1980s). The nearest recent records of the species are located at least 60 km east of the Project disturbance footprint. As noted above there are no identified important breeding locations or habitat critical to the survival of the species as identified in the *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016a) which are within or near the MNES study area. The nearest known breeding location is Durikai State Forest which is 75 km south of the Project. The species occurs as a single widely dispersed interbreeding population. The species is only likely to occur in the area transiently (in winter) if the species occurs in the area at all. It is estimated the Project will result in the loss of 156.25 ha of *potential habitat* (foraging) for the species, although this does not reflect the actual presence of the species. Nevertheless, the species can occur in woodland, and disturbed habitats (including urban areas). It is considered likely that, should they be present, foraging individuals disturbed by construction activities will temporarily move away from the area of disturbance. The Project is a linear development and relatively narrow. There will be extensive tracts of suitable habitat remaining undisturbed in the surrounding landscape adjacent to the north and south of the Project disturbance footprint. The Project is considered unlikely to result in a long-term decrease in the size of a population.
Reduce the area of occupancy of the species	The species is not known from the MNES study area. The species known from vagrant records in the region. The nearest database records to the Project are few and old (1980s). The nearest recent records and located at least 60 km east of the Project disturbance footprint. The species is only likely to occur in the area transiently (in winter) if the species occurs in the area at all. It is estimated the Project will result in the loss of 156.25 ha of *potential habitat* for the species, although this does not reflect the actual presence of the species. No areas of known occupancy are considered to occur within the Project disturbance footprint. There is abundant identical habitat in the immediate surrounds including 1,732 ha within the MNES study area. The species now rarely visits the Durikai (Gore-Karara) region of Queensland (NESPTSRH 2019) where the majority of Queensland records are from. This may be a result of recent dry conditions in the region. Drought conditions reduces the number of locations where high quality food may be found in the landscape by suppressing flowering events in key eucalypt species. The species is only likely to occur in the MNES study area transiently (in winter during flowering events) in small numbers, if the species occurs in the area at all. Therefore, no areas of known occupancy are considered to occur within the Project disturbance footprint and the Project is not likely to reduce the potential area of occupancy for the species.
Fragment an existing population into two or more populations	The species is highly mobile and the Project is not considered to represent a barrier to movement for the species. The species is only likely to occur as individuals, pairs or small groups in the area transiently (in winter) if the species occurs in the area at all. It is considered inconceivable the Project will fragment an existing population into two or more populations.

Criterion	Assessment against significance criteria
Adversely affect habitat critical to the survival of the species	The *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016) identifies the following as habitat critical to the survival of the Regent honeyeater: ■ Any breeding or foraging area where the species is likely to occur ■ Any newly discovered breeding or foraging areas. The Project is located east of the Great Dividing Range in an area mapped as where the species may occur (DAWE 2020b), The Project is located 80 km north-east of a key region known to support this species (breeding and foraging) in Queensland (i.e. Durikai State Forest and surrounds). Recent studies have however noted this species now rarely visits the Durikai (Gore-Karara) region (NESPTSRH 2019), much less the area associated with the Project. The absence of the species may be the extended dry weather reducing the number of sites where high quality food may be found in the landscape. The MNES study area does not include any *habitat areas considered critical to the survival of the species* as per the *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016a). It is not known if the species occurs in the area at all. The nearest recent records of the species are located at least 60 km east of the Project disturbance footprint. There is no critical habitat mapped within the MNES study area (under the approach used for this assessment), although 156.25 ha of *potential habitat* may occur. There is abundant identical habitat in the immediate surrounds including 1,732 ha within the MNES study area. It is considered unlikely that the Project will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	It is uncertain how many individuals occur in the area or if the species occurs in the area at all. No breeding sites are known from or close to the MNES study area. Three known key breeding regions include: ■ North-east Victoria (Chiltern-Albury) ■ Capertee Valley NSW ■ Bundarra-Barraba region NSW (DotE 2016a). The nearest breeding records are located in Durikai State Forest and are over 75 km south of the Project disturbance footprint. This area is considered to be habitat critical for the species given the area is known to support the species. However, the species now rarely visits the Durikai (Gore-Karara) region (NESPTSRH 2019). It is considered unlikely that the Project will disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There are no historical recent records of the species within the MNES study area or the wider surrounds. The species is considered rare in the region. The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the disturbance footprint. The proliferation of native species such as the Noisy miner following construction may also be an issue for the species. The nearest Habitat critical to the survival of the species is in Durikai State Forest over 75 km south of the Project disturbance footprint. It is estimated the Project will result in the loss of 156.25 ha of *potential habitat* for the species, although this does not reflect the actual presence of the species. The Project is a linear development and there will be extensive tracts of suitable habitat remaining undisturbed in the surrounding landscape adjacent to the north and south of the Project disturbance footprint including 1,732 ha within the MNES study area. This impact is not considered to be of the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	Habitat degradation by European rabbit (Oryctolagus cuniculs) has been identified as a threatening process for Regent Honeyeater (DotEE 2016). Rabbits were not identified during Project-associated surveys. Weed invasion is not identified as a threat to this species. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. *Lantana* species (including *L. camara* and *L. montevidensis*) were common throughout the MNES study area with severe infestations at some sites. Other dominant invasive flora included Climbing asparagus fern (*Asparagus africanus*) and Small-leaved privet (*Ligustrum lucidum*). Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a).

Criterion	Assessment against significance criteria
	Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed species across the Project area. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	Recovery strategies listed in the *National Recovery Plan for the Regent Honeyeater (Anthochaera phrygia)* (DotE 2016a) include: ■ Improve the extent and quality of Regent honeyeater habitat ■ Bolster the wild population with captive-bred birds until the wild population becomes self-sustaining ■ Increase understanding of the size, structure, trajectory and viability of the wild population ■ Maintain and increase community awareness, understanding and involvement in the recovery program The Project is considered unlikely to interfere with any of the recovery strategies listed above. The species is only sporadically recorded in the wider area. Should Regent honeyeater be identified during Project activities this will contribute to current information on the species in the SEQ region.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, there is unlikely to be a 'significant residual impact' on Regent honeyeater as a result of the Project.

Australasian bittern (*Botaurus poiciloptilus*) – endangered

Ecology and distribution

The Australasian bittern (*Botaurus poiciloptilus*) is a large stocky, partially nocturnal heron which can reach up to a total body length of 75 cm with a wingspan just over 1 m. Australian bittern is largely a solitary species although sometimes can be found in pairs or small dispersed groups. Preferred habitat for the Australasian bittern consists of permanent freshwater wetlands with tall dense vegetation including bulrushes (*Typha* spp.), spike rushes (*Eleocharis* spp.) and tall emergent sedges. Rice paddies within the Murray-Darling basin are a known habitat for the species who disperse widely during periods of droughts to coastal wetlands and to ephemeral wetlands. The species breed around summer, between October and February, as solitary pairs and begin building nests in secluded, densely vegetated wetlands on platforms of reeds approximately 30 cm above water level. (Birdlife International 2016b; OEH 2017a).

This species occurs from Bundaberg in SEQ south to Victoria and west into South Australia.

Distribution in context to the Project

The species was not recorded during any Project-associated surveys, although conditions were dry at the time of surveys and not conducive to the species being present. The species was also not recorded on the adjacent Inland rail projects or or surveys for the adjacent TSRC project. The nearest records (AoLA) are two records from the 1980s located in the Lockyer Forest Reserves area (3 km and 14 km north of the eastern extent of the Project disturbance footprint). It is noted all records of the species have been generalised to protect the species and so may not reflect the actual occurrence location. The nearest recent record (2009) is from Lake Clarendon (near Gatton) approximately 24 km east of the Project disturbance footprint (AoLA 2020). Lake Clarendon is identified as a 'key area' for sightings of the species (TSSC 2019a). To the west there is an older record (<1976) in the Jondaryan area (26 km northwest of the Project) (refer Figure 5.2 in Appendix B).

There are no areas of remnant palustrine wetland or wetlands considered to be of high ecological value within the MNES study area. Wetland habitat is restricted to 0.19 ha within the Project disturbance footprint and is represented farm dams and some anthropogenic grasslands that form highly ephemeral wetlands during prolonged rainfall events. Dams and reservoirs are generally unlikely to provide suitable dense aquatic vegetation for the species. Riverine wetlands associated with Gowrie Creek in the western portion of the alignment are ephemeral and typically highly modified with little native riparian cover and little aquatic vegetation present suitable for Australasian bittern (refer Section 4.4.4.6 and EIS Appendix I: Terrestrial and aquatic ecology technical report for further detail regarding wetland values). Given the steep terrain within the Project footprint to the east of Gowrie Creek suitable wetlands with values supporting Australasian bittern are unlikely to be present.

Recovery plans/threat abatement plans

There is currently a draft *National recovery plan for the Australasian bittern (Botaurus poiciloptilus*) (DotEE 2019a) awaiting adoption by DAWE. The draft plan identifies the following threatening processes as applicable to the species:

- Reduced wetland availability due to changed hydrology
- Habitat loss and degradation such as reduced water quality
- Low genetic diversity
- Invasive species including herbivores impacting habitat (horses, pigs, goats and deer) and predators (red fox, cats, rats and pigs)
- Climate variability and change.

The following threat abatement plans have been identified as being relevant to this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d)
- *Threat abatement plan for predation by the European red fox* (DEWHA 2008m).

Important populations and habitat critical to the survival of the species

Population estimates of the number of adult birds in QLD from 2009 – 2010 are 3 to 16 individuals in QLD (Garnett et al 2011). The draft *National recovery plan for the Australasian bittern (Botaurus poiciloptilus*) (DotEE 2019a) identifies all populations of Australasian bittern should be considered as important. Habitat 'critical to the survival of the species' is described as:

- Any wetland habitat where the species is known or likely to occur (breeding or foraging habitat) within the indicative distribution map
- Any location with suitable habitat outside the above area that may be periodically occupied by Australasian Bittern.

The Project disturbance footprint is located outside of the known or likely to occur habitat mapped within the distribution map.

Impacts and mitigation measures associated with this species are identified within Table 5.7. Predictive habitat modelling for the species estimates that 8.9 ha of *potential habitat* may be impacted under the current disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). *Habitat critical to the survival of the species* is not considered to occur. The predictive habitat mapping has been approached in a conservative manner and is based on the inclusion of all wetland habitat within the Project disturbance footprint (refer Appendix A for methodology). This is largely modelled on available vegetation and corresponding wetland community mapping as provided by DES. This includes creek line vegetation and waterbodies and farm dams which are much less likely to present suitable habitat values (tall aquatic vegetation) for the species. Given the ephemeral nature of most natural wetlands in the area the predictive habitat figure is likely to be an overestimation of the available habitat suitable for this species in the Project disturbance footprint.

Nevertheless, given suitable habitat is predicted to be present and under the definition identified above there is potential the Project will impact potential habitat for Australasian bittern. Assessment against the significant impact criteria for endangered species is shown in Table 5.24.

Table 5.24 Assessment against the significant impact criteria – Australasian bittern

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	The species occurs as a widely dispersed population across south-eastern Australia. As such, no resident population can be attributed to the MNES study area or immediate surrounds. No individuals or suitable habitat have been observed during field investigations associated with the Project or the TSRC. The nearest database records (AoLA) are old (1980s). The nearest recent records and likely site of occurrence is located 24 km east of the Project disturbance footprint in the Lockyer Valley. There is no evidence the species occurs in the area. Should the species occur within the disturbance footprint it is unlikely to occur as more than one or two individuals at a site (i.e. the Project is unlikely to impact a population). As outlined in Section 4.4.4.6 and above there are wetlands present surrounding the Project. Predictive mapping estimates that 8.9 ha of *potential habitat* will be impacted by the Project although this is likely to be an overestimation given that the wetland systems identified are highly ephemeral and have limited vegetation cover (dense aquatic vegetation is a key feature of preferred habitat). In general, the landscape and habitat (either heavily degraded by agricultural/grazing land use or is steep montane country) within the MNES study area is less likely to provide suitable wetland habitat values for the species presence. As noted in Section 5.1.2 the Project has the potential to impact on aquatic habitats within and downstream of the Project disturbance footprint. Construction activity at watercourse crossings will disturb the riparian zone and instream habitats, including potential habitat for the species. Activities will include clearing of vegetation, reprofiling of banks and instream substrate, deposition of material (e.g. rip rap for erosion and sediment control), erection of temporary barriers (e.g. coffer dam), water extraction, disturbance of sediment causing elevated nutrients and turbidity, and result in the loss of wetlands and direct disturbance of local individuals (should they occur within the Project disturbance footprint). However, the species is less likely to occur in riverine environments and this disturbance is expected to be restricted to the construction period with occasional works during the operation of the Project (design life of 100 years). The Project will not create any permanent barriers to flow as watercourse crossings will consist of bridges or culverts. Following construction localised habitat suitable for the species is expected to return to its prior natural conditions. The use of bridge structures across some of the major watercourses and associated floodplains (e.g. Lockyer Creek) will also avoid and/or minimise the impact to riparian zones, wetlands and instream habitat (e.g. footings are outside the channel or the highwater banks). Flood modelling (refer EIS Appendix M: Hydrology and Flooding) indicates local changes to the catchment hydrology is minimal. Under the Flora and Fauna Sub-plan pre-construction surveys will be carried out following optimal (wet) conditions to assess whether wetland habitat values are suitable for the species, and if so, if the species actually occurs. Surveys will follow Commonwealth survey guidelines for the species (DEWHA 2010a). If the species or habitat is identified during pre-construction surveys, further pre-clearance surveys will be carried out to assess whether the species is present with mitigation measures in place should this be the case (refer Table 5.7). Should the species be found individuals would be expected to disperse from the construction area. The impacts of the Project are considered unlikely to lead to a long-term decrease in the size of the population.
Reduce the area of occupancy of the species	There are no reliable records of this species within or close to the Project disturbance footprint. Predictive mapping estimates that 8.9 ha of potential habitat may be impacted by the Project, although this is likely to be an overestimation. It is unknown at this stage to what extent the predicted wetland habitat within the Project disturbance footprint comprises values suitable for the presence of Australasian bittern. No database records of the species occur within or near the MNES study area. The nearest recent database records are 24 km east of the Project It is unknown to what extent the species may utilise wetland habitats associated with the Project disturbance footprint, or if it occurs at all. The species is nomadic and unlikely to use these areas in more than a transient manner dependent on local conditions. The impacts of the Project are considered unlikely to reduce the area of occupancy of the species.

Criterion	Assessment against significance criteria
Fragment an existing population into two or more populations	The species is highly mobile. Individuals have been shown to disperse over 100 km in response to changing wetland conditions (Bitterns in Rice Project 2016). The Project is not considered to represent a barrier to movement for the species. It is uncertain if the species or suitable habitat occurs. It is considered unlikely that the Project will fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of the species	There are no reliable records of this species within or close to the Project disturbance footprint. Predictive mapping estimates that 8.9 ha of *potential habitat* will be impacted by the Project, although this is likely to be an overestimation. *Habitat critical to the survival of the species* is not considered to occur. The Project is considered unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	There are no reliable records of this species within or close to the Project disturbance footprint. Predictive mapping estimates that 8.9 ha of *potential habitat* will be impacted by the Project, although this is likely to be an overestimation. The species is known to breed from October to February, nesting in densely vegetated freshwater wetlands, building nests within dense cover over shallow water placed about 30 cm above the water level. This type of habitat is absent/limited from the Project disturbance footprint. It is noted that if population densities are high, the species may resort to more open wetlands for nesting (DotEE 2019b). However, the population in Queensland is considered low, with Garnett et al (2011) estimating it to be between 3 and 16 mature individuals. Pre-construction surveys will be carried out to assess whether wetland habitat values are suitable for the species, and where suitable habitat is identified whether the species actually occurs. Should the species be observed as nesting measures will be in place within the Flora and Fauna Sub-plan to allow nesting to occur undisturbed (refer Table 5.7). It is possible that Australasian bittern individuals could be disrupted during breeding, but it is considered very unlikely that the Project will disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There are no reliable records of this species within or close to the Project disturbance footprint. Predictive mapping estimates that 8.9 ha of potential habitat will be impacted by the Project, although this is likely to be an overestimation. It is unlikely any of this area is of a suitable quality to support the species. Through Project design considerations changes to hydrological conditions in the area are expected to be minor at worst, localised and transient (during flood events) and are unlikely to impact potential habitat for the species. Mitigation measures will be in place to ensure surface water quality associated with the Project surrounds is not impacted as a result of Project activities (e.g. erosion and sediment controls and water quality monitoring program) (refer Table 5.7). Nevertheless, given the species wide range of occurrence it is unlikely the Project would impact suitable habitat to the extent the species would decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	Weed species identified as relevant to Australasian bittern include those that may negatively affect habitat values for the species such as Common reed (*Phragmites australis*) (TSSC 2019a). Project-associated surveys did not note any aquatic weed species present within the MNES study area. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. This will include measures to ensure aquatic weeds are not introduced as a result of the Project. The Project is not expected to lead to increased abundances of introduced predator species. Nevertheless, measures will be incorporated to monitor pest species observations associated with Project activities, and pest control actions where considered necessary. The Plan will be in place for the life of the Project and will minimise the potential for weed invasion and pest proliferation and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral predators are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.

Criterion	Assessment against significance criteria
Interfere with the recovery of the species	Conservation objectives listed in the draft Commonwealth recovery plan for the species (DotEE 2019a) include: ■ Identify the key sites where Australasian bittern occurs throughout their range and establish a baseline measure of abundance. This baseline will then be used to track change over time. ■ Manage key sites to ensure habitat is suitable for Australasian bittern. This will require measures that primarily target adequate water flow and quality, and measures to ensure weed species and grazing animals do not compromise wetland structure and function. ■ Improve understanding of foraging and breeding behaviour, in order to better design recovery actions. ■ Engage community and stakeholders in Australasian bittern conservation. The Project is considered unlikely to interfere with any of the recovery strategies listed above. Key sites are unlikely to occur and should Australasian bittern be identified during Project activities this will contribute to current information on the species in the SEQ region.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, there is unlikely to be a 'significant residual impact' on Australasian bittern as a result of the Project.

Curlew sandpiper (*Calidris ferruginea*) – critically endangered

Ecology and distribution

In Australia, the Curlew sandpiper forages mainly on invertebrates, including worms, molluscs, crustaceans, and insects, as well as seeds. Curlew sandpipers usually forage by pecking and probing in water, near the shore or on bare wet mud at the edge of wetlands. They glean from mud, from the surface of water, or in drier areas above the edge of the water. Curlew sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They have also been recorded inland around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand (DAWE 2020a).

The species breeds in Siberia in the northern hemisphere summer. The species has been recorded in all Australian states and territories. In QLD, widespread records occur along the coast south of Cairns with sparsely scattered records inland. The species migrates to Australia in the non-breeding season arriving in early September and leaving in March-April. Younger birds may over-winter in Australia (DotE 2015e).

Distribution in context to the Project

The species was not recorded during any Project-associated surveys, although conditions were dry at the time of surveys and not conducive to the species being present. The species was also not recorded on the adjacent Inland rail projects or or surveys for the adjacent TSRC project. Curlew sandpiper has not been recorded within the MNES study area or surrounds. The nearest record (2018) is located 13 km north of the Project at Cooby Creek Reservoir (2018) with an older record (1971) located 23 km north. To the west there is a 1980 record from the Oakey area (16 km west). To the east there is a 2002 record at Lake Apex in Gatton (16 km east). There are further recent records in the Lockyer Valley to the east of Gatton (AoLA 2020) which are associated with several wetlands and large waterbodies in the area. Nevertheless, the majority of records from the region are coastal or from inshore islands in Moreton Bay (refer Figure 5.13 in Appendix B).

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species.

The DAWE Approved Conservation Advice (DotE 2015e) notes the following potentially threatening processes identified for Australian habitat as relevant to Curlew sandpiper:

- In non-breeding grounds in Australia, this species mostly occurs in highly populated areas and is therefore vulnerable to possible habitat alteration
- Threats to the Curlew sandpiper include the loss and fragmentation of feeding and roosting habitat from human development, human disturbance at roost and feeding sites, disturbance by wild dogs, water pollution and invasive plants.

Important populations and habitat critical to the survival of the species

The breeding population of Curlew sandpiper migrating to Australia occurs across much of the Australian coastline as well as some inland sites. As such there is no important population relevant to individual locations. There is no description of Habitat critical to the survival of the species. 'Nationally important habitat' for migratory shorebirds in Australia is described as comprising 0.1 per cent of the flyway population of a single species of migratory shorebird (DotE 2017a). For Curlew sandpiper this equates to 90 individuals based on current population estimates (Hansen et al 2016). There is no evidence the Project disturbance footprint or surrounding MNES study area comprises any areas of suitable open wetland habitat capable of supporting this many individuals. The species is very unlikely to utilise riverine wetland habitat in the area (the dominant wetland type within the MNES study area), although these areas have been conservatively mapped as *potential habitat*. All known inland records of the species occurrence in the local region are located on large permanent or semi-permanent waterbodies in the Lockyer Valley and located well away from the Project disturbance footprint. The nearest area that may be considered as 'critical habitat' is Moreton Bay and the Great Sandy Strait. This is considered an internationally important site for the species (Bamford et al. 2008) and is located over 90 km east of the Project.

The Project is predicted to impact 8.9 ha of *potential habitat* for Curlew sandpiper (refer Table 5.4 and habitat figure in Appendix G). However, the predictive habitat mapping has been approached in a conservative manner and is largely modelled on available vegetation and corresponding wetland communities mapping provided by DES. This includes creek line habitat which is far less suitable for Curlew sandpiper (the species prefers large, open shallow wetlands). Given the species coastal habits and the ephemeral nature of most natural wetlands in the area the predictive habitat figure is likely to be an overestimation of the available habitat suitable for this species in the Project disturbance footprint. As such, there is no *Habitat critical to the survival of the species* identified within or close to the disturbance footprint.

Assessment against the significant impact criteria for critically endangered species is shown in Table 5.25.

Table 5.25 Assessment against the significant impact criteria - *Calidris ferruginea*

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	Based on habitat modelling the Project is predicted to impact 8.9 ha of *potential habitat* for Curlew sandpiper although this is likely an overestimation (i.e. habitat mapping includes watercourses mapped as riverine wetlands/waterbodies, although the species is not associated with this type of habitat). In addition, bridge structures will be provided to avoid/minimise impacts on instream habitats and wetlands. It is unlikely the Project disturbance footprint or immediate surrounds comprises habitat likely to support large numbers of individuals of the species. The species was not recorded from ecological surveys for Project, and was also not recorded as part of the adjacent Inland Rail projects and the TSCR project works. There are no historic records of this species within the MNES study area. The nearest recent records (2018) are from Cooby Creek Reservoir. The reservoir is located 13 km north of the Project and will not possibly be impacted by Project activities. The species occurs as a dispersed population around coastal Australia.

Criterion	Assessment against significance criteria
	As noted in Section 5.1.2 the Project has the potential to impact on aquatic habitats within and downstream of the Project disturbance footprint. Construction activity at watercourse crossings will disturb the riparian zone and instream habitats, including potential habitat for the species. Activities will include clearing of vegetation, reprofiling of banks and instream substrate, deposition of material (e.g. rip rap for erosion and sediment control), erection of temporary barriers (e.g. coffer dam), water extraction, disturbance of sediment causing elevated nutrients and turbidity, and result in the loss of wetlands and direct disturbance of local individuals (should they occur within the Project disturbance footprint). However, the species is unlikely to occur in riverine environments and this disturbance is expected to be restricted to the construction period with occasional works during the operation of the Project (design life of 100 years). The Project will not create any permanent barriers to flow as watercourse crossings will consist of bridges or culverts. Following construction localised habitat suitable for the species is expected to return to its prior natural conditions. The use of bridge structures across some of the major watercourses and associated floodplains (e.g. Lockyer Creek) will also avoid and/or minimise the impact to riparian zones, wetlands and instream habitat (e.g. footings are outside the channel or the highwater banks). Flood modelling (refer EIS Appendix M : Hydrology and Flooding) indicates local changes to the catchment hydrology is minimal. The Project is unlikely to result in a long-term decrease in the size of a population of Curlew sandpiper.
Reduce the area of occupancy of the species	Based on habitat modelling the Project is predicted to impact 8.9 ha of *potential habitat* for Curlew sandpiper although this is likely an overestimation. It is unknown if the species actually occurs within or near the Project disturbance footprint, and it is unlikely the Project disturbance footprint or surrounds comprises habitat likely to support large numbers of individuals of the species. There are no historic records of this species within the MNES study area. The nearest recent records (2018) are from Cooby Creek Reservoir. The reservoir is located 13 km north of the Project and will not possibly be impacted by Project activities. The species occurrence is largely coastal and it occurs as a dispersed population around coastal Australia. The Project is considered unlikely to reduce the potential area of occupancy for the species.
Fragment an existing population into two or more populations	The population of Curlew sandpiper is dispersed across much of coastal Australia. It is considered unlikely that the Project will fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of a species	The Project disturbance footprint does not comprise *Habitat critical to the survival of the species* (as described for this assessment), or nationally important habitat as described by DotEE (2017a). The nearest important habitat for the species is over 90 km to the east. It is considered unlikely that the Project will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	The species breeds in the northern hemisphere. It is considered unlikely that the Project will disrupt the breeding cycle of a population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Based on habitat modelling the Project is predicted to impact 8.9 ha of *potential habitat* for Curlew sandpiper although this is likely a substantial overestimation. The nearest recent records (2018) are from Cooby Creek Reservoir. The reservoir is located 13 km north of the Project and will not possibly be impacted by Project activities. Nevertheless, the species occurrence is largely coastal. Through Project design considerations changes to hydrological conditions in the area are expected to be minor at worst, localised and transient (during flood events) and are unlikely to impact potential habitat for the species. Mitigation measures will be in place to ensure surface water quality associated with the Project surrounds is not impacted as a result of Project activities (e.g. erosion and sediment controls and water quality monitoring program) (refer Table 5.7). Nevertheless, the species occurrence is largely coastal. The Project is not considered to impact the species to the extent that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	There are no particular weed species identified as relevant to Curlew sandpiper, although invasion of wetland habitat by weeds is considered a potential threat (DotE 2015e). Project-associated surveys did not aquatic weed species as present. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The Plan will be a part of the CEMP and Operation EMP. This will include measures to ensure aquatic weeds are not introduced as a result of the Project. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral predators (i.e. wild dogs/dingo) are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	There is no recovery plan for Curlew sandpiper or migratory shorebirds in general. The approved conservation advice for this species notes the following management actions: ■ Improve protection, management, and monitoring of roosting and feeding sites ■ Control of invasive species at important sites ■ Manage disturbance at important sites (e.g. horse riding, pet dog controls, and vehicle access) ■ Incorporate coastal planning and management requirements addressing Curlew sandpiper (TSSC 2015). The Project is considered unlikely to interfere with the management actions listed above and is very unlikely to interfere with the recovery of the species.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, there will be no 'significant residual impact' on Curlew sandpiper as a result of the Project.

Swift parrot (*Lathamus discolor*) – critically endangered

Ecology and distribution

The Swift parrot feeds mostly on nectar, mainly from Eucalypts, but also eats psyllid insects and lerps (waxy secretion on Eucalypt leaves produced as a protection by young psyllid insects), seeds and fruit. Foraging habitat on the mainland includes inland box-ironbark and grassy woodlands, and coastal Swamp mahogany (*Eucalyptus robusta*) and Spotted gum (*Corymbia maculata*) woodland when in flower. In northern NSW and SEQ, Forest red gum (*E. tereticornis*) forests and Yellow box (*E. melliodora*) forest are commonly utilised by Swift parrots (Saunders and Tzaros 2011, OEH 2017b). In northern New South Wales the species is known to use Northern grey box (*E. mollucana*) and Blackbutt (*E. pilularis*) (Saunders and Heinsohn 2008), both of which also occur in south-east Queensland.

The Swift parrot typically inhabits dry eucalypt forests and woodlands, occasionally wet sclerophyll forests, suburban parks and sometimes gardens with flowering fruit trees (Saunders and Tzaros 2011). Coastal forests from eastern Victorian to the central coast of NSW are utilised during periods of drought as refuge habitats. The species is found to prefer large mature trees for foraging as these provide more reliable resources than smaller immature trees (Saunders and Tzaros 2011).

The Swift parrot breeds in Tasmania during summer (mid-September to late-January) and migrates north to mainland Australia during the winter. Small numbers of Swift parrots occur in SEQ on a regular basis (TSSC 2016a).

Distribution in context to the Project

The species was not recorded during any Project-associated surveys or surveys for the adjacent TSRC project. There are a number of records (AoLA) from the Toowoomba area. A single record for this species exists within the Project disturbance footprint near the western tunnel entrance to the north of Toowoomba. It is noted that this record does not have a date recorded and the location has been generalised to 0.1 degree due to the sensitivity of the species. A record from 1998 occurs approximately 2.5 km south of the Project disturbance footprint at the northern end of Toowoomba. There are several records from the area of Glen Lomond Park which is a 'priority habitat area' for the species (Saunders and Tzaros 2011) and is located approximately 10 km south of the Project disturbance footprint. There are records from this area dated from 2000 and 2010 whilst there are six occurrences in the same area without dates. Further east there are records south of Withcott (1998) and Flagstone Creek (undated) located 4 km and 6 km south of the Project respectively and there is a 2010 record north of Helidon (4.3 km north of the Project) (refer Figure 5.27 in Appendix B).

Recovery plans/threat abatement plans

The *National Recovery Plan for the Swift Parrot (Lathamus discolor)* (Saunders and Tzaros 2011) identifies the following threatening processes as applicable to the species:

- Habitat loss and alteration from forestry activities (including firewood harvesting), and land developments
- Suppression of tree regeneration and loss/dieback of eucalypts on agricultural land
- Climate change and frequent fires
- Mortality resulting from collision with wire netting or mesh fences
- Competition with noisy miner (*Manorina melanocephala*) and other aggressive honeyeaters

The following threat abatement plans have been identified as being relevant to this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d).

Important populations and habitat critical to the survival of the species

The overall population is poorly known but estimated at 2000 mature individuals and is declining (Garnett et al 2011). The wintering population of Swift parrot is spread across much of mainland south-east Australia. As such there is no important population relevant to individual locations. The species' recovery Plan does not define habitat critical to the survival of the species but does identify priority habitats which are used by large proportions of the population (*repeatedly between seasons* or *for prolonged periods of time*).

Priority habitat areas identified in SEQ include the following localities:

- Bowman Park, Bardon
- Rafting Ground Reserve, Kenmore Hills
- Glen Lomond Park, Toowoomba (Saunders and Tzaros 2011).

The nearest of these to the MNES study area (Glen Lomond Park) is located on the south-eastern outskirts of Toowoomba and is 10 km south of the Project. Other habitats considered important for the species are nesting and habitats used by a large proportion of the population (Saunders and Tzaros 2011). The species nests in Tasmania and there is no evidence provided by available records indicating the disturbance footprint, MNES study area or surrounds provides habitat considered as a 'priority habitat' i.e. regularly used by the species either repeatedly or for extended periods. For the purposes of this assessment habitat considered 'critical to the survival' of Swift parrot has been considered as foraging habitat in mature (remnant) vegetation communities comprising the tree species discussed above as relevant to south-east Queensland (refer Appendix A for methodology).

Impacts and mitigation measures associated with this species are identified within Table 5.7. Predictive habitat mapping estimates that 8.54 ha of *Habitat critical to the survival of the species* for the Swift parrot will be impacted by the Project (refer Table 5.4 and habitat figure in Appendix G). There is no habitat identified as important (priority habitat areas) within or near the Project footprint, although a further 180.47 ha of *potential habitat* for the species has been modelled as being present within the Project disturbance footprint (refer Table 4.4) (refer Appendix A for methodology). The predictive habitat modelling has taken a conservative approach and includes regrowth woodlands (that dominate the mapped vegetation in the MNES study area) and which may not be likely to provide favoured foraging habitat given the species prefers large mature trees (Saunders and Tzaros 2011). There is approximately 858.77 ha of *Habitat critical to the survival of the species* within the immediate surrounds of the MNES study area (refer Table 4.4 and Table 5.4) and over 116,000 ha within a 50 km radius of the disturbance footprint (refer Table 7.1).

Assessment against the significant impact criteria for critically endangered species is shown in Table 5.26.

Table 5.26 Assessment against the significant impact criteria – Swift parrot

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	The population of Swift parrot is dispersed across mainland south-eastern Australia in the winter months. Small numbers of individuals occur sporadically in SEQ in a variety of habitats including urban areas. The nearest reliable database record of Swift parrot is located 2.5 km from the Project disturbance footprint, although is relatively old (1998). The species may occur regularly in the Toowoomba area. There is a 'priority habitat area' identified for the species located 10 km south of the Project. There is no evidence the species uses the MNES study area or surrounds on a regular basis or provides habitat considered to be of importance to the species. It is considered very unlikely the Project will result in direct mortality of individuals of the species. The Project will not impact any of the identified priority habitat areas (where the species is thought to regularly occur) in QLD. Predictive habitat modelling indicates the project may impact 8.54 ha of *Habitat critical to the survival of the species* (refer Table 4.5) and 180.47 ha of *potential habitat*, although this is likely an overestimate of the potential for the species to occur in the area. The opening up of corridors within tracts of habitat may have potential to lead to an increase in aggressive/competitive honeyeater species accessing previously undisturbed woodlands. It is noted the western portion of the Project occurs largely in heavily disturbed lands. The proposed tunnel will leave a substantial area of vegetation in the Toowoomba Range undisturbed. Nevertheless, the species ranges widely and can occur in woodland, and disturbed habitats (including urban areas). The Project is a linear development and there is extensive identical habitat in the immediate surrounds and throughout the wider region that will not be impacted. There is over 800 ha of identical *Habitat critical to the survival of the species* adjacent to the Project (within the MNES study area, refer Table 4.4) and over 115,000 ha estimated within a 50 km radius that will remain undisturbed. The Project is considered unlikely to result in a long-term decrease in the size of a population.
Reduce the area of occupancy of the species	Small numbers of individuals occur sporadically in SEQ in a variety of habitats including urban areas. The nearest reliable database record of Swift parrot is located 2.5 km from the Project disturbance footprint, although is relatively old (1998). The species may occur regularly in the Toowoomba area. The Project will not impact any identified priority habitat areas in QLD. The Project has been predicted to impact 8.54 ha of *Habitat critical to the survival of the species* (refer Table 4.5) and 180.47 ha of *potential habitat*. Nevertheless, the species forages widely and may utilise a wide variety of habitats including urban parklands. The Project is linear in nature and there is extensive habitat in the immediate surrounds and throughout the wider region that will not be impacted. There is over 800 ha of identical *Habitat critical to the survival of the species* adjacent to the Project. The Project is considered unlikely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	This is a highly mobile species. The Project is not considered to represent a barrier to movement for the species. It is considered unlikely the Project will fragment an existing important population into two or more populations.

Criterion	Assessment against significance criteria
Adversely affect habitat critical to the survival of the species	The Project will not impact any identified priority habitat areas in Queensland. Small numbers of individuals occur in SEQ in winter. The species breeds in Tasmania. Predictive habitat modelling indicates that the Project has been predicted to impact 8.54 ha of *Habitat critical to the survival of the species* and 180.47 ha of *potential habitat*, although this may be an overestimate of the potential for the species to occur. Nevertheless, the species ranges widely and can occur in woodland, and disturbed habitats (including urban areas). The Project is a linear development and there is extensive identical habitat in the immediate surrounds and throughout the wider region that will not be impacted. There is over 800 ha of *Habitat critical to the survival of the species* adjacent to the Project (within the MNES study area, refer Table 4.5) and over 115,000 ha estimated within a 50 km radius that will remain undisturbed. Nevertheless, given *Habitat critical to the survival of the species* may occur there is potential the Project may adversely affect *Habitat critical to the survival of the species*.
Disrupt the breeding cycle of a population	The species breeds in Tasmania. Small numbers of birds occur in SEQ each year. The Project will not disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The Project will not impact any identified priority habitat areas in Queensland. The Project has been predicted to impact 8.54 ha of *Habitat critical to the survival of the species* and 180.47 ha of *potential habitat*. Nevertheless, the species may utilise a wide variety of habitats including urban parklands. The Project is a linear development and there is extensive identical habitat in the immediate surrounds and throughout the wider region that will not be impacted. That is, the predictive modelling indicates that there is 800 ha of *Habitat critical to the survival of the species* adjacent to the Project (within the MNES study area, refer Table 4.5) and over 115,000 ha of identical habitat estimated within a 50 km radius that will remain undisturbed. As outlined in Section 5.1.2, the Project may impact the quality of habitat available as a result of edge effects; habitat fragmentation and barrier effects. These impacts however are unlikely to result in changes to flowering events or result in the suppression of tree regeneration and loss/dieback of eucalypts. The Project is a linear development and there is extensive identical habitat in the immediate surrounds and throughout the wider region that will not be impacted. The Project will not impact habitat suitable for Swift parrot to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	Weed invasion is not considered as a threat to the species. The relevant threat abatement plan for Swift parrot include management measures to address the impact of feral cats. Although feral cat was not observed during Project-associated surveys it is likely present to some degree. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral predators are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	The National Recovery Plan for the Swift Parrot *Lathamus discolor* (Saunders and Tzaros 2011) lists the following recovery actions: ■ Identify the extent and quality of habitat ■ Manage and protect Swift Parrot habitat at the landscape scale ■ Monitor and manage the impact of collisions, competition and disease ■ Monitor population and habitat. The Project is considered unlikely to interfere with any of the recovery actions listed above. Should Swift parrot be identified during Project activities this will contribute to current information on the species in the SEQ region.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, the Project is considered to have potential to have a significant impact on Swift parrot through clearing of 8.54 ha of habitat identified as *Habitat critical to the survival of the species*.

Australian painted snipe (*Rostratula australis*) – endangered

Ecology and distribution

The Australian painted snipe generally inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans. The species has also been observed to use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. The Australian painted snipe has been recorded nesting in and near swamps, canegrass swamps, flooded areas, including samphire, grazing land, among cumbungi, sedges, grasses, salt water couch, saltbush (*Halosarcia* sp.) and grass, in ground cover of water-buttons and grasses, at the base of tussocks and under low saltbush (DAWE 2020).

Australian painted snipe is a very cryptic species that generally occurs in low numbers and has been recorded at wetlands in all states and territories of Australia but is more common in eastern Australia, where it has been recorded at scattered locations throughout much of QLD, NSW, Victoria and south-eastern South Australia. It is a highly nomadic species dependent on wetland conditions throughout its range. There is evidence that part of the population may migrate from south-eastern Australia to central and northern QLD during autumn and winter. It's known distribution has likely declined by approximately 50 per cent in Australia since European settlement (Garnett et al 2011).

Breeding has been recorded at all times of the year and is likely a response to wetland conditions. Nesting habitat appears quite specific requiring shallow wetlands, exposed mud and nearby vegetative cover. Nests are often located on or near islands within the wetland (DAWE 2020).

Distribution in context to the Project

The species was not recorded during any Project-associated surveys, although conditions were dry at the time of surveys and not conducive to the species being present. The species was also not recorded on the adjacent Inland rail projects or or surveys for the adjacent TSRC project. Australian painted snipe has been recorded at several sites to the east of the Project. This includes including two sightings (1982 & 1983) within the MNES study area 500 m from the eastern end of the Project disturbance footprint. Recent records from nearby include 2013 records in the Helidon area (2 km and 4 km south-east of the eastern extent of the Project disturbance footprint). Most other records for this species occur further east of the Project in the Lockyer Valley where numerous wetlands and large waterbodies occur. However, there is a 1995 record approximately 13 km to the north of the Gowrie area from Cooby Creek Dam (refer Figure 5.4 in Appendix B).

There are no areas of remnant palustrine wetland or wetlands considered to be of high ecological value within the MNES study area. Wetland habitat is restricted to 0.19 ha within the Project disturbance footprint and is represented by farm dams and grassy paddocks that flood during rainfall events (i.e. highly ephemeral wetlands). Dams and reservoirs are generally unlikely to provide suitable dense aquatic vegetation for the species. Riverine wetlands associated with Gowrie Creek in the western portion of the alignment are ephemeral and typically highly modified with little native riparian cover and little aquatic vegetation present suitable for Australian painted snipe (refer Section 4.4.4.6 and EIS Appendix I: Terrestrial and Aquatic Ecology technical report for further detail regarding wetland values). Given the steep terrain within the Project footprint to the east of Gowrie Creek suitable wetlands with values supporting Australian painted snipe are generally unlikely to be present.

Recovery plans/threat abatement plans

There is currently a draft *National recovery plan for the Australian painted snipe (Rostratula australis*) (DotEE 2019b) awaiting adoption by DAWE. The draft Plan identifies the following threatening processes as applicable to the species:

- Reduced wetland availability due to draining, fragmentation and changed hydrology
- Habitat degradation such as reduced water quality
- Low genetic diversity

- Invasive species including herbivores impacting habitat (horses, pigs, goats and deer) and predators (red fox and cats)
- Wetland vegetation structure change caused by native plants (e.g. *Typha* spp.) and non-native plants ((e.g. Lippia (*Phyla canescens*))
- Climate variability and change.

There are no Commonwealth adopted threat abatement plan considered relevant to this species.

Important populations and habitat critical to the survival of the species

The Australian population is thought to range between 1,000 to 1,500 mature individuals (Garnett et al 2011). The draft *National recovery plan for the Australian painted snipe (Rostratula australis*) (DotEE 2019b) identifies the population as a single homogenous breeding population spread thinly across much of Australia. The species is widespread with an extent of occurrence estimated at 7,100,000 km^2 (Garnett et al 2011). As such there is no population relevant to individual locations. Habitat 'critical to the survival of the species' is described as:

- Any wetland habitat where the species is known or likely to occur (especially with suitable breeding habitat) within the indicative distribution map
- Any location with suitable habitat outside the above area that may be periodically occupied by Australian Painted snipe when conditions are favourable.

The Project disturbance footprint is located within the 'known or likely to occur' habitat mapped within the distribution map from the draft recovery plan.

Impacts and mitigation measures associated with this species are identified within Table 5.7. Predictive habitat mapping indicates that the Project is predicted to impact 8.9 ha of *Habitat critical to the survival of the species* for Australian painted snipe (refer Table 5.4 and habitat figure in Appendix G). However, the predictive habitat mapping has been approached in a conservative manner and is largely modelled on available vegetation and corresponding wetland communities mapping provided by DES (refer Appendix A for methodology). This includes creek lines, associated riparian habitat and farm dams which are less likely to provide habitat for Australian painted snipe (large shallow wetlands with dense vegetative cover). The predictive habitat figure is likely to be an overestimation of the available habitat suitable for this species within the Project disturbance footprint.

Assessment against the significant impact criteria for endangered species is shown in Table 5.27.

Table 5.27 Assessment against the significant impact criteria – Australian painted snipe

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	Australian painted snipe occurs as a single homogenous breeding population dispersed thinly across much of Australia. As such, no resident population can be attributed to the MNES study area or immediate surrounds. There are no records within MNES study area. Most records are located east of the Project in the Lockyer Valley. It is unknown to what extent the species may utilise wetland habitats associated with the Project disturbance footprint, or if it occurs at all. The species is highly nomadic and unlikely to use these areas in more than a transient manner as a response to local conditions. As outlined in Section 4.4.4.6 and above there are wetlands present surrounding the Project. Predictive mapping estimates that 8.9 ha of *Habitat critical to the survival of the species* will be impacted by the Project although this is likely to be an overestimation given that the wetland systems identified are highly ephemeral and have limited vegetation cover (dense aquatic vegetation is a key feature of preferred habitat). In general, the landscape and habitat (either heavily degraded by agricultural/grazing land use or is steep montane country) within the MNES study area is less likely to provide suitable wetland habitat values for the species presence.

Criterion	Assessment against significance criteria
	As noted in Section 5.1.2 the Project has the potential to impact on aquatic habitats within and downstream of the Project disturbance footprint. Construction activity at watercourse crossings will disturb the riparian zone and instream habitats, including potential habitat for the species. Activities will include clearing of vegetation, reprofiling of banks and instream substrate, deposition of material (e.g. rip rap for erosion and sediment control), erection of temporary barriers (e.g. coffer dam), water extraction, disturbance of sediment causing elevated nutrients and turbidity, and result in the loss of wetlands and direct disturbance of local individuals (should they occur within the Project disturbance footprint). However, the species is less likely to occur in riverine environments and this disturbance is expected to be restricted to the construction period with occasional works during the operation of the Project (design life of 100 years). The Project will not create any permanent barriers to flow as watercourse crossings will consist of bridges or culverts. Following construction localised habitat suitable for the species is expected to return to its prior natural conditions. The use of bridge structures across some of the major watercourses and associated floodplains (e.g. Lockyer Creek) will also avoid and/or minimise the impact to riparian zones, wetlands and instream habitat (e.g. footings are outside the channel or the highwater banks). Flood modelling (refer EIS Appendix M : Hydrology and Flooding) indicates local changes to the catchment hydrology is minimal. Under the Flora and Fauna Sub-plan pre-construction surveys will be carried out following optimal (wet) conditions (where possible) to assess whether wetland habitat values are suitable for the species, and if so, if the species actually occurs. Surveys will follow Commonwealth survey guidelines for the species (DEWHA 2010a). If the species or habitat is identified during pre-construction surveys, further pre-clearance surveys will be carried out to assess whether the species is present with mitigation measures in place should this be the case (refer Table 5.7). Should the species be found individuals would be expected to disperse from the construction area. The impacts of the Project are considered unlikely to lead to a long-term decrease in the size of the population.
Reduce the area of occupancy of the species	Predictive habitat mapping indicates the Project has the potential to impact 8.9 ha of *Habitat critical to the survival of the species* (as defined under the draft recovery plan for the species), although this is likely to be a substantial overestimate. It is unknown at this stage to what extent the predicted wetland habitat within the Project disturbance footprint comprises values suitable for the presence of Australian painted snipe. No database records of the species occur within the MNES study area. Most records are located east of the Project in the Lockyer Valley. It is unknown to what extent the species may utilise wetland habitats associated with the Project disturbance footprint, or if it occurs at all. The species is highly nomadic and unlikely to use these areas in more than a transient manner dependent on local conditions, while the Project is linear in nature and will not result in the substantial loss of wetland habitats (i.e. palustrine, lacustrine and riverine). The impacts of the Project are considered unlikely to reduce the area of occupancy of the species.
Fragment an existing population into two or more populations	Australian painted snipe occurs as a single homogenous breeding population dispersed thinly across much of Australia. As such, no resident population can be attributed to the Project disturbance footprint. The species is highly mobile and dispersive. The Project is not considered to represent a barrier to movement for the species. It is considered unlikely that the Project will fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of the species	Predictive habitat mapping indicates the Project has the potential to impact 8.9 ha of *Habitat critical to the survival of the species*, although this is likely to be a substantial overestimate. It is unknown at this stage to what extent the predicted wetland habitat within the Project disturbance footprint comprises values suitable for the presence of Australian painted snipe. The habitat identified as critical for the species is as defined under the draft *National recovery plan for the Australian painted snipe (Rostratula australis)* (DotEE 2019b) but does not reflect the likely value of the habitats within the Project disturbance footprint for the species. Pre-construction surveys will be carried out to assess whether wetland habitat values are suitable for the species, and where suitable habitat is identified whether the species actually occurs. Through Project design considerations changes to hydrological conditions in the area are expected to be minor at worst, localised and transient (during flood events) and are unlikely to impact any potential habitat for the species. Mitigation measures will be in place to ensure surface water quality associated with the Project surrounds is not impacted as a result of Project activities (e.g. erosion and sediment controls and water quality monitoring program) (refer Table 5.7). Until specific site assessments for the species are carried out it is uncertain whether the Project will adversely affect *Habitat critical to the survival of the species*.

Criterion	Assessment against significance criteria
Disrupt the breeding cycle of a population	Australian painted snipe occurs as a single homogenous breeding population dispersed thinly across much of Australia. As such, no resident population can be attributed to the Project disturbance footprint. The species is known to breed in SEQ, with breeding habitat considered to be quite specific (i.e. shallow wetlands with areas of bare wet mud and mixed heights of low vegetation) (DotEE 2019c). The species may breed at any time of year dependent on local wetland conditions. Predictive habitat mapping indicates the Project has the potential to impact 8.9 ha of *Habitat critical to the survival of the species*, although this is likely to be a substantial overestimate (i.e. mapping includes riverine wetlands and regional ecosystem wetlands, likely to be of limited value). Pre-construction surveys will be carried out to assess whether wetland habitat values are suitable for the species, and where suitable habitat is identified whether the species actually occurs. Should the species be observed as nesting measures will be in place within the Flora and Fauna Sub-plan to allow nesting to occur undisturbed (refer Table 5.7). It is possible that Australian painted snipe individuals will be disrupted during breeding, but it is considered unlikely that the Project will disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No database records of the species occur within the MNES study area. The species is widespread with an extent of occurrence estimated at 7,100,000 km^2 (Garnett et al 2011). Predictive habitat mapping indicates the Project has the potential to impact 8.9 ha of *Habitat critical to the survival of the species*, although this is likely to be a substantial overestimate. Predictive habitat mapping also identifies approximately 272 ha of additional *Habitat critical to the survival of the species* within the MNES study area. It is unknown at this stage to what extent the predicted wetland habitat within the Project disturbance footprint comprises values suitable for the presence of Australian painted snipe. Through Project design considerations changes to hydrological conditions in the area are expected to be minor at worst, localised and transient (during flood events) and are unlikely to impact potential habitat for the species. Mitigation measures will be in place to ensure surface water quality associated with the Project surrounds is not impacted as a result of Project activities (e.g. erosion and sediment controls and water quality monitoring program) (refer Table 5.7). Given the very minor extent of habitat within the Project disturbance footprint the potential impacts of the Project are considered unlikely to be of the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	Aquatic weed species have been identified as a potential threat to Australian painted snipe habitat (DotEE 2019b). Project-associated surveys did not note any aquatic weed species present within the MNES study area. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. This will include measures to ensure aquatic weeds are not introduced as a result of the Project. The Project is not expected to lead to increased abundances of introduced predator species. Nevertheless, measures will be incorporated to monitor pest species observations associated with Project activities, and pest control actions where considered necessary. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and pest proliferation and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral species (i.e. wild dogs/dingo, Red fox and pigs) are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	The draft recovery Plan for the species identifies the following recovery objectives for Australian painted snipe: ■ Manage and protect known Australian Painted Snipe breeding habitats at the landscape scale ■ Develop and apply techniques to measure changes in population trajectory in order to measure the success of recovery actions ■ Reduce, or eliminate threats at breeding and non-breeding habitats ■ Improve knowledge of the habitat requirements, biology and behaviour of Australian Painted Snipe

Criterion	Assessment against significance criteria
	■ Engage community stakeholders to improve awareness of the conservation of Australian Painted Snipe ■ Coordinate, review and report on recovery process (DotEE 2019b). At this stage it is uncertain the Project disturbance footprint comprises habitat likely to support breeding. The Project is considered unlikely to interfere with any of the recovery actions listed above to the extent it will interfere with the recovery of the species. Should Australian painted snipe be identified during Project activities this will contribute to current information on the species in the SEQ region. Weed and pest mitigation measures applied within the Biosecurity Management Plan will contribute to eliminating threats to the species across the wider area.
Assessment of potential for significant residual impacts	Although it remains uncertain there is some potential for the Project to have a significant impact on Australian painted snipe through impacts to wetland habitat considered *Habitat critical to the survival of the species*. Extended dry conditions in the Project disturbance footprint during construction may minimise any direct impacts on the species, while risks of impacts may be increased where optimal conditions are present, including potential impacts to breeding habitat.

Spotted-tail quoll (mainland) (*Dasyurus maculatus maculatus*) – endangered

Ecology and distribution

Spotted-tail quolls have been recorded from a wide range of habitats, including temperate and subtropical rainforests in mountain areas, wet schlerophyll forest, lowland forests, open and closed eucalypt woodlands, inland riparian and River red gum (*Eucalyptus camaldulensis*) forests, dry 'rainshadow' woodland, sub-alpine woodlands, coastal heathlands and occasionally in open country/other treeless areas. Habitat requirements include suitable den sites such as hollow logs, tree hollows, rock outcrops or caves (DAWE 2020). The species requires large home ranges of several hundred hectares (Australian Government Department of Environment, Land, Water and Planning (DELWP) 2016).

In QLD, the Spotted-tail quoll occurs in the southeast, coastally from Bundaberg to the NSW border, and inland to Monto and Stanthorpe. Spotted-tail quolls are known from five broad geographic regions: four from coastal ranges and the Great Dividing Range from the NSW border to Gladstone. The fifth is centred on the eastern Darling Downs-Inglewood Sandstone provinces of the Brigalow Belt South Bioregion. Unconfirmed reports suggest the subspecies may also occur in the Clarke and Conway Range areas, along the central QLD coast.

Distribution in context to the Project

There are a number of older database records that occur from Crows Nest to Clifton to the north and south of the MNES study area. The nearest record is from 1979 to the south of Toowoomba located approximately 16 km south of the Project disturbance footprint. To the north the nearest record is from 1966 and located west of Ravensbourne National Park (20 km from the Project). The nearest post 1990 record within 50 km of the Project disturbance footprint is from 1991 and located approximately 14 km southwest of the Project disturbance footprint in the Biddeston area (west of Toowoomba). Further records from 1993 occur to the south in the Day Range area (over 30 km south of the Project) (refer Figure 4.20 in Appendix B). The nearest recent record (2011) is from the Lake Wivenhoe area over 50 km northeast of the Project.

Habitat assessments carried out for the EIS studies identified very little suitable rocky denning habitat within the MNES study area and none within the Project alignment itself (refer habitat assessment sheets in Appendix H). The most likely habitat for the species is where the Project intersects habitat within the Toowoomba Range and to a lesser extent the southern portion of Helidon Hills given the extensive habitat remaining in these areas. Suitable denning habitat (extensive rocky areas) for the species was not observed in this area during Project surveys.

Recovery plan/threat abatement plans

The *National recovery plan for the Spotted-tail quoll (Dasyurus maculatus*) (DELWP 2016) identifies the following threatening processes as applicable to the species:

- Habitat loss and fragmentation
- Targeted killing and poison baiting (directed at introduced predators)
- Ingestion of Cane toads (*Rhinella marina*)
- Invasive predators (red fox, cats and wild dogs)
- Road mortality
- Climate change and increased fire frequency/intensity

The following threat abatement plans have been identified as being relevant to this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d)
- *Threat abatement plan for predation by the European red fox* (DEWHA 2008m)

Important populations and habitat critical to the survival of the species

The overall Australian population (including all subspecies) is not reliably known but is estimated to be 20,000 mature individuals (Woinarski et al 2014). Important populations in southern QLD include the Granite belt region around Stanthorpe, the Cherrabah area, the ranges extending from Main Range to Lamington National Parks, the Burnett Range and the Dalby region (DELWP 2016). Main Range is the nearest of these areas and located over 35 km southeast from the MNES study area.

The recovery plan describes *habitat critical to the survival* of Spotted-tail quoll as 'large patches of forest with adequate denning resources and relatively high densities of medium-sized mammalian prey' (DELWP 2016). The recovery plan also notes given the difficulty defining the threshold habitat requirements of these resources it currently impossible to map *Habitat critical to the survival of the species*. This assessment has taken a conservative approach and included all areas of '*potential habitat*' that intersect with remnant vegetation that are greater than 200 ha in size (given the species extensive home range) as *Habitat critical to the survival of the species* (refer Table 5.2 in Appendix A for further information).

Impacts and mitigation measures associated with this species are identified within Table 5.7. Habitat within Toowoomba Range extending north and south of the Project disturbance footprint comprises an extensive tract of relatively contiguous habitat which may support the species. The Project is predicted to impact 129.53 ha of *potential habitat* and 24.46 ha of *Habitat critical to the survival of the species* under the approach used for this assessment (refer Table 5.4 and habitat figure in Appendix G). This assessment has taken a conservative approach and the identified habitat is likely to comprise foraging habitat rather than denning/breeding sites. The following significant impact assessment (refer Table 5.28) under the MNES guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.28 Assessment against the significant impact criteria - Spotted-tail quoll

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population of a species	It is uncertain if the species occurs. There are no records of this species within or close to the MNES study area. The nearest record from the 1990s is located 14 km south of the Project. The nearest recent record (2011) is located over 50 km from the Project. Nevertheless, predictive habitat modelling indicated that the Project may impact 153.99 ha of suitable habitat (129.53 ha of *potential habitat* and 24.46 ha of *Habitat critical to the survival of the species*) for the species. This habitat is largely associated with the Toowoomba Range and the southern edge of Helidon Hills. Preferred rocky shelter sites for the species have generally been avoided and were not observed within the Project disturbance footprint during site surveys. It is noted the area to the south of the Lockyer Forest Reserves is subject to substantial existing disturbance where the Project disturbance footprint occurs (the existing QR West Moreton System rail corridor).

Criterion	Assessment against significance criteria
	Where the alignment intersects steeper habitat within the Toowoomba Range the Project includes the tunnel and several viaducts (such as Oaky Creek) (refer Section 5.2.1) encompassing habitat modelled as *Habitat critical to the survival of the species* (refer species habitat figure in Appendix G). This will maintain connectivity along the vegetated habitat within the range. These measures will also help to avoid or at the very least significantly reduce the risk of vehicle strikes during operations. This species is susceptible to road mortality due to scavenging for carrion with juvenile males most likely at risk due to extensive ranging behaviour. The Project will result in increased traffic through adjacent potential habitat for this species during construction increasing the risk of vehicle strikes. Similarly, the operating rail line may also pose a threat once operational. Fauna fencing will be used to aid in excluding the species from the alignment. As such, this impact is unlikely to lead to the long-term decline of the species. The Project may also result in changes to prey interactions, including competition from feral animals such as the Red fox, Wild dogs and feral cats. Under the Flora and Fauna Sub-plan targeted pre-construction surveys will be carried out if suitable denning habitat for this species is identified within or adjacent to the final construction footprint to identify whether the species actually occurs or not (refer Table 5.7). Should the species be found individuals are expected to be moved away from the area of disturbance prior to construction activities. The species requires large home ranges. The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint. The Project is considered unlikely to lead to a long-term decrease in an important population.
Reduce the area of occupancy for a population	The estimated extent of occurrence is estimated at 575,991 km^2 and the area of occupancy at 10,388 km^2 (although this is considered to be a significant underestimate) (Woinarski et al 2014). There are no records of this species within or close to the MNES study area. The nearest record from the 1990s is located 14 km south of the Project. Predictive habitat modelling indicated that the project may impact 153.99 ha of habitat considered suitable for the species. Preferred rocky shelter sites for the species have been avoided. Nevertheless, should the species occur in the area the Project has potential to reduce the occupancy of a population across the local region although to no more than a minor extent.
Fragment an existing population into two or more populations	This species has large home ranges with the female home ranges (88–1515 ha) generally non-overlapping, while male home ranges are much larger, from 359–5512 ha in size, and overlap and encompass multiple female home ranges (DEWLP 2016). There are no records of this species within or close to the MNES study area. Predictive habitat modelling indicated that the project may impact 153.99 ha of habitat considered suitable for the species. The Project is linear but impacts areas which are already subject to extensive fragmentation. The eastern section of the alignment is located adjacent to the existing QR West Moreton System rail corridor. West of this area the alignment is located in close vicinity to the Toowoomba Bypass and passes through heavily disturbed agricultural lands. Where it crosses the Toowoomba Range the Project design incorporates the tunnel and several viaduct structures allowing connectivity across the alignment where habitat is mapped for the species. The Project is considered unlikely to fragment an existing important population.
Adversely affect habitat critical to the survival of the species	There are no records of this species within or close to the MNES study area. Predictive mapping indicates 24.46 ha of habitat considered as *Habitat critical to the survival of the species* (for the purposes of this assessment) occurs within the Project disturbance area as well as a further 129.53 ha of *potential habitat*. The Project disturbance footprint largely intersects already disturbed (cleared) habitat through much of the alignment. Nevertheless, the Project has a minor potential to adversely affect habitat critical to the survival of the species, should the species be found to occur.
Disrupt the breeding cycle of a population	There are no records of this species within or close to the MNES study area. Predictive habitat modelling indicated the project may impact 153.99 ha of suitable habitat including 24.46 ha of *Habitat critical to the survival of the species*. Where the alignment intersects the Toowoomba Range preferred rocky shelter sites potentially used for denning/breeding for the species have been avoided and were not observed during Project surveys. The Project will result in the removal and potential relocation of hollow logs and hollow bearing trees into adjacent landscapes. The disturbance of these features during the breeding season (i.e. the winter months (June to August)) may have some potential to result in the death of individuals. Connectivity will be maintained via the tunnel area and several viaducts through the Toowoomba Range (construction and operations) allowing (if the species is present) roaming males the potential to mate with multiple females during the breeding season.

Criterion	Assessment against significance criteria
	Pre-clearance surveys will be carried out if suitable den habitat for this species is identified within or adjacent to the construction footprint. The species breeds in the winter months (June to August). Where possible the Project will avoid clearing/construction activities in sensitive habitat (should such habitat be identified) during the breeding season. The Project has the potential to disrupt the breeding cycle of an important population when clearing in winter months.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The subspecies occurs from central coastal QLD, south to south-west Victoria. It's uncertain whether the species occurs within or close to the Project disturbance footprint. The Project is predicted to impact 153.99 ha of habitat considered as suitable for the species including 8.54 ha of *Habitat critical to the survival of the species*. The predictive mapping also identified an additional area of approximately 464.14 ha of *habitat critical for the survival of the species*, along with approximately 1,662.16 ha of *potential habitat* within the MNES study area. As outlined in Section 5.1.2, the Project may impact the quality of habitat available as a result of edge effects; displacement and mortality of fauna, habitat fragmentation and barrier effects. The disturbance footprint intersects *Habitat considered critical for the species* within the Toowoomba Range. However, the tunnel minimises some aboveground habitat disturbance in this area and viaducts incorporated into the Project design allow connectivity across the alignment in this area. It is anticipated that the tunnel construction and operational activities will not impact quoll use of this area (e.g. foraging and movement corridor). These changes may influence predator-prey interactions with many of the prey species hollow-dependent and the loss of these resources as a result of the Project impacting their abundance and distribution. However, where possible microhabitat features such as hollow logs, hollow bearing trees and rocky outcrops will be relocated into adjacent habitats. Given the extent of occurrence of Spotted-tail quoll the Project is considered unlikely to decrease the availability of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to an endangered species becoming established in the endangered species' habitat	Relevant threat abatement/recovery plans for Spotted-tail quoll include management measures to address the impact of feral cats and Red fox. Feral cat was not identified as present during Project-associated surveys, but is likely present. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The Plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral predators (i.e. wild dogs/dingo and cat) are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	Recovery strategies listed in the *National Recovery Plan for the Spotted-tailed quoll Dasyurus maculata* (DELWP 2016) include: ■ Determine population trends for the species including distribution and abundance ■ Investigate key aspects of the species biology/ecology to improve management ■ Reduce the rate of habitat loss and fragmentation ■ Determine and manage threats from introduced predators and uncontrolled fires ■ Assess and minimise sources of mortality including road deaths, deliberate killings and the threat of cane toads. If the species does occur on and around the Project disturbance footprint there is some potential for the Project to interfere with the recovery objectives outlined in the Plan through potential habitat loss. The MNES study area is already subject to high levels of fragmentation. The Biosecurity Management Plan will control introduced predators associated with Project infrastructure. Nevertheless, any impact on the species will be minor, and is considered unlikely to interfere with the recovery of the species.

Criterion	Assessment against significance criteria
Assessment of potential for significant residual impacts	The Project will result in the clearance of 153.99 ha of suitable habitat predicted to occur in the footprint including 24.46 ha of *Habitat critical to the survival of the species* that potentially supports a population. In addition to the loss of habitat there is the potential to disrupt breeding during the winter months. Although it remains uncertain if the species occurs the assessment has been carried out in a conservative manner and the Project has the potential to have significant residual impacts on Spotted-tail quoll.

Condamine earless dragon (*Tympanocryptis condaminensis*) - Endangered

Ecology and distribution

The Condamine earless dragon (*Tympanocryptis condaminensis*) is a small, plump, spiny earless dragon lizard that grows to an average size of 12 cm. This species has only recently been taxonomically split from the Grassland earless dragon (*Tympanocryptis pinguicolla*). This dragon species appears to survive in areas that are intensely cropped and previously occupied as naturally treeless grassland. The dragon uses surface debris, including train ballast, surface rocks and rocky outcrops as shelter, while cracks in the black clays of the Condamine River floodplain provide holes to seek alternate shelter when disturbed. Knowledge of the diet is still limited; however it is thought the species feeds on small invertebrates with anecdotal evidence suggesting ants are a popular source of food (DES 2017b).

Limited information is also known about the reproductive behaviour and biology of the Condamine earless dragon, but it has been observed males will take on their breeding colours, which are canary yellow at the throat and chin, during December and a gravid female was recorded in November (Melville et al. 2007).

The known distribution of the Condamine earless dragon is within the eastern Darling Downs region in SEQ. Condamine earless dragons are often found in the Condamine River floodplains surrounded by Jimbour in the northeast, Millmerran in the southwest, Clifton in the southeast and Toowoomba in the northeast with records from Oakey, Bongeen, Bowenville, Brookstead and Mt Tyson (TSSC 2016b).

Distribution in context to the Project

The species was not identified during any Project-associated surveys. There is a database record for Condamine earless dragon approximately 2 km south of the Project disturbance footprint in north Toowoomba from 2013. However, the location of this record is erroneous, and it should be located in the Bongeen area (pers. comm. R. Hobson) over 35 km west of the Project. The nearest record is from 2008 and is located west of Oakey and approximately 23 km to the northwest of the Project disturbance footprint. Most records are concentrated on the Condamine River floodplain west of Toowoomba between 25 and 50 km southwest of the Project disturbance footprint between Jondaryan in the north and south to Pittsworth (refer Figure 3.4 in Appendix B). The species is not confirmed to occur within the Toowoomba area.

Recovery plans/threat abatement plans

The *National recovery plan for the Grassland earless dragon Tympanocryptis pinguicolla* (Robertson and Evans 2009) is the adopted plan as it comprised populations of the Condamine earless dragon at the time of writing. The plan identifies the following threatening processes as applicable to the species:

- Further habitat loss and fragmentation from urban and agricultural development
- Degradation of habitat by introduced livestock and agricultural practices (such as ploughing)
- Predation by introduced species including red fox (*Vulpes vulpes*)
- Inappropriate fire regimes
- Climate change and increased fire frequency/intensity

The following threat abatement plans have been identified as being relevant to this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d).

Important populations and habitat critical to the survival of the species

The *National recovery plan for the Grassland earless dragon Tympanocryptis pinguicolla* (Robertson and Evans 2009) observes that given the extent of decline of the species habitat all extant populations are considered extremely important and any habitat in which the species is known to occur may be considered critical to the survival of the species.

As such, this assessment has defined *Habitat critical to the survival of the species* by applying a 1 km buffer on known records that intersect '*potential habitat*' for the species (refer Appendix A for methodology). The Project is predicted to impact 16.22 ha of *potential habitat* for the species (refer Table 5.4 and habitat figure in Appendix G) in the western portion of the Project disturbance footprint. The predictive habitat mapping has taken a conservative approach and includes pre-clearance mapping of suitable REs in which the species is thought to occur. This is not likely to reflect the actual occurrence of the species within the Project disturbance footprint. Impacts and mitigation measures associated with this species are identified within Table 5.7. The following significant impact assessment (refer Table 5.29) under the MNES Guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.29 Assessment against the significant impact criteria – Condamine earless dragon

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of a population	The species is not known to occur in the Toowoomba area. All records are located west and southwest of the Project with the nearest being 23 km west near Oakey. Nevertheless, there is suitable cracking clay soil habitat in the western portion of the Project disturbance footprint. The Project is predicted to impact 16.22 ha of *potential habitat* for the species. Most potential habitat for the species is located above the proposed tunnel and will not be impacted (refer habitat figure in Appendix G). The species is found in a relatively restricted area and may occur in heavily modified habitats such as croplands. The species is cryptic, and it is uncertain if it may occur within the Project area. It is unknown if the species occurs as sub-populations or as a continuous single population (TSSC 2016b). Pre-construction surveys will be carried out where suitable habitat for this species is identified (refer habitat figure in Appendix G) within the final construction footprint to identify if the species actually occurs as part of the Flora and Fauna Sub-plan. Survey methods will follow the relevant Commonwealth survey guidelines (detailed within Appendix 2 of the Recovery plan for the species). Should the species be found individuals will be relocated from the area of disturbance prior to construction/disturbance activities (refer Table 5.7). The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint. The Project is considered unlikely to lead to a long-term decrease in an important population (or analogous important habitat).
Reduce the area of occupancy of the species	The species is not known to occur in the Toowoomba area. All records are located west and southwest of the Project with the nearest being 23 km west near Oakey. The Project is predicted to impact 16.22 ha of *potential habitat* for the species. The species has a restricted range. The Project has a very minor potential to reduce the occupancy of the population, should the species be found to occur within the Project disturbance footprint.
Fragment an existing population into two or more populations	The species is not known to occur in the Toowoomba area. All records are located west and southwest of the Project with the nearest being 23 km west near Oakey. The species is found in a relatively restricted area and it is unknown if the species occurs as sub-populations or as a continuous single population (TSSC 2016b). The Project is linear and intersects suitable habitat for the species. Although most potential habitat for the species is located above the proposed tunnel and will not be impacted. Nevertheless, aboveground infrastructure in the western portion of the alignment is located adjacent to the existing QR West Moreton System rail corridor. The Project is considered unlikely to fragment an existing population.

Criterion	Assessment against significance criteria
Adversely affect habitat critical to the survival of the species	The species is not known to occur in the Toowoomba area. All records are located west and southwest of the Project with the nearest being 23 km west near Oakey. The *National recovery plan for the Grassland earless dragon Tympanocryptis pinguicolla* (Robertson and Evans 2009), which is relevant to the Condamine earless dragon observes any habitat in which the species is known to occur may be considered *habitat critical to the survival of the species.* The Project is not predicted to impact habitat in which the species is known to occur. As such, the Project will not adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population	The species is not known to occur in the Toowoomba area. The Project is predicted to impact 16.22 ha of *potential habitat* for the species, although it is uncertain if the species occurs in the area at all. Most potential habitat for the species is located above the proposed tunnel and will not be impacted. Information regarding the species breeding biology is scant. Breeding behaviour has been observed in November/December (TSSC 2016b). Nevertheless, the Project is considered unlikely to disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The species has a restricted range occurring from Milmerran and Clifton north to Toowoomba and Jimbour. The Project is predicted to impact 16.22 ha of *potential habitat* for the species. The Project impact footprint is linear and relatively narrow and located adjacent to existing rail infrastructure. As such, the Project is considered unlikely to decrease the availability of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	The relevant threat abatement and recovery plans for Condamine earless dragon include management measures to address the impact of feral cats and red fox. Neither of these species have been observed in the area but are likely present. Weeds are not identified as a threat to the species. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral predators (i.e. red fox and cat) are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	The *National recovery plan for the Grassland earless dragon Tympanocryptis pinguicolla* (Robertson and Evans 2009), which is relevant to this species includes the following recovery actions: ■ Determine the current distribution and abundance of the species, and potential available habitat ■ Determine key biological data and life history characteristics of the species ■ Determine the effects of land management activities on the species (such as fire and grazing) ■ Identify threats to the species ■ Secure the species in conservation reserves and establish management agreements with landholders where the species occurs on private lands. There is no reason the Project will substantially interfere with the management actions outlined above. The Project may increase the knowledge of the species distribution in the region.
Assessment of potential for significant residual impacts	The Project may result in the clearance of up to 16.22 ha of *potential habitat* for Condamine earless dragon, although it is uncertain if the species occurs in the area. Nevertheless, the assessment has taken a conservative approach and under the nine-part test detailed above, there is a minor potential for a 'significant residual impact' on Condamine earless dragon through a reduction in the occupancy, should the species actually be found to occur.

5.3.5.2 Vulnerable fauna species populations

The assessments commence with an evaluation of the likely importance of the population of vulnerable flora species associated with the MNES study area. Under the MNES Guidelines vulnerable species are considered as subject to significant impacts when an 'important population' is impacted. Therefore, those species that are not considered to have an important population present are not considered further in the assessment.

An 'important population' as defined within the MNES Guideline significant impact criteria for vulnerable species is as follows:

'*An important population is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:*

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

Given the specificity of the above definition and the scarcity of information and records available for most listed species and populations in the region (and Australia), it is difficult to determine:

- Attributes such as breeding and dispersal behaviour and whether the population is a 'key source'
- The genetic diversity of individuals inhabiting a population or sub-population.

Given the paucity of information available, significance of impacts to threatened species has been based on professional experience of the assessment team and the latest available information relating to habitat and ecological requirements and distribution. This information is compiled in Appendix B for all the species assessed including mapping of database records associated with the wider Project area.

Table 5.30 provides an evaluation of the populations and potential Habitat critical to the survival of the species for vulnerable fauna species associated with the MNES study area. Note that species for which no habitat has been predicted to occur within the MNES study area (Dunmall's snake (*Furina dunmalli*)) (refer Table 5.4) are not considered as potentially present and are not assessed in the following sections.

Table 5.30 Assessment of status of vulnerable fauna species population against Guideline criteria

Species name	Common name	Project area population evaluation
Anomalopus mackayi	Five-clawed worm-skink	There is an older database record (1983) within the Project disturbance footprint near Gowrie Junction. The nearest records to this are at Oakey (1983) located 13.5 km west, and three records near Pittsworth (2002 and 2009) located 28 km southwest of the Project disturbance footprint (AoLA 2020). There are a number of records within 50 km to the west of the MNES study area on the Condamine River floodplain in the Cecil Plains area, and from Oakey to Dalby (refer Figure 3.8 in Appendix B). No recovery plan exists for this species. A review of the available literature has not revealed any important populations or Habitat critical to the survival of the species when referring to DAWE's SPRAT database (2020). The *Draft referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) identifies 'important habitat' as a surrogate for important populations given the difficulty of detecting many of the species. As per species-specific mapping within the guidelines for the nationally listed Brigalow Belt reptiles, the western section of the Project disturbance footprint (near Toowoomba) is located within habitat considered 'known/likely to occur' for the species and is therefore considered 'important habitat'. Nevertheless, the species occurs in grassy woodlands and grasslands on dark cracking clay soils and its presence appears heavily affected by livestock grazing impacts to micro-habitat structure (soil compaction and loss of cover). Available habitat within the Project disturbance footprint is heavily degraded by current land use. As such, predictive habitat mapping (refer Appendix A for methodology) has identified no suitable habitat for the species or *Habitat critical to the survival of the species* within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G) As such the Project is considered unlikely to significantly impact this species and it is not considered further.

Species name	Common name	Project area population evaluation
Delma torquata	Collared delma	Collared delma has been recorded during Project-associated surveys (refer Figure 4.5). The species is also known to occur nearby in the Toowoomba Range as derived from early surveys in 2006 (Peck and Hobson 2007) and more recent studies associated with the TSRC project. There are further records to the east in the Lockyer Reserves, the closest of which is from 1995 and 10 km east of the eastern extent of the Project. There is no recovery plan for this species. Given the difficulty in detecting this species the *Draft referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) considers the presence of suitable habitat for this species as important habitat and as a surrogate for an important population of the species. The Project is located within the southern edge of species-specific habitat mapped as 'known/likely to occur' and therefore is considered as 'important habitat'. The Project is predicted to impact 197.41 ha of suitable habitat for this species (refer Table 5.4). Therefore, important habitat for this species may be impacted and result in a significant impact to the species. As such the Project has the potential to significantly impact this species and is assessed as per the Guidelines in Table 5.31.
Erythrotriorchis radiatus	Red goshawk	The nearest reliable database record is from 2012 approximately 15 km south of the Project disturbance footprint to the east of Barry Griffin Park east of Toowoomba. Further records of varying age occur between Toowoomba Range and the Lockyer Reserves. It is noted available records have all been generalised in order to protect the species (AoLA 2020). The Project disturbance footprint is located near the southern limit of the species current range. The species may be extinct in northern NSW. The *National recovery plan for the red goshawk Eryhtrotriorchis radiatus* (Department of Environment and Resource Management (DERM) 2012) does not identify important populations. Specific important populations have not been identified for this species due to the sparse distribution of the species. *Habitat critical to the survival of the species* is considered those areas which supports nesting and associated habitat factors to support nesting. (Nests (i.e. exposed fork in the upper quarter of a tree between 10 to 20 m above ground and used each year) are usually located on an emergent tree within 1 km of permanent water. Delineating an important population for this species is complicated by the ecology of the species. The species occupies large home ranges estimated to be up to 120 km^2 (females) and 200 km^2 (males). Preferred habitat requirements are extensive tracts or remnant woodlands/forests on fertile soils with a mosaic of vegetation types, access to permanent water, and large populations of birds (DERM 2012). It is estimated that in SEQ only 10-30 pairs of the species remain (DAWE 2020). The Project is predicted to impact 71.83 ha of *Habitat critical to the survival of the species* and 3.98 ha of *potential habitat* for the species (refer Table 5.4). Given the species occurs at the southern limit of its distribution in relation to the Project the nearby records could be considered a significant population. Therefore, further consideration as to whether there will be a significant impact on this species is assessed in Table 5.32.
Falco hypoleucos	Grey falcon	The species consists of a single population. The total population size is now generally accepted to be <1,000 mature individuals (DAWE 2020). This species has not been identified during Project surveys. There is a single database record within the western extent of the Project footprint (refer Figure 4.3). There is another record of this species within the Toowoomba Range (dated 2013) approximately 8.5 km south of the Project disturbance footprint. A third record dated 1983 occurs approximately 20 km north of the eastern extent of the Project disturbance footprint (within the Lockyer Reserves area) (AoLA 2020). This species was also identified during Project surveys for the H2C project in the Gatton area. This reflects that fact that this species mainly occurs in arid and semi-arid zones of Australia (i.e. The arid zone is defined as areas which receive an average rainfall of 250mm or less. The semi-arid zone is defined as areas which receive an average rainfall between 250-350mm). It is noted average annual rainfall in the Toowoomba area in which the Project footprint occurs is 952.4 mm (BoM 2020) which is outside the generally accepted range of the species as identified above.

Species name	Common name	Project area population evaluation
		Younger individuals may disperse outside of this habitat in drought years that follow wet years in inland Australia. The species preferred habitat includes sparsely timbered lowland plains, particularly acacia shrublands that are crossed by tree-lined water courses. The species has been observed hunting in treeless areas and frequents tussock grassland and open woodland, especially in winter (TSSC 2020). Given the sparse distribution of the overall population, specific important populations and *Habitat critical to the species survival* have not been identified in the approved conservation advice for the species (TSSC 2020). *Habitat critical to the species survival* may be considered those areas which supports nesting and associated habitat factors to support nesting (The nests chosen are usually in the tallest trees along watercourses, particularly River red gum (*Eucalyptus camaldulensis*) and Coolibah (*E. coolabah*), but the species also nest in telecommunication towers). The species does not nest in the region. As such, this assessment has defined Habitat critical to the survival of the species by applying a 1 km buffer on known records that intersect 'potential habitat' for the species (refer Appendix A for methodology). The Project is predicted to impact 211.69 ha of *potential habitat* and with 66.13 ha of this constituting *Habitat critical to the survival of the species* (as defined for this assessment – refer Appendix A for methodology) in which this species is predicted to occur (refer Table 4.4 and habitat figure in Appendix F). This is very likely to be a substantial over-estimate of suitable habitat for the species as it encompasses woodlands within the Toowoomba Range which are unlikely to support the species which prefers open habitats. It is acknowledged *Habitat critical to the survival of the species* is identified within the MNES study area, although the species is only likely to occur in the area very occasionally during dispersal events. Nevertheless, further consideration as to whether there will be a significant impact on this species is assessed in Table 5.33.
Grantiella picta	Painted honeyeater	There are several database records close to the MNES study area including a 2006 record at Gowrie (1 km north of the Project disturbance footprint), a 2013 record from Toowoomba (6 km south of the Project), and several 2019 records from the Highfields area (4.5 km north of the Project) which are very likely to be of the same bird (AoLA 2020). The majority of other records for this species occur substantially west of the Project (refer Figure 5.19 in Appendix B). The Project disturbance footprint is not located near the limit of the species' range (AoLA 2020). The species population is sparsely dispersed across south-east Australia to northwest QLD and eastern Northern Territory. While vagrant individuals occur in the Toowoomba area and further east, the species distribution occurs on and west of the inland slopes of the Great Dividing Range (Higgins et al. 2001). Rowland (2012) notes non-breeding individuals are recorded occasionally from coastal areas along the eastern seaboard. There is no Commonwealth adopted recovery plan for this species. A review of the available literature including the approved conservation advice for the species has not revealed any important populations or Habitat critical to the survival of the species (DotE 2015f). The species is considered to occur as a single wide-ranging population (Garnett et al 2011). As such no important populations have been identified that are key to the long-term survival and recovery of this species. The approved conservation advice for the species (DotE 2015f) notes the greatest concentrations of individuals and almost all breeding records are located on the inland slopes of the Great Dividing Range. The Project largely encompasses the coastal slope of the range and habitat in the western portion of the MNES study area has been heavily impacted by agriculture and grazing land use. In the absence of a definition for Habitat critical to the survival of the species this assessment has applied a 1 km buffer on known records that intersect 'potential habitat' (refer Appendix A for methodology). As such, there is no Habitat critical to the survival of the species identified within or close to the Project disturbance footprint. Predictive habitat mapping indicates that the Project has the potential to impact 8.54 ha of potential habitat (refer Appendix A for methodology) in which this species may occur (refer Table 5.4 and habitat figure in Appendix G). There is widespread identical habitat surrounding the Project disturbance footprint that will remain unimpacted.

Species name	Common name	Project area population evaluation
		The Project disturbance footprint is located on the eastern edge of the species normal distribution. There are no identified important populations and there is no habitat critical to the species survival associated with the Project. While the Project may remove a minor area of potential foraging habitat for the species it is inconceivable this will be to the extent it will adversely impact the species or affect the species recovery. Therefore, the Project is unlikely to significantly impact this species and it is not considered further.
Maccullochella peelii	Murray cod	The nearest database record is from 2014 in a parkland area in Toowoomba which is very likely to be the result of artificial introduction. As such it has been disregarded. The nearest downstream record (2008) is from Oakey Creek near Jondaryan (30 km northwest of the Project). There is a 2009 record further downstream from the Bowenville area (45 km northwest). There are scattered records further downstream of the confluence of the Condamine River and Oakey Creek at Dalby and Chinchilla. Oakey Freshwater Fish Restocking Association has been actively involved in restocking Gowrie Creek downstream of the Project, including cod. Stocking of fish into impoundments and dams may have been undertaken by local landholders within the ecology study area. Stocking of species outside of their natural range/drainage system (e.g. cod) may have historically occurred and may account for any records of such species within the local area. The Draft referral guidelines for the vulnerable Murray cod (*Maccullochella peelii*) (DotE 2016b) identifies important populations for Murray cod in QLD. These include the Condamine River upstream of Warwick. Gowrie Creek or downstream habitat on Oakey Creek is not identified. The guidelines describe Habitat critical to the survival of the species as 'any section of a waterway that comprises a connected system of habitats suitable for sustained use by a Murray cod population for sheltering, foraging, breeding and upstream and downstream movement'. The western portion of the Project occurs within the upper reach of the catchment of the species potential range and there is no evidence the species (or a population) occurs in the waterway adjacent to and intersected by the Project (Gowrie Creek). Nevertheless the predictive habitat modelling has taken a conservative approach has assumed the species is potentially present. As such, the Project is predicted to impact 3.21 ha of *Habitat critical to the survival of the species* in which this species may occur (refer Table 5.4 and habitat figure in Appendix G). Therefore, further consideration as to whether there will be a significant impact on this species is assessed in Table 5.34.
Petauroides volans volans	Southern greater glider	The species has not been recorded during Project-associated surveys (including feeder trees) or surveys for the adjacent Inland Rai projects or the TSRC project. There are no database records (AoLA) within the MNES study area. The nearest records are from 2010 and 2016 and located north of Toowoomba (5 km and 10 km north of the Project) (refer Figure 4.4 in Appendix B). There are several records (all from the 1990s) located in the Lockyer Forest Reserves (all between 7.5 km and 19 km northeast of the Project). There are no records to the south of the Project in the Toowoomba Range. The species occurs from south-east Australia to central and north-east QLD. The northern subspecies (*Petauroides volans minor*) occurs on the Atherton Tablelands. The Project disturbance footprint is not located near the limit of the species range. No recovery plan exists for this species. A review of the available literature including the approved conservation advice for the species (TSSC 2016c) has not identified any important populations. No populations have been identified that are key to the long-term survival and recovery of this species. There is no *Habitat critical to the survival of the species* defined for the species in approved conservation advice for the species (TSSC 2016c). In the absence of a definition for *Habitat critical to the survival of the species* this assessment has applied a 1 km buffer on known records that intersect '*potential habitat*' (refer Appendix A for methodology). The predictive habitat mapping indicates there is 109.04 ha of *potential habitat* within the Project disturbance footprint for the species (refer Table 5.4 and habitat figure in Appendix G). The habitat modelling has been carried out in a conservative manner and includes mapped high-value regrowth communities which are much less likely to support the species as suitable large hollows are much less likely to be present. As such, the predicted habitat is likely to be a substantial overestimate.

Species name	Common name	Project area population evaluation
		No important populations or *Habitat critical to the survival of the species* have been identified for this species in relation to the Project. The Project may impact 109.04 ha of *potential habitat* for the species. The assessment has taken a conservative approach for this species and it is considered further in the following section (refer Table 5.35).
Petrogale penicillata	Brush-tailed rock-wallaby	The species has not been recorded during Project-associated surveys or surveys for the TSRC project. Database records (AoLA 2020) indicate this species has been recorded from the Toowoomba Range 2 km north of the alignment (two records from 1978). To the east of the alignment there is a record north of Helidon from 1996 (3 km east). There is a 1997 and 2004 record located in Helidon Hills to the northeast of the eastern extent of the alignment (6 km and 12 km northeast). Other database records exist to the north of the eastern end of the alignment in or near Ravensbourne National Park and Crows Nest National Park (over 14 km north of the Project). To the west there is a single 2018 record from Gowrie Mountain (2.7 km south of the western extent of the Project) although the source of this record cannot be verified. There are no records in the Toowoomba Range to the south of the Project (refer Figure 4.2 in Appendix B). The *National Recovery Plan for the Brush-tailed Rock-wallaby Petrogale penicillata* (Menkhorst and Hynes 2010) identifies important populations in Victoria and NSW and outlines important populations as being at the limit of the species' range, outlying populations, stronghold populations, research populations and other where recovery actions are being implemented. *Habitat critical to the survival of the species* is not described. Whilst the Project area is not located at the limit of the species range it may be adjacent to a stronghold population that occurs in the Helidon Hills. Although the Project is linear it passes through habitat already intersected by the existing Toowoomba Bypass and as such is not considered likely to present a barrier to dispersal that doesn't already exist in the area. It is also noted that here will be multiple opportunities for fauna passage via viaducts, and Bridges which is likely to mitigate against impacts to movement There is no recent evidence of the species occurring in the area. Predictive mapping (refer Appendix A for methodology) indicates there may be 10.75 ha of *potential habitat* for this species in the wider MNES study area, however no potential habitat is located within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). Therefore, the Project is unlikely to significantly impact this species or Habitat critical to the survival of the species and it is not considered further.
Phascolarctos cinereus	Koala combined populations of QLD, NSW and the ACT)	Koala individuals and signs of presence (scats/scratches) have been detected during site surveys for the Project (refer Figure 4.6). Database records indicate this species occurs from 2019 within the MNES study area. There are a number of recent records of the species in the Toowoomba Range including within the Project disturbance footprint (refer Figure 4.3). Many records exist in all directions around the Project disturbance footprint within a 50 km buffer (AoLA 2020). Habitat critical to the survival of the species for Koala is used as a 'surrogate' for important populations as per the *EPBC Act referral guideline for the vulnerable Koala* (DoE 2014). The Project disturbance footprint is considered as habitat critical to the survival of the species under the guidelines. Noting that this includes areas that have been extensively cleared where the species is unlikely to occur (clearing greater than 2 km). An assessment has been carried out based on the available habitat within the MNES study area. Based on this assessment there is *Habitat critical to the survival of the species* within the Project disturbance footprint. The potential for significant impacts is assessed further in Table 5.37.
Potorous tridactylus tridactylus	Long-nosed potoroo (SE mainland)	There are five database records occurring within 50 km of the Project, although none of these occurs within the MNES study area. The nearest database record is from 2015 and located 13 km south of the Project in the Toowoomba Range. Other database records occur to the north and northeast including Crows Nest National Park (2012 – 20km north), Lockyer National Park (1990), Ravensbourne National Park (four records from 1977 to 1986 – 19 km north) and Deongwar State Forest (2014 – 24 km north). There is also a 1991 record from Lockyer National Park (19 km northeast).

Species name	Common name	Project area population evaluation
		No recovery plan exists for this species. A review of the available literature has not revealed any important populations when referring to DAWE's SPRAT database (2020). The available literature does not reveal any populations that are key to the long-term survival and recovery of this species. In QLD and NSW, the species is sparsely distributed along the Great Diving Range and there is no consistent pattern of habitat preference (DAWE 2020). SEQ and northern New South Wales is considered a stronghold of the species northern distribution. The Project is located on the western edge of its distribution in SEQ and as such the species may be considered as on the western limit of the species range in the area. The Project is predicted to impact 156.25 ha of *potential habitat* in which this species may occur (refer Table 5.4). Although there are no nearby records the Project occurs on the western limit of the species distribution in relation to the Project and any individuals could be considered an 'important population'. Therefore, further consideration as to whether there will be a significant impact on this species is assessed in Table 5.38.
Pseudomys novaehollandiae	New Holland mouse	Two records (2000) exist in the Helidon Hills 6 km to the northeast of the eastern end of the Project. Other records within a 50 km buffer of the Project disturbance footprint occur 15 km to 30 km north of these records between Lockyer National Park and Crows Nest. Records also exist to the south-east of the Project disturbance footprint from 1997 at Main Range National Park (AoLA 2020). No recovery plan exists for this species. A review of the available literature has not revealed any important populations when referring to DAWE's SPRAT database (2020). No populations have been identified that are key to the long-term survival and recovery of this species and critical habitat for the species has not been identified or defined. In the absence of a definition for Habitat critical to the survival of the species this assessment has applied a 1 km buffer on known records that intersect 'potential habitat' (refer Appendix A for methodology). As such, there is no Habitat critical to the survival of the species identified within or close to the Project disturbance footprint (refer Table 5.4). The Project is predicted to impact 156.25 ha of *potential habitat* in which this species may occur (refer Table 5.4). Given the local population of New Holland mouse occurs at the northern limit of its distribution in relation to the Project the nearby records could be considered an 'important population'. Therefore, further consideration as to whether there will be a significant impact on this species is assessed in Table 5.39.
Pteropus poliocephalus	Grey-headed flying-fox	Five records exist for this species from within the Toowoomba Range from 2004 to 2011. Four of these are associated with a known roost site located 540 m south of the Project disturbance footprint (to the east of Ruthven Street). A second local flying-fox roost is known from Helidon, located 1.8 km southeast of the eastern extent of the Project. There are a number of database records in the surrounds largely to the south in Toowoomba but also to the north on Murphy's Creek and the Highfields area (AoLA 2020). The species main distribution extends from Rockhampton south to Victoria and South Australia. The Project disturbance footprint is not at the limit of the species range. Based on quarterly flying-fox data collected by DES in the SEQ region there are three Flying-fox camps located within 15 km of the Project which regularly comprise Grey-headed flying-fox: Murphy's Creek, Toowoomba and Highfields. The draft *National recovery plan for the Grey-headed flying-fox (Pteropus poliocephalus*) (DotEE 2017a) does not identify important populations for the species. The Plan does not specifically identify habitat critical to the survival of the species but does recommend management of habitat associated with a number of tree species located within the MNES study area. This is a highly mobile species and the linear nature of the Project is not expected to impact dispersal or breeding capacity. Predictive impact assessment has taken a conservative approach for this species and included all habitat within a 15 km radius of the known regular roost sites for the species that are local to the MNES study area (refer Appendix A for methodology). As such, the predictive assessment estimates that 201.19 ha of *Habitat critical to the survival of the species* may be impacted under the current disturbance footprint (refer Table 5.4). The Project has potential to impact *Habitat considered critical to the survival of the species* under the approach used for this assessment. The potential for significant impacts are assessed further in Table 5.40.

Species name	Common name	Project area population evaluation
Turnix melanogaster	Black-breasted button-quail	There are two database records from within the Project disturbance footprint in the Gowrie area one of which is from 1901. The other record does not have an associated collection date and has a high spatial uncertainty. The nearest recent records are also from the Gowrie area (1999 and 1.8 km north of the Project disturbance footprint) and Redwood Park at the base of the Toowoomba Range (2006 and 5 km south). The species is also known to occur nearby to the Project in the Toowoomba Range as derived from recent studies associated with the TSRC project. There are further records to the east in the Lockyer Reserves, the closest of which is from 1995 and 10 km east of the eastern extent of the Project. Records from the west and north of the Project range from 1927 – 2018 at Toowoomba and between Crows Nest, Ravensbourne and Lockyer National Parks (AoLA 2020). The species occurs from Byfield in the north south to the Dorrigo area (Mathieson and Smith 2009). The Project area is located on the western edge of the species range. This *National recovery plan for the black-breasted button-quail Turnix melanogaster* (Mathieson and Smith 2009) identifies important populations from the Yarraman-Nanango, the Jimna-Conondale Range and Great Sandy Regions. Habitat critical to the survival of the species includes vine thickets, dense acacia thickets and woodland with dense shrub understorey, including *Lantana camara*. This habitat has been identified within the Project disturbance footprint. The linear nature of the Project is not expected to impact dispersal or breeding capacity. Given the local population of Black-breasted button-quail occurs at the western limit of its distribution in relation to the Project the nearby records could be considered an 'important population'. The Project is also predicted to impact 9.18 ha of *Habitat considered critical to the survival of the species* (refer Table 5.4). Therefore, further consideration as to whether there will be a significant impact on this species is assessed in Table 5.41.

5.3.5.3 Significant impact assessment - Vulnerable fauna species

Collared delma (*Delma torquata*)

Ecology and distribution

The Collared delma typically inhabits eucalypt-dominated woodlands and open-forests in QLD on RE land zones 3, 9 and 10 (Brigalow Belt Reptiles Workshop 2010). Recent studies in the Toowoomba Range associated with the species indicated the species was frequently associated with open *Eucalyptus crebra* woodland located on northwest facing slopes on land zone 9 (Schell and Stark pers. obs. 2017).

The Collared delma has been recorded from rocky areas associated with dry open forests. This species occurs in open eucalypt and *Acacia* woodland with an understorey of native grasses and loose rocks. The Collared delma has also been recorded from Eucalypt woodland adjacent to semi-evergreen vine thicket. This species shelters under rocks, fallen timber, leaf litter and in soil cracks (Richardson 2006). The presence of rocks, logs, bark and other coarse woody debris, and mats of leaf litter (typically 30 to 100 mm thick) appears to be an essential characteristic of the Collared delma microhabitat and is always present where the species occurs (Brigalow Belt Reptiles Workshop 2010; Davidson 1993; Schell and Stark pers. obs. 2017).

The Collared delma is endemic to the SEQ and Brigalow Belt South bioregions. The known distribution of the species includes Western Creek near Millmerran, the Toowoomba Range, and the Lockyer Forest Reserves north of Helidon, eastward to Moggill on the western outskirts of Brisbane. The largest known occurrence of this species occurs on the Toowoomba range where large numbers of this species were subject to translocation activities associated with the TSRC project (DAWE 2020; Schell and Stark pers. obs. 2017).

Distribution in context to the Project

Collared delma was recorded in the Toowoomba Range during Project-associated surveys (refer Figure 4.3). The species is also known to occur in the Toowoomba Range as derived from early surveys in 2006 (Peck and Hobson 2007) and more recent studies associated with the TSRC project. There are 2003 database records (AoLA) located within the Project disturbance footprint (refer Figure 4.3). There are also two 1995 records approximately 10 km to the northeast in the Lockyer Reserves northeast of Helidon (refer Figure 3.2 in Appendix B).

Project associated surveys noted potential habitat for the species (woodlands with loose surface rocks) as occurring where the Project disturbance footprint intersects the Toowoomba Range (refer assessment proformas in Appendix H) and the species has been identified during EIS field investigations within the Toowoomba range (refer Section 4.3.2.1).

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species. The *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) is applicable to this species and outlines primary threats, impacts and mitigations to this species and other Brigalow Belt reptiles.

The DAWE Approved Conservation Advice (DEWHA 2008n) notes the following potentially threatening processes identified for Australian habitat as relevant to Collared delma:

- Loss and modification of habitat due to urban and agricultural development
- Landscaping activities removing surface rocks
- Fire and invasive weed species, particularly Dwarf lantana (*Lantana montevidensis*).

Important populations and habitat critical to the survival of the species

There are no identified important populations or definitions of habitat critical to the survival of the species. The *Draft referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) considers the presence of suitable and important habitat for this species a surrogate for an important population of the species. This includes known/likely habitat for the species as mapped within the guidelines. The Project lies within known/likely habitat throughout the alignment. Other important habitat factors include: habitat near the limit of the species known range; and large patches of contiguous, suitable habitat and viable landscape corridors. Habitat within the Toowoomba Range and the adjacent Lockyer Forest Reserves is extensive, acts as a wildlife corridor, and includes the following habitat types which the species is known to occur in:

- Open forest eucalypt woodland dominated by ironbarks
- Woodland adjacent to exposed rocky areas
- Regional ecosystems on land zones 3, 9 and 10 (DAWE 2020).

As such, the Project disturbance footprint includes habitat that may be considered as ‘important habitat’ for Collared delma.

Impacts and mitigation measures associated with this species are identified within Table 5.7. Predictive habitat mapping for this species estimates that 197.41 ha of *important habitat* may be impacted under the current disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). This habitat is associated with the Toowoomba Range and the southern edge of the Lockyer Forest Reserves (north of Helidon in the eastern portion of the Project alignment). This is a conservative figure and may overestimate the actual extent of suitable habitat for the species. Therefore, the Project has potential to impact *important habitat* for Collared delma. Assessment against the significant impact criteria for vulnerable species is shown in Table 5.31.

Table 5.31 Assessment against the significant impact criteria - Collared delma

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population of a species	The species is known to occur in the Toowoomba Range (including within the Project disturbance footprint) from Project surveys and surveys for the adjacent TSRC. The species has also been recorded located 10 km northeast of the Project in the Helidon Hills area. Predictive habitat mapping indicates the Project has the potential to impact 197.41 ha of *important habitat* for the species, although this may be an overestimation. It is uncertain how much of this area comprises suitable habitat features (surface rocks) for the species. In accordance with the *Draft referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) the presence of *important habitat* is a surrogate for an important population and the species has been found to occur. The Project has the potential to result in the long-term decrease in the size of an important population through: ■ Loss of habitat ■ Fragmentation of an important population ■ Mortality of individuals during construction. Further surveys are being carried out where suitable habitat for this species has been identified to identify to what extent the species occurs within the Project disturbance footprint. Survey methods will follow the relevant MNES survey guidelines. Should the species be found individuals will be relocated from the area of disturbance prior to construction/disturbance activities (refer Table 5.7). The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint. The Project is considered unlikely to lead to a long-term decrease in an important population (or analogous important habitat).
Reduce the area of occupancy for an important population	The species is known to occur in the Toowoomba Range (including within the Project disturbance footprint) from Project surveys and surveys for the adjacent TSRC. The species has also been recorded located 10 km northeast of the Project in the Lockyer Forest Reserves area. Predictive habitat mapping indicates the Project has the potential to impact 197.41 ha of *important habitat* for the species, although this may be an overestimation. Pre-construction surveys will be carried out where suitable habitat for this species is identified within the final construction footprint to identify to what extent the species occurs within the Project disturbance footprint. The Project will likely reduce the occupancy of an important population (or analogous *important habitat*) across the local region.
Fragment an existing important population into two or more populations	The species is known to occur in the Toowoomba Range (including within the Project disturbance footprint) from Project surveys and surveys for the adjacent TSRC. The *Draft referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) notes that fragmentation of *important habitat* or landscape corridors through the introduction of a barrier to dispersal presents a 'high risk' of significant residual impacts to the species. The Project is linear. The project is co-located with the west Moreton system at Gowrie and east of Lockyer creek and west of Helidon. The remainder of the Project largely lies roughly adjacent to the Toowoomba Bypass and passes through heavily disturbed agricultural lands. The alignment crosses through the more elevated area within the Toowoomba Range via a tunnel allowing unimpeded movement above this area. Nevertheless, this is a small and sedentary species. The Project alignment runs through habitat from which the species has been recorded. There is potential to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The species is known to occur within the Project disturbance footprint and *important habitat* is present. The *Draft referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011e) notes that the loss of 2 ha of *important habitat* for this species poses a high risk of causing a significant residual impact to the species. The Project disturbance footprint occurs along the southern limit of 'known/likely habitat' for the species (as per DSEWPaC 2011b). The Project disturbance area has potential to impact 197.41 ha of *important habitat* for the species, although this may be an overestimate. Although critical habitat is not defined for this species, given a known population occurs and the potential extent of impact, the Project may adversely affect *Habitat critical to the survival of the species*.
Disrupt the breeding cycle of an important population	This species is known to produced eggs in December, which hatch in February–March. As noted above the Project disturbance footprint incorporates 197.41 ha of *important habitat* in which the species is known to occur. Clearing activities within this habitat between December and March has the potential to impact the species breeding cycle. Potential habitat will be inspected prior to clearing activity. Provisions to relocate individuals of Collared delma will be in place within the Flora and Fauna Sub-plan should any be recorded. Although the Project may impact individuals it is considered unlikely that the Project will disrupt the breeding cycle of an important population as a whole.

Criterion	Assessment against significance criteria
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The species is known to occur within the Project disturbance footprint and *important habitat* is present. Predictive habitat mapping indicates the Project has the potential to impact 197.41 ha of *important habitat* for the species. As noted in Section 5.1.2, Project impacts are not restricted to the footprint and there is the potential to impact on potential habitat as a result of edge effects, dust deposition, noise and light, changes to soil and changes to hydrology. These indirect impacts on habitat are not likely to be of the extent that the species is likely to decline. The *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b) notes that the introduction of invasive weeds, including the deliberate or accidental sowing of pasture grasses, within 30 m of important habitat without appropriate and ongoing control measures also poses a high risk to the species. The rail corridor will be cleared and stabilised, including revegetation using grass species (i.e. woody vegetation will be permanently cleared from the operational rail corridor). Lands within the construction footprint not required for operations will also be rehabilitated, with rehabilitation works likely to reflect pre-existing conditions and as such there is a risk that pastoral grass may be re-introduced to areas within 30 m of *important habitat*. Fire is also a key threat to the species and species habitat with both construction and operation activities potential points sources. The risk of bushfires as a result of the Project are low, while the Project may also provide access to manage bushfires in the vicinity of the alignment. Nevertheless, the Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint. Predictive mapping indicates 2,376 ha of similar important habitat occurs in the immediate surrounds of the MNES study area. This impact is not considered to be of the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Project-associated surveys have noted areas within the alignment are already heavily infested with weed species including 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Dwarf lantana has been identified as a particular threat to Collared delma habitat (DEWHA 2008n) and noted as present in high densities some areas within the alignment during Project EIS surveys (ELA 2019a). Relevant habitats for the species (eucalypt woodlands) within the MNES study area were often noted to have high levels of introduced species including *Lantana camara* and Climbing asparagus fern (*Asparagus africanus*). Feral predators including cat and dog were not observed during Project site surveys but are likely present to some extent in the area. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no recovery plan for this species. The Approved conservation advice (DEWHA 2008n) notes the following priority actions applicable to the species: ■ Protect and monitor known populations and identify threats ■ Develop a fire management strategy for known populations and habitat ■ Minimise adverse impacts from land use including road widening and maintenance ■ Identify and control threatening weeds in Collared delma habitat. The Project will interfere with the priority actions listed above through impacting a known population and minimising impacts from land use. The Biosecurity Management Plan will help to control weeds in the vicinity of the Project. Nevertheless, it is considered unlikely the Project will impact Collared delma to the extent it will interfere substantially with the recovery of the species.
Assessment of potential for significant residual impacts	There is an important population (or analogous *important habitat*) present in the area. The Project is estimated as impacting 197.41 ha of *important habitat*. Under the nine-part test detailed above, the Project is considered likely to cause 'significant residual impacts' on *an important population* of Collared delma as a result of edge effects, habitat loss and fragmentation.

Red goshawk (Erythrotriorchis radiatus)

Ecology and distribution

The solitary Red goshawk is known to mostly prey on larger birds such as Australian brush-turkeys (*Alectura lathami*), Kookaburras (*Dacelo novaeguineae* and *leachii*), Rainbow lorikeet (*Trichoglossus moluccanus*), and other parrots, as well as small mammals, reptiles and insects. The species is known to attack its prey from the air, gliding straight down or chasing it down. The species occupies large home ranges estimated to be up to 120 km^2 (females) and 200 km^2 (males). Preferred habitat requirements are extensive tracts or remnant woodlands/forests on fertile soils with a mosaic of vegetation types, access to permanent water, and large populations of birds (DERM 2012).

The male of the species will build nests using dead sticks lined with twigs and green leaves within an exposed fork in the upper quarter of a tree between 10 to 20 m above ground and used each year. Nest sites are usually located on an emergent tree within 1 km of permanent water. The breeding season for Red goshawk occurs from September to December with one to two eggs being laid by the females between August and October in the southeast regions (DES 2017c; OEH 2017c).

The species is sparsely distributed across coastal and near-coastal areas of northern Australia, with occasional records along major inland rivers. The distribution range of Red goshawk previously included north-eastern NSW but has contracted since European settlement (DERM 2012). The southern limit of the species in NSW has undergone a 500 km northward contraction (Debus and Czechura 1988) and may be extinct.

Distribution in context to the Project

There are a number of database records from the Toowoomba area, many of which are older records (<1990). There is a 1992 record (Wildlife online) located 600 m south of the Project disturbance footprint in the Toowoomba Range (refer Figure 4.3). It is noted all available AoLA records have all been generalised in order to protect the species and may not reflect the actual record location. The nearest database record is from 2008 located 3 km north of the eastern extent of the Project. The most recent record in the region is a 2012 record 15 km south of the Project disturbance footprint in the Toowoomba Range. There is a 2002 and 2003 record from the Grantham area 11 km southeast of the Project. Further records of varying age occur to the northeast, north and south of Toowoomba, as well as further east in the Lockyer Valley.

An intensive study on the species was carried out in favoured sites (largely well-vegetated montane and foothill areas) in south-east Queensland over 60 survey days from December 2013 to May 2014. No individuals and a single potential nest site were observed across the survey period (Seaton 2014).

The species has not been recorded during any Project-associated surveys or during surveys for the nearby Inland Rail projects or the TSRC project. General pre-clearance surveys within the Project disturbance footprint targeting bird nest locations have not located the species (e.g. ELA (2019b) and EMM (2018b, 2018c, 2019d)). The population in the south-east Queensland bioregion is thought to consist of 10 to 30 breeding pairs (Garnett et al 2011).

Recovery plans/threat abatement plans

The *National recovery plan for the Red goshawk (Erythrotriorchis radiatus)* (DERM 2012) came into effect under the EPBC Act in July 2012. The Plan identifies the following threatening processes as applicable to the species:

- Loss of habitat
- Fragmentation of existing habitat
- Reduction in nest sites through the loss of mature trees
- Reduction to the prey base
- Threats to prey availability

- Knowledge and communication gaps for this species
- Poor management practices.

The are no Commonwealth adopted threat abatement plans considered relevant to this species.

Important populations and habitat critical to the survival of the species

The *National recovery plan for the red goshawk Eryhtrotriorchis radiatus* (DERM 2012) does not identify important populations. Specific important populations have not been identified for this species due to the sparse distribution of the species. Delineating an important population for this species is complicated by the ecology of the species. The species occupies large home ranges estimated to be up to 120 km^2 (females) and 200 km^2 (males). The population in the SEQ bioregion is thought to consist of 10 to 30 breeding pairs (Garnett et al 2011). It is considered likely that the SEQ population of Red goshawk represents the southernmost limit of the species at the time of this assessment. Under the definition provided in the MNES guidelines (DotE 2013a), any individuals occurring in or near the Project may be are considered an important population as they are part of a population near the limit if the species range.

Habitat critical to the survival of the species is considered those areas which supports nesting and associated habitat factors to support nesting. Preferred habitat requirements are extensive tracts or remnant woodlands/forests on fertile soils with a mosaic of vegetation types, access to permanent water, and large populations of birds (DERM 2012). This requires riverine areas with permanent water located within or near extant tracts of woodland supporting bird prey populations.

Impacts and mitigation measures associated with this species are identified within Table 5.7. Predictive habitat mapping (refer Appendix A for methodology) for this species estimates that 3.98 ha of *potential habitat* and 84.79 ha of *Habitat critical to the survival of the species* may be impacted under the current disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). Assessment against the significant impact criteria for endangered species is shown in Table 5.32.

Table 5.32 Assessment against the significant impact criteria - Red goshawk

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population of a species	A single historical record (1992) occurs within the MNES study area. No individuals were observed during surveys for the Project or the adjacent TSRC project. Most records from the Toowoomba area are older. The nearest recent records are located 3 km north (2008), 15 km south (2012) and 11 km southeast (2002 and 2003) of the Project disturbance footprint. There are several old and recent records to the east of the Project in the Lockyer Valley. Nevertheless, the species habits are generally discrete and it is difficult to detect in wooded habitat. The MNES study area incorporates a mosaic of habitat types suitable for the specie presence. Should individuals occur in the area they may be considered as part of an 'important population'. Predictive habitat mapping indicates the Project may to impact 3.98 ha of *potential habitat* and 84.79 ha of *Habitat critical to the survival of the species*. This habitat is largely associated with the Toowoomba Range. The species requires large home ranges of between 120 km^2 and 200 km^2. The species does not generally occur in cleared habitat or in dense vegetation and there are no breeding records from areas where vegetation is extensively fragmented. Through this area the Project will remove mature trees reducing the availability of potential nest trees, though no nests have been identified from the Project disturbance footprint. The Project also has the potential to impact this species through the following: - Fragmentation of existing habitat - Reduction to the prey base - Threats to prey availability The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint in the Toowoomba Range. The potential area of impact would be a very minor percentage of an individual's overall range.

Criterion	Assessment against significance criteria
	Potential nesting habitat (emergent trees within 1 km of permanent waterbodies in larger tracts of woodland) will be inspected during targeted pre-construction surveys of the Project disturbance footprint (refer Table 5.7). Given the steep terrain in much of the Project disturbance footprint this is likely to only occur in the area near Lockyer Creek. Provisions to protect Red Goshawk nest sites will be in place within the Flora and Fauna Sub-plan should any nest sites be recorded. It is considered likely that foraging individuals disturbed by construction activities will temporarily move away from the area of disturbance and return post-construction. The Project is considered unlikely to result in a long-term decrease in the size of an important population should the species be found to occur in the area.
Reduce the area of occupancy for an important population	Predictive habitat mapping indicates the Project may to impact 3.98 ha of *potential habitat* and 84.79 ha of *Habitat critical to the survival of the species*. It is uncertain if the species occurs in the area. The nearest recent record is located 3 km from the Project disturbance footprint and there are a number of other recent records (post 2000) in the surrounding area, although the actual locality of these sighting is uncertain. Should individuals occur in the area they may be considered as part of an 'important population'. Nevertheless, the species habits are generally discrete and it is difficult to detect in wooded habitat. The MNES study area incorporates a mosaic of habitat types suitable for the specie presence. The species requires large home ranges of between 120 km^2 and 200 km^2. The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint in areas of extensive habitat. Nevertheless, the Project has some potential to reduce the area of occupancy of an important population should the species be found to occur in the area.
Fragment an existing important population into two or more populations	The species is highly mobile and the Project is not considered to represent a barrier to movement for the species. It is considered unlikely that the Project will fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	Predictive habitat mapping indicates the Project has the potential to impact 88.77 ha of suitable habitat for the species, of which 84.79 ha may be considered as *Habitat critical to the survival of the species*. The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the disturbance footprint in areas of extensive habitat (such as the Toowoomba Range). The species requires large home ranges (between 120 km^2 and 200 km^2) and the Project will impact a minor proportion of the available habitat in the wider area. Nevertheless, although minor in extent, the Project has potential to adversely affect *habitat critical to the survival of the species*.
Disrupt the breeding cycle of an important population	No historical records or recent field observations for the species exist within the MNES study area, although the species has been recorded in the wider region. No breeding sites are known to the MNES study area. Potential nesting habitat (emergent trees within 1 km of permanent waterbodies in the Teviot Range) will be inspected prior to clearing activity. The Project will result in the clearing of mature trees up to a kilometre from watercourses, with these trees as potential suitable nest sites. Tree clearing during the breeding season (generally occurs in spring), egg-laying (August to October) or fledging (65-80 days) may present a direct impact on the species breeding cycle. Provisions to protect Red Goshawk nest sites will be in place within the CEMP should any nest sites be recorded. This will likely include buffer zones and the erection of barriers and/or signage around the trees during construction and micrositing of the clearing works to avoid nests. The recovery plan notes Red goshawks are very tolerant of moderate numbers of people visiting their nest sites. It is considered unlikely that the Project will disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There are no historical records of the species within the MNES study area and the species is currently considered as rare in the region. Predictive habitat mapping indicates the Project may to impact 3.98 ha of *potential habitat* and 84.79 ha of *Habitat critical to the survival of the species*. However, the species has large home ranges and The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint in areas of extensive habitat (such as the Toowoomba Range). Impacts will be temporary and restricted to the construction period. This impact is not considered to be of the extent that the species is likely to decline, should the species be found to occur in the area.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	There are no weeds or pests identified as relevant to Red goshawk. Project-associated surveys have noted areas within the alignment are already heavily infested with weed species including 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Project surveys within the MNES study area were often noted to have high levels of introduced species including *Lantana camara*. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	Recovery strategies listed in the *National recovery plan for the red goshawk Erythrotriorchis radiatus* (DERM 2012) include: ■ Identify and map important Red goshawk habitat ■ Protect and appropriately manage important habitat area to ensure long-term survival of the Red goshawk ■ Increase knowledge about the Red goshawk's productive success and its survival ■ Identify important populations of Red goshawks ■ Increase community awareness about the Red goshawk and the conservation of the species. The Project is considered unlikely to interfere with any of the recovery strategies listed above. Should Red goshawk be identified during Project activities this will contribute to current information on the species in the SEQ region.
Assessment of potential for significant residual impacts	The Project is considered to have a minor potential to cause significant residual impacts on the Red goshawk through impact to habitat considered as *Habitat critical to the survival of the species* and the reduction in occupancy of an important population, should the species be found to occur.

Grey falcon (*Falco hypoleucos*)

Ecology and distribution

Grey falcon is a solitary species considered to occupy the arid and semi-arid zone of Australia where annual rainfall is <500 mm. This includes the Murray-Darling Basin, Eyre Basin, central Australia and Western Australia (Marchant and Higgins 1993). The species is often difficult to detect, perching amongst foliage or sitting on branches prior to hunting prey at tree-top height attacking mainly bird species. Targets for the falcon include finches, doves, parrots and pigeon but also know to consume insects and small mammals and carrion (Birdlife International 2016c).

The species likely occupies large home ranges with preferred habitat including sparsely timbered lowland plains, particularly acacia shrublands that are crossed by tree-lined water courses. The species appears to be partially nomadic, responding to local drought conditions. Younger individuals may disperse outside of this habitat in the non-breeding season (Garnett et al 2011), particularly in drought years that follow wet years in inland Australia. The species has been observed hunting in treeless areas and frequents tussock grassland and open woodland, especially in winter (DAWE 2020b).

Grey falcon are solitary nesters, laying one to four eggs in late winter to early spring. This species, like most falcons, utilise old nests of other birds such as other species of raptor and ravens, usually positioned high in eucalyptus trees (such as *Eucalyptus camaldulensis*) close to water. The species may also use artificial sites such as telecommunication towers. During times of drought the species has been known to not breed (AWC 2018; Johnson 2011). Sub-adults will remain with the parents for extended periods following fledging (at least 12 months) including during subsequent nesting attempts. The breeding range has contracted to the arid parts of its range since the 1950s (OEH 2017e). Known breeding sites in Queensland are all in the arid zone well west of the Project (Schoenjahn 2018).

Distribution in context to the Project

This species has not been identified during and Project surveys or surveys for the TSRC project. There is a single database record within the western extent of the Project footprint (refer Figure 4.3). There is another record of this species within the Toowoomba Range (dated 2013) approximately 8.5 km south of the Project disturbance footprint. A third record dated 1983 occurs approximately 20 km north of the eastern extent of the Project disturbance footprint (within the Lockyer Reserves area) (AoLA 2020) (refer Figure 8.10 in Appendix B). Records across the wider region surrounding the Project are sparse and older (<1990).

It is noted average annual rainfall in the Toowoomba area in which the Project footprint occurs is 952.4 mm (BoM 2020) which is well outside the generally accepted range of the species as identified above.

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species. The DAWE Approved Conservation Advice (DAWE 2020b) notes the following potentially threatening processes identified as relevant to Grey falcon:

- Predation by feral cats
- Habitat degradation caused by land clearing over-grazing of arid zone rangelands
- Habitat degradation caused by introduced herbivores (such as camels)
- Climate change impacts of increasing temperatures in species habitat
- Collisions with fences and powerlines
- Human disturbance including by egg collectors, birdwatchers and for falconry.

There are no threat abatement plans considered applicable to this species.

Important populations and habitat critical to the survival of the species

The total population size is now generally accepted to be <1,000 mature individuals (Schoenjahn 2018). Given the species widespread and sparse distribution there are no important populations or definition of *habitat critical to the survival of the species* in the approved conservation advice for the species (DAWE 2020b). The species occurs sparsely across the arid and semi-arid zones of Australia. The Project is located outside the species normal range and there is no evidence to suggest the area supports a key source population. *Habitat critical to the species survival* may be considered those areas which support nesting and associated habitat factors to support nesting (The nests chosen are usually in the tallest trees along watercourses, particularly River red gum (Eucalyptus camaldulensis) and Coolibah (E. coolabah), but the species also nest in telecommunication towers). The species does not nest in the region. In the absence of any other habitat definition for the species this assessment has defined *Habitat critical to the survival of the species* by applying a 1 km buffer on known records that intersect '*potential habitat*' for the species (refer Appendix A for methodology).

Predictive habitat mapping for this species estimates that 145.56 ha of *potential habitat* and 66.13 ha of *Habitat critical to the survival of the species* may be impacted under the current disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). The habitat mapping is very conservative in approach. The occurrence of *Habitat critical to the survival of the species* is a result of the local database record for the species (from 2008) and overstates the importance of this habitat to the species (i.e. cleared habitat in the Gowrie Creek area). *Potential habitat* encompasses a range of habitats in the Toowoomba Range where the species is unlikely to occur given its preference for open habitats. The predicted habitat for the species is very likely a substantial overestimation of the species potential occurrence in the area.

Impacts and mitigation measures associated with this species are identified within Table 5.7. Assessment against the significant impact criteria for endangered species is shown in Table 5.33.

Table 5.33 Assessment against the significant impact criteria – Grey falcon

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population of a species	No individuals were observed during surveys for the Project or the adjacent TSRC project. A single database record (2008) occurs within the MNES study area. There are scattered sparse records in the surrounding area including a 2013 record approximately 8.5 km south of the Project. All other records in the wider region are older (<1990). The species is sparsely distributed over a wide area of inland Australia. As such, no important population can be attributed as occurring within the MNES study area. Predictive habitat mapping indicates the Project may to impact 145.56 ha of *potential habitat* and 66.13 ha of *Habitat critical to the survival of the species*. The habitat mapping for the species has taken a very conservative approach (refer Appendix A). This habitat is associated with largely cleared habitat associated with the species record in the area and woodlands in the Toowoomba Range (where the species is unlikely to occur given its preference for open habitats). The predicted habitat for the species is very likely a substantial overestimation of the species potential occurrence in the area. The species occupies the arid and semi-arid zone of Australia where annual rainfall is <500 mm. Average annual rainfall in the Toowoomba area in which the Project footprint occurs is 952.4 mm (BoM 2020) which is therefore well outside the generally accepted range of the species. Known breeding sites in Queensland are all in the arid zone well west of the Project (Schoenjahn 2018). Younger individuals may disperse outside of the core inland habitat in the non-breeding season, particularly in drought years that follow wet years in inland Australia (Garnett et al 2011). As such the record within the MNES study area is likely to be a vagrant individual. The Project area is not within the normal range of the species. The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint. Given the steep terrain in much of the Project disturbance footprint this is likely to only occur in the open habitat surrounding Gowrie Creek. It is considered likely that foraging individuals disturbed by construction activities will temporarily move away from the area of disturbance and return post-construction. The Project is considered unlikely to result in a long-term decrease in the size of an important population should the species be found to occur in the area.
Reduce the area of occupancy for an important population	Predictive habitat mapping indicates the Project may to impact 145.56 ha of *potential habitat* and 66.13 ha of *Habitat critical to the survival of the species*. It is likely the species occurs in the area only sporadically as vagrant individuals dispersing from core inland habitat. A single database record (2008) occurs within the MNES study area. There are scattered sparse records in the surrounding area including a 2013 record approximately 8.5 km south of the Project. All other records in the wider region are older (<1990). The species is sparsely distributed over a wide area of inland Australia. As such, no important population can be attributed as occurring within the MNES study area. The species occupies the arid and semi-arid zone of Australia where annual rainfall is <500 mm. Average annual rainfall in the Toowoomba area in which the Project footprint occurs is 952.4 mm (BoM 2020) which is therefore well outside the generally accepted range of the species. Known breeding sites in Queensland are all in the arid zone well west of the Project (Schoenjahn 2018). The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the Project disturbance footprint in areas of extensive habitat. The Project is considered unlikely to reduce the occupancy of an important population.
Fragment an existing important population into two or more populations	The species is highly mobile and the Project is not considered to represent a barrier to movement for the species. It is considered unlikely that the Project will fragment an existing important population into two or more populations.

Criterion	Assessment against significance criteria
Adversely affect habitat critical to the survival of the species	Predictive habitat mapping indicates the Project may to impact 145.56 ha of *potential habitat* and 66.13 ha of *Habitat critical to the survival of the species*. Nevertheless, the habitat mapping for the species has taken a very conservative approach (refer Appendix A). This habitat is associated with largely cleared habitat associated with the species record in the area and woodlands in the Toowoomba Range (where the species is unlikely to occur given its preference for open habitats). The predicted habitat for the species is very likely a substantial overestimation of the species potential occurrence in the area. The species occupies the arid and semi-arid zone of Australia where annual rainfall is <500 mm. Average annual rainfall in the Toowoomba area in which the Project footprint occurs is 952.4 mm (BoM 2020) which is therefore well outside the generally accepted range of the species. Known breeding sites in Queensland are all in the arid zone well west of the Project (Schoenjahn 2018). Younger individuals may disperse outside of the core inland habitat in the non-breeding season, particularly in drought years that follow wet years in inland Australia (Garnett et al 2011). As such the record within the MNES study area is likely to be a vagrant individual. The Project area is not within the normal range of the species. The Project is a linear development and there will be substantial tracts of suitable habitat remaining undisturbed adjacent to the north and south of the disturbance footprint in areas of extensive habitat. It is acknowledged that *Habitat critical to the survival of the species* has been mapped within the Project disturbance footprint under the conservative methodology used for this assessment. Nevertheless, the Project is located well outside the normal range of Grey falcon and the species does not breed in the region. Adverse impacts to habitat critical to the survival of the species is considered highly unlikely.
Disrupt the breeding cycle of an important population	The species is sparsely distributed over a wide area of inland Australia. As such, no important population can be attributed as occurring within the MNES study area. The species is not known to breed in the MNES study area, or the surrounding region and no nests for this species were observed during field investigations. Known breeding sites in Queensland are all in the arid zone well west of the Project (Schoenjahn 2018). It is considered unlikely that the Project will disrupt the breeding cycle of an important population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There is a single database records of the species within the MNES study area and sparsely scattered records in the surrounding region, most of which are older (<1990). Predictive habitat mapping indicates the Project may to impact 145.56 ha of *potential habitat* and 66.13 ha of *Habitat critical to the survival of the species*. However, the habitat mapping for the species has taken a very conservative approach and the predicted habitat for the species is very likely a substantial overestimation of the species potential occurrence in the area. The species occupies the arid and semi-arid zone of Australia where annual rainfall is <500 mm. Average annual rainfall in the Toowoomba area in which the Project footprint occurs is 952.4 mm (BoM 2020) which is therefore well outside the generally accepted range of the species. Known breeding sites in Queensland are all in the arid zone well west of the Project (Schoenjahn 2018). The Project area is not within the normal range of the species. The species has large home ranges and the linear nature of the Project will ensure that there are substantial tracts of suitable habitat remaining undisturbed to the north and south of the Project disturbance footprint. Any impacts will be temporary and restricted to the construction period. This impact is not considered to be of the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	There are no weeds or pests identified as relevant to Grey falcon. Project-associated surveys have noted areas within the alignment are already heavily infested with weed species including 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Project surveys within the MNES study area were often noted to have high levels of introduced species including *Lantana camara.* The species is threatened by predation from feral cats. Project-associated surveys observed feral predators including cats as present in the area. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.

Criterion	Assessment against significance criteria
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	Conservation actions listed in the Approved Conservation Advice for *Falco hypoleucos* (Grey falcon) (DAWE 2020b) include: ■ Support improved fire management and grazing practises where the species is known to occur ■ Protect known nest sites including trees and artificial structures ■ Control feral cats and camels where the species is known to occur ■ Conduct annual surveys of breeding and locate active nest sites There is no reason for the Project to substantially interfere with the recovery strategies outlined above. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. Should the species occur any impact will be very minor and is considered unlikely to interfere substantially with the recovery of the species.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, the Project is considered unlikely to cause significant residual impacts to Grey falcon.

Murray cod (*Maccullochella peelii*)

Ecology and distribution

The Murray cod (*Maccullochella peelii*) is the largest freshwater species of fish in Australia, measuring up to 1.8 m in length and weighing about 10 kg although some records indicate the species may reach over 100 kg in weight. The habitat of the species is diverse, ranging from clear rocky streams to slow-flowing, turbid lowland rivers or billabongs where the fish is found frequently in the main channel. Due to the species preferred breeding environment, it is often found in streams containing large rock, snags, overhanging vegetation, stumps or other woody structures. Due to the size of the Murray cod, it is considered the apex predator of the Murray-Darling river system and known to ambush its prey. The demersal species is known to hunt from sunset to sunrise, feeding on spiny crayfish and shrimp as well as reptiles and other fish species including cod (DAWE 2020).

The species is known to take long distance journeys prior to spawning travelling up to several hundred kilometres upstream despite their naturally sedentary nature (Koehn et al. 2009). The Murray cod has relatively low fertility compared to many other freshwater fish with the species generally reaching sexual maturity, which is heavily dependent on size, at 5 years of age. Male Murray cod, who are known to guard and fan the eggs during incubation, mature at a larger size than females with the species breeding as a pair. A female cod weighing 3 kg can produce up to 10,000 eggs often laid in logs or snags after developing them through winter until spawning, which is triggered by an increase in temperature and day length (DAWE 2020).

The Murray cod was once a widespread species and abundant in the lower and mid reaches of the Murray-Darling Basin between QLD and South Australia (refer Figure 4.2). However, the distribution of the species has now reduced to several bioregions between QLD and Victoria, including the Brigalow Belt South Bioregion (NMCRT 2010).

Distribution in context to the Project

The nearest database record (AoLA) is from 2014 in a parkland area in Toowoomba (7 km south of the Project) which is very likely to be the result of artificial introduction. As such it has been disregarded. The nearest downstream record (2008) is from Oakey Creek near Jondaryan (30 km northwest of the Project). There is a 2009 record further downstream on Oakey Creek from the Bowenville area (45 km northwest) (refer Figure 2.2 in Appendix B). There are scattered records further downstream of the confluence of the Condamine River and Oakey Creek at Dalby and Chinchilla. It is noted DAWE habitat mapping does not indicate the species as occurring in the Toowoomba area or Gowrie Creek.

Aquatic habitat assessments within the MNES study area along three sections of Gowrie Creek were carried out during low flow conditions (although flow was present). In general, the surveyed areas were dominated by shallow pools with little riparian cover and little instream woody debris present (refer to EIS Appendix I: Terrestrial aquatic ecology technical report). These areas along Gowrie Creek appear to show poor habitat values for Murray cod. Nevertheless, Platypus (*Ornithorhynchus anatinus*) was observed during the survey indicating the presence of some larger pools and as such Murray cod may utilise the area, potentially during upstream migrations in flood events when water levels are higher.

Recovery plans/threat abatement plans

The *National Recovery Plan for the Murray Cod Maccullochella peelii peelii* (NMCRT 2010) identifies the following threatening processes as applicable to the species:

- River regulation of flows and instream impoundments impact spawning movements and recruitment processes and impact water quality in rivers
- Habitat degradation caused by the removal of habitat elements (large woody debris), sedimentation and siltation events from broad-scale land clearing and following large fires
- Competition/predation from introduced fish species including European carp (*Cyprinus carpio*), Redfin perch (*Perca fluviatilis*), Goldfish (*Carassius auratus*) and Mosquitofish (*Gambusia holbrooki*)
- Commercial and recreational fishing
- Stocking and translocation of the species impacting the genetic integrity of populations.

There are no threat abatement plans considered applicable to this species.

Important populations and habitat critical to the survival of the species

The *Draft referral guidelines for the vulnerable Murray cod (Maccullochella peelii)* (DotE 2016b) identifies the following important populations for Murray cod in QLD:

- Condamine River upstream of Warwick
- Border rivers (see also populations listed for NSW):
  - the Macintyre-Dumaresq Rivers to approximately 50 km downstream of Goondiwindi
  - Weir River
  - Macintyre Brook downstream of Inglewood
  - Severn River, and
  - Pike Creek downstream of Glenlyon Dam
- Warrego River between Charleville and Cunnamulla

None of these populations are relevant to the Project disturbance footprint. The draft guidelines describe *Habitat critical to the survival of the species* as 'any section of a waterway that comprises a connected system of habitats suitable for sustained use by a Murray cod population for sheltering, foraging, breeding and upstream and downstream movement'. The western portion of the Project occurs within the upper reach of the catchment of the species potential range and there is suitable habitat for the species. There is no evidence the species occurs in Gowrie Creek and the catchment immediately above the Project disturbance footprint drains Toowoomba city. Nevertheless, the predictive habitat modelling has taken a conservative approach as has assumed the species is potentially present. As such, the Project is predicted to impact 3.21 ha of *Habitat critical to the survival of the species* in which this species may occur (refer Table 5.4 and habitat figure in Appendix G).

Impacts and mitigation measures associated with this species are identified within Table 5.7. The following significant impact assessment (refer Table 5.34) under the MNES guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.34 Assessment against the significant impact criteria – Murray cod

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population	Murray cod is not known from Gowrie Creek. The nearest record is located 30 km downstream from Oakey Creek. Gowrie Creek is not considered as supporting an 'important population' under the draft referral guidelines for the species. Waterways elsewhere along the alignment are outside the catchment for the species. Predictive habitat mapping indicates that the Project may impact 3.21 ha of *Habitat critical to the survival of the species* (as defined for this assessment). The Project design incorporates culverts, bridges and viaducts to allow fish passage, including a road bridge over Gowrie Creek (refer Section 5.2.1). Flood modelling indicates that stream flows (e.g. flood heights and flow velocities) will not be adversely impacted as a result of the Project (refer EIS Appendix L: Surface water quality technical report and Appendix M: Hydrology and Flooding). Groundwater modelling (refer EIS Appendix N: Groundwater technical report) predicts the following: ■ The construction of the intermediate ventilation shaft (Week 62) has the potential to reduce groundwater levels up to a 1 m within the shallow MRV and deep MRV in the vicinity of Gowrie Creek ■ The construction of the tunnel (Week 107) has the potential to reduce groundwater levels up to a 1 m within the shallow MRV in the vicinity of Gowrie Creek. ■ The construction of the tunnel (Week 107) has the potential to reduce groundwater levels up to a 5 m within the deep MRV under Gowrie Creek during Week 107. ■ The construction of the tunnel (Week 107) has the potential to reduce groundwater levels up to a 25 m within the Koukandowie Formation under Gowrie Creek during Week 107. However, this groundwater unit is not likely to be hydrologically linked to Gowrie Creek. ■ No impact on Gowrie Creek is predicted during operations with groundwater modelling indicating that drawdown in the shallow and deep MRVs during operations is limited to the tunnel portal areas. The drawdown in the MVR may influence flows in Gowrie Creek, however, inflows mainly occur in West and East creeks upstream of the Project, from fractured basalt aquifers beneath the upper catchment areas and alluvial blankets of limited permeability clay in the valleys. While the release of water during construction and operations will also contribute to environmental flows from the Wetalla Wastewater Treatment Plant. It is therefore considered unlikely that drawdown form the construction and operation of the tunnel will impact on this species. The Project's construction phase may require temporary stream impoundments at waterway crossing points, along with the removal of instream habitat. These works will be temporary and localised. Dewatering activities of impounded areas will be carried out with consideration of the DAF Guidelines for fish salvage in impounded areas under the Flora and Fauna Sub-plan (refer Table 5.7). The impacts of the Project are considered unlikely to lead to a long-term decrease in the size of an important population.

Criterion	Assessment against significance criteria
Reduce the area of occupancy of an important population	Murray cod is not known from Gowrie Creek. The nearest record is located 30 km downstream from Oakey Creek. Gowrie Creek is not considered as supporting an 'important population' under the draft referral guidelines for the species. Predictive habitat mapping indicates that the Project may impact 3.21 ha of critical habitat (as defined for this assessment). The Project design incorporates culverts, bridges and viaducts to allow fish passage, including two crossings on Gowrie Creek. Stream impoundments may be required temporarily only during the construction phase. The impacts of the Project are temporary and considered unlikely to reduce the area of occupancy of the species.
Fragment an existing important population into two or more populations	Murray cod is not known from Gowrie Creek. The nearest record is located 30 km downstream from Oakey Creek. Gowrie Creek is not considered as supporting an 'important population' under the draft referral guidelines for the species. The Project is not considered to represent a barrier to movement for the species. The Project design incorporates culverts, bridges and viaducts to allow fish passage, including two crossings on Gowrie Creek. Stream impoundments may be required temporarily only during the construction phase. These structures and construction measures will avoid fragmentation of an existing population. It is considered unlikely that the Project will fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The Project will intersect *Habitat critical to the survival of the species* (as defined under this assessment) on Gowrie Creek. However, onsite assessments indicate Gowrie Creek provides poor habitat values for Murray cod. Project disturbance to Gowrie Creek will be temporary being restricted to the construction period. Following construction, no impact to flows will occur as a result of the Project. It is considered unlikely that the Project will adversely affect *habitat critical to the survival of the species*.
Disrupt the breeding cycle of a population	Murray cod is restricted to areas of permanent water and is known to complete their lifecycle entirely within freshwater habitats (i.e. potamodromous). Breeding occurs in Spring as associated with warmer temperatures and increased day length. The species is known to make significant upstream migrations prior to spawning. The temporary impoundment of Gowrie Creek may pose a risk to the species given they are potamodromous. The Project design incorporates culverts, bridges and viaducts to allow fish passage, including two crossings on Gowrie Creek. Stream impoundments may be required temporarily only during the construction phase. Where possible construction will be timed to occur outside of the potential spawning season. Project disturbance to waterways will be temporary being restricted the construction period. It is considered unlikely that the Project will disrupt the breeding cycle of a population.
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Aquatic habitat degradation is a contributing factor to the decline in Murray cod populations. The degradation generally occurs at a catchment scale such as land clearing, broad-scale fires and river regulation which influence water quality. The Project will require works within instream habitats, which may result in the localised removal of important habitat features such as woody debris and changes to the local geomorphology. Instream habitat complexity is limited along surveyed areas of Gowrie Creek. Project disturbance to waterways will be localised and temporary being restricted the construction period. Changes to water quality may also occur if not appropriately managed during construction (e.g. erosion and sediment controls) or operations (accidental spills and maintenance of waterway barriers). However, the risk of impact is likely to be low and localised. Mitigation measures will be in place to ensure surface water quality associated with the Project surrounds is not impacted as a result of Project activities (e.g. erosion and sediment controls and water quality monitoring program) (refer Table 5.7). The impacts of the Project are considered unlikely to be of the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species' habitat	Introduced fish species are identified as a potential threat to the species. The Project is considered very unlikely to introduce fish species as a result of construction activities. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction of novel weeds and spread of existing weed species across the Project disturbance footprint. This will include measures to ensure aquatic weeds and pest species are not introduced as a result of the Project. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.

Criterion	Assessment against significance criteria
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere with the recovery of the species	The *National Recovery Plan for the Murray Cod Maccullochella peelii peelii* (NMCRT 2010) includes the following recovery objectives: ■ Determine the distribution, structure and dynamics of Murray cod populations across the Murray-Darling Basin ■ Manage river flows to enhance recruitment to Murray cod populations ■ Evaluate the risks of threats and benefits of recovery options on Murray Cod populations for each management unit ■ Determine the habitat requirements of Murray cod life stages and populations ■ Manage the recreational fishery for Murray Cod in a sustainable manner while recognising the social, economic and recreational value of the fishery ■ Encourage community ownership for Murray Cod conservation With mitigation measures in place, particularly for the construction phase, the Project is considered unlikely to interfere with any of the recovery actions listed above and will not interfere with the recovery of the species.
Assessment of potential for significant residual impacts	Under the nine-part test detailed above, the Project is considered unlikely to have a significant impact on Murray cod

Greater glider (*Petauroides volans*)

Ecology and distribution

The Greater glider (*Petauroides volans*) is the largest species of gliding possum. It has large ears fringed with thick fur and a gliding membrane which attaches to the elbows and ankles. Greater gliders are typically found in mature eucalypt forests and woodlands with a variety of eucalypt species and a high density of large tree hollows (van der Ree et al. 2004). The diet is largely composed of eucalypt leaves and sometimes flowers. Large hollows in old trees are favoured as shelter sites during the daytime (Goldingay 2014). Sites with a high abundance of suitable hollows appear to support higher populations. The species uses relatively small home ranges of 1 ha – 4 ha in more productive forests (Gibbons and Lindenmayer 2002), but up to 16 ha in more open and dry habitats or up to 19.3 ha where den trees are limited in supply (Smith et al. 2007).

Females breed in their second year giving birth to a single young each year (March to June). Their low birth rate may cause isolated populations in small forest fragments to be vulnerable to extinction (van der Ree et al. 2004).

The Greater glider occurs in eucalypt forests along the ranges and coastal plains of eastern Australia from central Victoria near Daylesford to the Windsor Tablelands in far northern Queensland. It has an elevational range from sea level to 1,200 m above sea level (TSSC 2016b; OEH 2018a).

Distribution in context to the Project

The species has not been recorded during Project-associated surveys or surveys for the TSRC project. There are no database records (AoLA) within the MNES study area. The nearest records are from 2010 and 2016 and located north of Toowoomba (5 km and 10 km north of the Project) (refer Figure 4.4 in Appendix B). There are several records (all from the 1990s) located in the Lockyer Forest Reserves (all between 7.5 km and 19 km northeast of the Project). There are no records to the south of the Project in the Toowoomba Range. The species occurs from south-east Australia to central and north-east QLD. The northern subspecies (*Petauroides volans minor*) occurs on the Atherton Tablelands. The Project disturbance footprint is not located near the limit of the species range.

The results of the EIS habitat surveys and targeted pre-clearance surveys (ELA 2020) observe that trees comprising large tree hollows suitable for Greater glider are scattered throughout remnant woodlands within the Project disturbance footprint in the Toowoomba Range and Helidon areas.

Recovery plan/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species.

The DAWE Approved Conservation Advice (TSSC 2016b) notes the following potentially threatening processes identified for Australian habitat as relevant to Greater glider:

- Habitat loss and fragmentation through tree clearing and logging (including for timber production) and loss of dead stag trees (with hollows) due to prescribed burning
- Changed fire regimes (including from climate change) leading too intense and/or frequent fires
- Entanglement in barbed wire is a minor threat
- Impacts from native bird species including hyper-predation by owls and competition with cockatoos for tree hollows
- Impact to habitat from *Phytophthora cinnamomi*.

Important populations and habitat critical to the survival of the species

There are no important populations or definition of *habitat critical to the survival of the species* in any available literature for the species. The species occurs across eastern Australia and the Project footprint is not located on the edge of the species range and there is no evidence to suggest the area supports a key source population. In the absence of any other habitat definition for the species this assessment has defined *Habitat critical to the survival of the species* by applying a 1 km buffer on known records that intersect '*potential habitat*' for the species (refer Appendix A for methodology). As such, the Project disturbance footprint is not considered to comprise *habitat critical to the survival of the species*, but it is acknowledged that foraging, denning and dispersal habitat does occur within the Project disturbance footprint. To capture this habitat this has been included within "potential habitat". Predictive habitat mapping indicates the Project may impact 109.05 ha of *potential habitat* in which this species may occur (refer Table 5.4 and habitat figure in Appendix G). Assessment against the significant impact criteria for vulnerable species is shown in Table 5.35. It is noted that detailed investigations are being undertaken to validate habitat contained within the Project disturbance footprint. Pending the results of this data, a reassessment of significance of impacts will be undertaken. Should *Habitat Critical to the survival of the species* be identified during this process, this will most likely result in a significant residual impact to the Greater glider.

Table 5.35 Assessment against the significant impact criteria: Greater glider

Criteria	Assessment against significance criteria (vulnerable species)
Lead to a long-term decrease in the size of an important population of the species	The species has not been recorded within or near the Project footprint during Project surveys or surveys for the adjacent TSRC project. There are no database records within 5 km of the Project footprint with the nearest records all located north of Toowoomba (>2000s) and in the Helidon Hills area (1990s). There are no records to the south of the Project in the Toowoomba Range or Helidon areas. There is no indication an 'important population' of Greater glider is predicted to occur in the area. The species is known to glide over a distance of up to 100 m, but usually tends not to glide further than 30 m. The species also has a steeper trajectory than other species of glider. As the rail corridor is over 60 m wide there is the potential for the Project to impact movement, noting that individuals appear to use the same routes repeatedly as they move from hollows to feeding areas and occupy relatively small home ranges (average 1 ha to 4 ha in productive habitat). In addition, the species requires large hollow within which to shelter, and the project will result in the loss of this resource. Where the Project intersects the Toowoomba Range suitable remnant eucalypt habitat located above the tunnel area is not expected to be impacted.

Criteria	Assessment against significance criteria (vulnerable species)
	Pre-construction surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final temporary construction disturbance footprint. Provisions to protect the species will be in place within the Project Flora and Fauna Management Sub-plan should individuals be located within the disturbance footprint (refer Table 5.7). Should the species be found individuals will be relocated from the area of disturbance by qualified fauna spotter-catchers. The Project is predicted to impact 109.05 ha of *potential habitat* for the species. Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint including 1,449 ha within the MNES study area. It is considered unlikely the Project will lead to a long-term decrease in the size of an important population of the species.
Reduce the area of occupancy of an important population	The species has not been recorded within or near the Project footprint and no 'important population' is predicted to occur in the area. The nearest database records are at least 5 km from the Project and are all located to the north. Pre-construction surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final temporary construction disturbance footprint. The Project is predicted to impact 109.05 ha of *potential habitat* for the species. Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint including 1,449 ha within the MNES study area. The Project is considered unlikely to reduce the area of occupancy of an important population of the species.
Fragment an existing important population into two or more populations	The species has not been recorded within or near the Project footprint and no 'important population' is predicted to occur in the area. The nearest database records are at least 5 km from the Project and are all located to the north. The species is known to glide over a distance of up to 100 m, but usually tend not to glide further than 30 m. The species also has a steeper trajectory than other species of glider. As the rail corridor is over 60 m wide there is the potential for the Project to impact movement, noting that individuals appear to use the same routes repeatedly as they move from hollows to feeding areas. If any of these routes are impacted by the Project there is the potential to fragment a population unless appropriate fauna passage is provided. The Project is linear but impacts areas which are already subject to extensive fragmentation. The section of the alignment east of Helidon lies adjacent to the existing QR West Moreton System rail corridor. The remainder of the Project largely lies roughly adjacent to the Toowoomba Bypass and passes through heavily disturbed agricultural lands. The alignment crosses through the more elevated area within the Toowoomba Range via a tunnel allowing unimpeded movement above this area and a series of bridges and viaducts which will minimise disturbance to habitat. It is considered unlikely that the Project will fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	It is uncertain if the species occurs in the Project disturbance footprint. The only records in the wider area are all located north of the Project. The Project is predicted to impact 109.05 ha of *potential habitat* for the species. There is no *Habitat critical to the survival of the species* (as defined for this assessment). The Project is located within an area already subject to substantial adjacent disturbance including the recent Toowoomba Bypass. As such, the Project is considered unlikely to adversely affect habitat critical to the survival of Greater glider.
Disrupt the breeding cycle of an important population	The species has not been recorded within or near the Project footprint and no 'important population' is predicted to occur in the area. It is uncertain if the species occurs in the Project disturbance footprint at all. The species is known to breed from March to June. Pre-clearance surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final construction footprint. It is considered unlikely the Project will disrupt the breeding cycle of an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is uncertain if the species occurs in the Project disturbance footprint. The Project is predicted to impact 109.05 ha of *potential habitat* for the species. As noted in Section 5.1.2, Project impacts are not restricted to the footprint and there is the potential to impact on potential habitat as a result of edge effects, dust deposition, noise and light, changes to soil and changes to hydrology. Nevertheless, these indirect impacts on habitat are not likely to be to the extent that the species is likely to decline. Intense fires are a recognised threat to the species and species habitat with both construction and operation activities providing potential points sources of ignition. The risk of bushfires as a result of the Project are considered low, while the Project may also provide access to manage bushfires in bushland areas along the alignment.

Criteria	Assessment against significance criteria (vulnerable species)
	Nevertheless, there is abundant similar habitat in the wider area to the north and south of the Project disturbance footprint in the Toowoomba Range including 1,449 ha within the MNES study area. There is no *Habitat critical to the survival of the species* present (as defined for this assessment). It is considered unlikely the Project will impact the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	There are no particular weed or pest species identified as relevant to Greater glider. *Phytophthora cinnamomi* is considered a potential threat to the species habitat. Weed and pest control measures will be incorporated into the Project Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The Plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction, *Phytophthora cinnamomi* outbreaks and associated diseases resulting from Project activities (refer Table 5.7). The Plan will consider relevant guidelines to control *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities. This will include at a minimum vehicle washdown procedures and contractor education (including procedures regarding cleaning clothing). This will be particularly important during any revegetation activities in the vicinity of potential Greater glider habitat. Revegetation plant species will be obtained from a reliable source that is certified free of the pathogen. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no State or Commonwealth recovery plan for Greater glider. The Approved conservation advice (TSSC 2016b) notes the following priority management actions applicable to the species: ■ Active threat mitigation in Greater glider habitat including managing fire regimes, constraining timber harvesting activity and clearing in forests with significant subpopulations ■ Avoid fragmentation and habitat loss from developments and upgrades of transport corridors ■ High priority monitoring actions include designing an integrated monitoring program across major subpopulations and monitor the abundance/size structure of critical tree species and their responses to management actions ■ Assess the impacts of fire management strategies on habitat values and Greater glider populations ■ Assess the abundance, density and types of hollow-bearing trees required to support viable populations It is not known if the species occurs within the Project disturbance footprint. The Biosecurity Management Plan will control introduced predators and weeds associated with Project infrastructure, and ensure *Phytophthora cinnamomi* is not introduced to the area as a result of Project activities. Should the species occur any impact will be minor, and is considered unlikely to interfere substantially with the management actions identified above or the recovery of the species.
Assessment of potential for significant residual impacts	Due to the potential of habitat fragmentation and loss of resources such as hollows and habitat, there is potential that this species will be impacted. Under the current Project disturbance footprint there will be clearance of up to 109.05 ha of *potential habitat* for the species. There is extensive identical habitat remaining in the immediate surrounds. Based on the nine-part test above the Project has potential have a significant residual impact on Greater glider. It is to be noted that ARTC have committed to and are conducting additional investigations to determine if Habitat Critical to the survival of the species is present within the Project disturbance footprint. If Critical habitat is conformed as present, the SRI for this species will be reassessed to determine the significant of the project impacts upon this species.

Koala (*Phascolarctos cinereus*)

Ecology and distribution

The Koala is a leaf-eating specialist feeding primarily during dawn, dusk or during the night. Its diet is restricted mainly to foliage of Eucalyptus spp.; however, it may also consume foliage of related genera, including *Corymbia* spp., *Angophora* spp. and *Lophostemon* spp. Koala habitat can be broadly defined as any environment containing Koala food tree species or shelter trees. Along the Great Dividing Range and the coastal belt throughout the species' range, Koalas inhabit moist forests and woodlands dominated by *Eucalyptus* species. Koalas are also known to occur in highly modified (e.g. urbanised) or regenerating native vegetation communities. Home range size is dependent on the quality of habitat. In central QLD home ranges may be as large as 135 ha (Ellis et al. 2002) and a s little as 37 ha in northern NSW (Goldingay and Dobner 2014). Koalas are generally sedentary with longer movements largely restricted to dispersing males which may extend several kilometres through lands cleared of vegetation (DAWE 2020).

Female Koalas generally produce one offspring each year with births occurring between October and May (DAWE 2020). Males are not involved with parental care. Mothers engage in increased feeding and related movements while lactating (Logan and Sanson 2003). The young vacate the pouch permanently at 7 months and then travels with the mother (generally carried on her back) becoming fully weaned at 12 months (van Dyck and Strahan 2009).

The Koala is distributed along the east coast of Australia extending from QLD to NSW (refer Figure 4.3). In QLD, the Koala's distribution extends across several bioregions, encompassing a great diversity of habitats with the greatest concentration in SEQ. In NSW, the species occurs mostly in central and north coasts with populations known to inhabit the area west of the Great Dividing Range (DES 2017d; OEH 2018b).

Distribution in context to the project

Koala individuals and signs of presence (scats/scratches) have been detected within during site surveys for the Project (refer Figure 4.6). Scat surveys noted high densities in some survey areas (Arup in 2016). There are numerous records (AoLA 2020) from the Toowoomba region including a 2019 record within the MNES study area to the north of the Project. There are a large number of records within the MNES study area from 2018 and 2019 (refer Figure 4.3) which are associated with Koala tracking surveys carried out by the DTMR for the TSRC. The records likely include multiple records of the same individual/s. Many records exist in all directions around the Project disturbance footprint within a 50 km buffer (refer Figure 4.8 in Appendix B).

The Koala Strategy (DES 2020d) was recently introduced by the Queensland Government. The Strategy aims to arrest the decline of Koalas in the region through the following targeted outcomes:

- Stabilise Koala population numbers in SEQ.
- A net increase in the total core koala habitat area in the region.
- Commence rehabilitation to restore 10,000 hectares of koala habitat.
- Commence 10 programs in threat priority areas to support at least a 25 per cent reduction in disease, injury and mortality rates in those locations.

The Strategy is supported by new Koala habitat mapping which maps the following key areas within the Project disturbance footprint:

- Koala priority areas: 10.18 ha - defined as large, connected areas to focus habitat conservation strategies with the highest likelihood of conserving SEQ Koala populations.
- Koala core habitat areas: 213.73 ha – defined as the best quality Koala habitat based on habitat modelling

Refer EIS Appendix I: Terrestrial and aquatic ecology technical report for further detail regarding State based mapping of Koala habitat values.

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plan applicable to Koala. The National Koala Conservation and Management Strategy 2009-2014 (Natural Resource Management Ministerial Council 2009) expired in 2014. The DAWE Approved Conservation Advice (DSEWPaC 2012) notes the following potentially threatening processes identified for Koala:

- Habitat loss, modification or fragmentation as a result of urbanisation
- Secondary threats such as predation by domestic dogs, vehicle strikes and stress
- Extreme heat events and drought
- Chlamydia and other diseases (such as Koala retrovirus) which reduces the life expectancy of the species
- Myrtle rust (*Austropuccinia psidii*) is an introduced fungus impacting trees in the Myrtaceae family which includes eucalypts. A small number of trees used by Koalas for foraging have been infected although it is uncertain if this is currently a threat to the species (DAWE 2020).

Important populations and habitat critical to the survival of the species

There are no 'important populations' identified for Koala in the Approved Conservation Advice (DSEWPaC 2012) or the (lapsed) National Koala Conservation and Management Strategy 2009 – 2014 (National Resource Management Ministerial Council 2009). The species occurs from north QLD south to Victoria and west to central QLD. The area is not on the edge of the species distribution and there is no evidence to suggest Koalas in the area are a source for breeding or dispersal or for maintaining genetic diversity.

The 'EPBC Act referral guidelines for the vulnerable Koala' (DotE 2014a) does not refer to any 'important populations' but provides a 'koala habitat assessment tool' to assist in the determining the sensitivity, value and quality of lands potentially impacted under development proposals. The assessment tool is used to determine whether lands may be considered as Habitat critical to the survival of the species and therefore critical to the long-term survival and recovery of the species. The results of the assessment are to aid the decision-making process and determine whether a Project may need to be referred to DAWE based on potential significant impacts to Koalas and/or habitat critical to the survival of the species. The identification of Habitat critical to the survival of the species may be used as a surrogate for 'important populations' when assessing a Project's impacts under the Guidelines. The assessment summarised in Table 5.36 is based on information obtained during opportunistic surveys within the MNES study area.

Table 5.36 Koala habitat assessment tool (DotE 2014) - Project area

Attribute	Score	Details
Koala occurrence	2	The species was detected during Project-associated surveys within the Project disturbance footprint. There is at least one 2019 database record of the species within the MNES study area near Blue Mountain Heights.
Vegetation composition	2	The vegetation communities within the Project disturbance footprint contain woodlands/open forest with two or more koala food trees.
Habitat connectivity	2	Based on koala habitat extent, the woodland areas east of Mount Kynock which are intersected by the Project disturbance footprint are a part of a contiguous landscape that is greater than 500 ha.
Key existing threats	0	There are likely to be populations of feral dogs/dingoes throughout the MNES study area, that would result in koala mortality. Sections of the Project area lie close to major roads where car mortality may be an issue including the TSRC, Warrego Highway, New England Highway and Murphy's Creek Road
Recovery value	1	It is uncertain whether the habitat is important for achieving interim recovery, as: ■ Continued mortality due to vehicle strikes and dog attacks
Koala habitat score	**7**	Habitat is 'critical to the survival of Koala' where Koala habitat score is ≥ 5

Habitat within the Project disturbance footprint is considered Habitat critical to the survival of the species based on the Koala habitat score (7) for the Project disturbance footprint. Under the referral guidelines for Koala (DotE 2014a) it is recommended that a project be referred where it is proposed to 'clear ≥ 20 ha of habitat containing known Koala food trees in an area with a habitat score ≥ 8.' For the significant impact assessment this habitat is considered a surrogate for an 'important population'.

The main impacts predicted from the Project include habitat removal, injury/mortality to individuals during clearing and vehicle/train collision, habitat fragmentation and barrier effects. The predictive habitat modelling indicates 189.01 ha of *Habitat critical to the survival of the species* and 70.6 ha of *potential habitat* occurs within the disturbance footprint (refer Table 4.4 and habitat figure in Appendix G) under the habitat modelling approach used for this assessment (refer Appendix A). Critical habitat includes all mapped remnant and regrowth vegetation communities containing eucalypt species and includes drainage lines which may provide suitable riparian habitat trees located outside of known vegetation mapping. *Habitat critical to the survival of the species* occurs throughout the MNES study area (but is particularly dominant in the Toowoomba Range) and is similar to the extent of 'core Koala habitat area' mapped under the State's Koala habitat mapping.

The *EPBC Act referral guidelines for the vulnerable Koala* (DotE 2014) broadly defines koala habitat as:

> *"any forest or woodland containing species that are known koala food trees, or shrubland with emergent food trees. This can include remnant and non-remnant vegetation in natural, agricultural, urban and peri-urban environments. Koala habitat is defined by the vegetation community present and the vegetation structure; the koala does not necessarily have to be present."*

The Project is located within the coastal context for the species and within this area koala habitat has been further defined as:

> *"large, connected areas of native vegetation including in forests and woodlands where logging has altered tree species composition, these areas may be*
>
> - *Remnant, regrowth or plantation vegetation*
> - *Small, isolated patches of native vegetation in rural, urban or peri-urban areas*
> - *Windbreaks and narrow areas of native vegetation along riparian areas of linear infrastructure*
> - *Isolated food and/or shelter trees (i.e. on farmlands, in suburban streetscapes, parks and yards)"* (Dote 2014).

The predictive habitat modelling indicate 189.01 ha of *Habitat critical to the survival of the species* and a further 70.6 ha of *potential habitat* for Koala occurs within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G) under the habitat modelling approach used for this assessment (refer Appendix A). Potential habitat is based on a 1 km buffer place on recent species records (refer Figure 4.3) located outside of mapped vegetation communities (remnant or regrowth). This encompasses habitat comprising scattered trees in grazing paddocks (in which the species may occur but do not necessarily link larger patches of vegetation and grazing and cropped areas which do not feature trees at all. As such, potential habitat significantly over-estimates areas of available habitat for the species. Habitat determination will be subject to further refinement during the final design stage of the Project.

In the context of the Project the western extent of the alignment has been heavily cleared for agriculture and grazing land uses. The *draft Guide to nationally protected species significantly impacted by paddock tree removal* (DotEE 2020) notes for Koala that an impact requiring approval (under the EPBC Act) may be required when 'removing paddock trees where they are *Habitat critical to the survival of the species* or provide the only movement opportunity / refuge to or between areas of Habitat critical to the survival of the species. This is unlikely to occur as a result of the Project given it is linear, there is an existing rail line adjacent to the Project in this area (West Moreton System) and there will be trees located adjacent to the Project footprint to allowed continued linkage between larger patches of vegetation.

Impacts and mitigation measures associated with this species are identified within Table 5.3 and Table 5.7. The main impacts predicted from the Project include habitat removal, injury/mortality to individuals during clearing and vehicle/train collision, and habitat fragmentation. The following significant impact assessment (refer Table 5.37) under the MNES guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.37 Assessment against the significant impact criteria - Koala

Criteria	Assessment against significance criteria (vulnerable species)
Lead to a long-term decrease in the size of an important population of the species	The species is known to occur within the Project disturbance footprint and surrounds. There is no evidence the MNES study area comprises habitat supporting an 'important population' of Koala. The species was identified as present in eucalypt habitat within the MNES study area. Evidence from Project-associated scat/scratch surveys for Koala suggests the species may occur in high densities. Pre-clearance surveys will be carried out where suitable habitat for this species is identified within the final construction footprint. Provisions to protect Koalas will be in place within the Flora and Fauna Sub-plan should individuals be located within the Project disturbance footprint (refer Table 5.3 and Table 5.7). Should the species be found individuals will remain undisturbed and allowed to leave the construction area of their own volition or be relocated from the area of disturbance by qualified fauna spotter-catchers. In addition to loss of habitat, the Project (construction and operations) will act as a potential barrier to movement (generally north south, with east west connectivity maintained). Fauna passage will be provided at a number of locations along the alignment to facilitate fauna movement in the form of viaducts (refer Section 5.2). Koala-proof fencing will be used to guide Koalas to the open viaduct areas with extent of Koala proof fencing dependent on surrounding Koala habitat availability and known movement corridors. The Project is predicted to require clearing up to 189.01 ha of *Habitat critical to the survival of the species* and 70.6 ha of *potential habitat* for the species. The Project is linear and there is abundant similar habitat in the region surrounding the Project alignment. It is considered unlikely the Project will lead to a long-term decrease in the size of an important population of Koala.
Reduce the area of occupancy of an important population	There is no evidence the MNES study area supports an important population of Koala. Evidence suggests the species may occur in high densities in the area. The Project is predicted to require clearing up to 189.01 ha of *Habitat critical to the survival of the species* and 70.6 ha of *potential habitat* for the species. As such the Project will likely reduce the potential area of occupancy of the local population, although as noted, an 'important population' is not known to occur in the area.
Fragment an existing important population into two or more populations	Lands surrounding the western extent of Project disturbance footprint (west of the top of the range) have been heavily modified and cleared. Nevertheless, the species is known to traverse cleared lands when foraging. The Project is linear. The project is co-located with the west Moreton system at Gowrie and east of Lockyer creek and west of Helidon, and is greenfield for 22 km of its length. The alignment crosses through the more elevated area within the Toowoomba Range via a tunnel (i.e. 6.24km) allowing unimpeded movement above this area. Several viaducts (i.e. 6.7km) along the alignment within the Toowoomba Range will also allow substantial movement opportunities across the project. The Project will also apply design mitigation with the incorporation of Koala-proof fencing at targeted areas as part of the final Project design (refer Section 5.2.1). Given the existing linear infrastructure already in place in the immediate surrounds and the incorporation of crossing structures the Project is considered unlikely to further fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	Habitat critical to the survival of the species for Koala has been assessed as occurring on the site as defined under the Koala referral guidelines. The Project is predicted to require clearing of up to 189.01 ha of *Habitat critical to the survival of the species*. As such the Project will adversely affect habitat critical to the survival of the Koala.
Disrupt the breeding cycle of an important population	Where possible, clearing activities will take place outside the breeding season for Koala (October-May). Provisions to protect Koalas will be in place within the Flora and Fauna Sub-plan should individuals be located within the Project disturbance footprint (refer Table 5.3 and Table 5.7). For example, should the species be found individuals will remain undisturbed and allowed to leave the construction area of their own volition or be relocated from the area of disturbance by qualified fauna spotter-catchers. There are no particular breeding requirements associated with the species. (young travel with the mothers within the individual's territory). Barriers to movement and dispersal have been incorporated into the design of the Project (fauna crossing structures, fencing and avoidance of habitat above the tunnel). Should the species be found individuals will remain undisturbed and allowed to leave the construction area of their own volition or be relocated from the area of disturbance by qualified fauna spotter-catchers. It is considered unlikely the Project will disrupt the breeding cycle of an important population.

Criteria	Assessment against significance criteria (vulnerable species)
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There is suitable woodland habitat for the species within the Project disturbance footprint. However; there is abundant suitable habitat for the species in the area surrounding the Project and the wider SEQ region. The species occurs across a wide area from northern central QLD south to Victoria. As noted in Section 5.1.2, Project impacts are not restricted to the footprint and there is the potential to impact on potential habitat as a result of edge effects, dust deposition, noise and light, changes to soil and changes to hydrology. Nevertheless, it is considered unlikely the Project will impact the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	There are no particular weed species identified as relevant to Koala. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. *Lantana* species (including *L. camara* and *L. montevidensis*) were common throughout the MNES study area with severe infestations at some sites. Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). Feral predators are identified as a threat to the species (DSEWPaC 2012). Although none were recorded during project surveys. Species such as feral dog are likely to be present to some extent in the area. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be a part of the CEMP and Operation EMP. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The local landscape is already subject to extensive weed infestation with *Lantana camara* in forest habitats and exotic grasses in agricultural habitats. The plan will be in place for the life of the Project and will minimise the potential for weed invasion or spread. Pest measures will ensure feral predators (i.e. wild dogs/dingo) are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction, *Phytophthora cinnamomi*, Myrtle rust outbreaks and associated diseases (such as Chlamydia) resulting from Project activities (refer Table 5.7). The plan will consider relevant guidelines to control Phytophthora cinnamomi and Myrtle rust (e.g. DotE 2015b) associated with Project activities. This will include at a minimum vehicle washdown procedures and contractor education (including procedures regarding cleaning clothing). This will be particularly important during any revegetation activities in the vicinity of Koala habitat. Revegetation plant species will be obtained from a reliable source that is certified free of these pathogens. Vegetation clearing within the Project disturbance footprint in Koala habitat will be carried out in a manner to minimise stress on potential individuals as much as is practicably possible (e.g. sequential clearing and minimising time of disturbance to animals) as stressed animals are more susceptible to Chlamydia infection. Where individuals are required to be handled during vegetation clearing they will be examined by experienced personnel. If the individual is suspected of Chlamydia infection it will be taken to a veterinarian/wildlife care facility for treatment prior to release. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	There is no State or Commonwealth recovery plan for Koala. The *EPBC Act referral guidelines for the vulnerable Koala* (DotE 2014a) notes the following actions that may substantially interfere with the recovery of the Koala in areas associated with Habitat critical to the survival of the species: ▪ Increasing koala fatalities due to dog attacks to a level that is likely to result in multiple, ongoing mortalities ▪ Increasing koala fatalities due to vehicle-strikes to a level that is likely to result in multiple, ongoing mortalities. ▪ Facilitating the introduction or spread of disease or pathogens for example Chlamydia or *Phytophthora cinnamomi*, to habitat critical to the survival of the koala ▪ Creating a barrier to movement that is likely to result in a long-term reduction in genetic fitness or access to habitat critical to the survival of the koala

Criteria	Assessment against significance criteria (vulnerable species)
	▪ Changing hydrology which degrades habitat critical to the survival of the koala to the extent that the carrying capacity of the habitat is reduced in the long-term The Project will employ a range of mitigation measures (refer Table 5.7) to minimise these impacts including measures identified in Section 8 of the referral guidelines (DotE 2014a). Of the identified actions the Project may increase mortality due to ongoing vehicle (rail line) strikes in the long-term. Evidence suggests the species may occur in high densities in the area. With mitigation of potential Project impacts through measures incorporated within the CEMP, any potential impact on Koala will be minor and is considered unlikely to interfere substantially with the recovery of the species.
Assessment of potential for significant residual impacts	The Project will result in the clearance of up to 189.01 ha of *Habitat critical to the survival of the species* and a further 70.6 ha of *potential habitat* for the species. Based on the nine-part test for significance the Project is likely to have a significant residual impact on Koala.

Long-nosed potoroo (*Potorous tridactylus tridactylus*)

Ecology and distribution

The Long-nosed potoroo (South-east Mainland) is a small nocturnal potoroid known to predominantly consume hypogeous and epigeous components of fungal fruit bodies (30 to 90 per cent of the diet) as well as invertebrates, roots and bulbs (Woinarski et al 2014). In NSW and QLD, there is no consistent pattern to the habitat of the Long-nosed potoroo. It can be found in wet eucalypt forests to warm temperate rainforest and coastal heaths and scrubs (Woinarski et al 2014). The species requires dense low vegetation and ground cover used for shelter and avoiding predators, although it may forage in more open areas. The species is known to utilise Lantana (*Lantana camara*) thickets for shelter (Lindemayer and Viggers 1994). The main habitat requirements appear to be some form of dense vegetation for shelter and the presence of light, friable soils and an abundance of fungi (Bennett 1987; Claridge et al. 1992; DES 2017e). Breeding may occur throughout the year, although births appear to peak in late winter and early spring (Woinarski et al 2014).

In NSW and QLD, the Long-nosed potoroo (SE Mainland) has scattered populations east of the Great Dividing Range extending from SEQ through to NSW. Its range is largely coastal extending up to 800 m asl and preferring areas with rainfall exceeding 760 mm (Woinarski et al 2014). In QLD the species has been recorded from southeast of Gladstone to Lamington National Park and the Border Ranges. The species is also found in southern Victoria (Amos 1982; Lindenmayer and Viggers 1994).

Distribution in context to the Project

The species has not been recorded during any Project-associated surveys or during surveys for the nearby TSRC project. There are five database records occurring within 50 km of the Project, although none of these occurs within the MNES study area. The nearest database record is from 2015 and located 13 km south of the Project in the Toowoomba Range. Other database records occur to the north and northeast including Crows Nest National Park (2012 – 20km north), Lockyer National Park (1990), Ravensbourne National Park (four records from 1977 to 1986 – 19 km north) and Deongwar State Forest (2014 – 24 km north). There is also a 1991 record from Lockyer National Park (19 km northeast of the eastern extent of the Project) (refer Figure 4.12 in Appendix B). Although there are few records from the wider area the species is known from montane areas and may be difficult to detect. There is abundant suitable habitat available within the MNES study area and it may utilise the dense Lantana thickets observed during Project surveys.

DAWE (2020) species habitat mapping indicates the species or species habitat as may occur in the Project disturbance footprint from Helidon to the Highfields area (north of Toowoomba).

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species.

The DAWE Approved Conservation Advice (TSSC 2019b) notes the following potentially threatening processes identified for Australian habitat as relevant to Long-nose potoroo:

- Loss and modification of habitat due to urban, industrial and agricultural development
- Habitat degradation caused by grazing from livestock and introduced herbivores such as deer and pigs (*Sus scrofa*)
- *Phytophthora* and Myrtle rust is thought to be a threat to the species habitat
- Introduced predators including Red fox (*Vulpes Vulpes*) cat (*Felis catus*) and dog (*Canis familiaris*)
- Inappropriate fire management
- Climate change impacts to habitat

The following threat abatement plans have been identified as being relevant for this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d)
- *Threat abatement plan for predation by the European red fox* (DEWHA 2008m).

Important populations and habitat critical to the survival of the species

There are no robust estimates of the subspecies overall population. Based on repeated surveys at a small number of known sites the overall population is thought to comprise less than 10,000 individuals (Woinarski et al 2014). A review of the available literature has not identified any important populations, populations that are key to the long-term survival and recovery of this species or *Habitat critical to the survival of the species* (TSSC 2019b; Woinarski et al 2014). SEQ and northern NSW is considered a stronghold of the species northern distribution. The Project is located on the western edge of its distribution in SEQ and as such the species may be considered as on the western limit of the species range in the area. As such the Project has some potential to impact an important population should the species occur in the area. In the absence of any other habitat definition for the species this assessment has defined *Habitat critical to the survival of the species* by applying a 1 km buffer on known records that intersect '*potential habitat*' for the species (refer Appendix A for methodology).

Impacts and mitigation measures associated with this species are identified within Table 5.7. The predictive habitat modelling indicates 156.25 ha of *potential habitat* may be impacted within the Project disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). The following significant impact assessment (refer Table 5.38) under the MNES guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.38 Assessment against the significant impact criteria – Long-nosed potoroo

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population of a species	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint. Although there are no records within or near the MNES study area the species has been recorded in the wider area to the, north northeast and south of the Project. The nearest record is recent (2015) is located 13 km south of the Project disturbance footprint. It is uncertain to what extent habitat within the footprint may be suitable for the species. The species habits are discrete and it is difficult to observe. There is substantial suitable habitat present and the species is known to utilise Lantana (*Lantana camara*) thickets which are common within the alignment. Pre-construction surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final construction footprint. Provisions to protect the species will be in place within the Flora and Fauna Sub-plan should individuals be located within the Project disturbance footprint (refer Table 5.7). Should the species be found individuals will be relocated from the area of disturbance by qualified fauna spotter-catchers. It is noted that the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event.

Criterion	Assessment against significance criteria
Reduce the area of occupancy of an important population	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint although it is unknown if the species occurs. Pre-construction surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final construction footprint. The Project is predicted to impact 156.25 ha of *potential habitat* for the species. Should the species be found to occur there is potential the Project will reduce the area of occupancy of an important population of the species.
Fragment an existing important population into two or more populations	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint. The Project is linear but impacts areas which are already subject to extensive fragmentation. The project is co-located with the west Moreton system at Gowrie and east of Lockyer creek and west of Helidon. The alignment crosses through the more elevated area within the Toowoomba Range via a tunnel allowing unimpeded movement above this area. Several viaducts along the alignment within the Toowoomba Range will also allow substantial movement opportunities across the project. It is considered unlikely that the Project will fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The Project is predicted to impact 156.25 ha of *potential habitat* for the species. There is no *Habitat critical to the survival of the species* (as defined for this assessment) present. The Project is located within an area already subject to substantial disturbance (such as the TSRC). As such, the Project is considered unlikely to adversely affect habitat critical to the survival of the Long-nosed potoroo.
Disrupt the breeding cycle of an important population	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint. The species may breed at any time of year. It is uncertain if the species occurs in the Project disturbance footprint. Pre-clearance surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final construction footprint. Should the species be found to occur there is some potential for the Project to disrupt the breeding cycle of an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is uncertain if the species occurs in the Project disturbance footprint. The Project is predicted to impact 156.25 ha of *potential habitat* for the species. Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint to the northeast where the species is known to occur. Predictive mapping indicates there is 1,724 ha of identical habitat located within the immediate surround of the MNES study area. It is considered unlikely the Project will impact the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	There are no particular weed species identified as relevant to Long-nosed potoroo. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. Lantana (*Lanatana camara*) was common throughout the MNES study area with severe infestations at some sites. The species is known to utilise the dense cover provided by Lantana. Feral predators are identified as a threat to the species (TSSC 2019b). Although none were recorded during project surveys species such as feral dog and cat are likely to be present to some extent in the area. *Phytophthora cinnamomi* is considered a potential threat to the species habitat. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction, *Phytophthora cinnamomi*, Myrtle rust outbreaks and associated diseases (such as Chlamydia) resulting from Project activities (refer Table 5.7). The plan will consider relevant guidelines to control *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities. This will include at a minimum vehicle washdown procedures and contractor education (including procedures regarding cleaning clothing). This will be particularly important during any revegetation activities in the vicinity of Long-nosed potoroo habitat. Revegetation plant species will be obtained from a reliable source that is certified free of these pathogens. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.

Criterion	Assessment against significance criteria
Interfere substantially with the recovery of the species	Conservation actions listed in the Approved Conservation Advice for the species (TSSC 2019b) includes: ■ Survey and monitoring of the species to ascertain distribution and population trends of existing populations and surveys to determine the species presence elsewhere where suitable habitat is identified ■ Implementing policies and processes to avoid further clearing/fragmentation of habitat and investigate revegetation programs where the species is known to occur ■ Remove and prevent livestock and introduced herbivores to prevent further habitat degradation ■ Implement landscape-scale predator control for priority population ■ Reduce the impact of timber harvesting practises ■ Manage fire regimes in known habitat There is no reason for the Project to substantially interfere with the conservation actions outlined in above. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. Any impact on the species is likely to be minor, at worst, and is considered unlikely to interfere substantially with the recovery of the species. Should the species be found to occur it will add to current information on the species distribution.
Assessment of potential for significant residual impacts	The Project may result in the clearance of 156.25 ha of *potential habitat* predicted to occur in the Project disturbance footprint. There is some evidence to suggest the species may occur within or adjacent to the Project disturbance footprint. Based on the nine-part test detailed the Project is considered to have potential to cause significant residual impacts on an *important population* of Long-nosed potoroo, should the species be found to occur.

New Holland mouse (*Pseudomys novaehollandiae*)

Ecology and distribution

The New Holland mouse is a native small, burrowing rodent. The species is a nocturnal and omnivorous species feeding on seeds, insects, leaves, flowers as well as fungi. This is a social species living in shared burrows. Considerable time is spent foraging above ground for food (DAWE 2020). The known breeding period for the species in NSW occurs between August and January but can extend to autumn with slight variation between years producing litters ranging from 2 to 6 young. Female New Holland mouse are capable of producing two litters in a breeding season (Woinarski et al 2014).

In the south of its range New Holland mouse is known to inhabit open heathlands, woodlands and forests with heathland understorey as well as vegetated sand dunes. However, populations in SEQ have also been trapped in dry sclerophyll forest with little shrub or ground cover (Van dyck and Lawrie 1997; Menkhorst and Knight 2011). Peak population abundance is thought to be in early to mid-stage vegetation succession typically induced by fire. Populations have also been noted as influenced by rainfall with higher numbers occurring during years of above average rainfall (Woinarski et al 2014). The species has a home range of between 0.44 to 1.4 ha (DAWE 2018; OEH 2017d).

The known distribution of the New Holland mouse is fragmented along the east coast of Australian from QLD through to Tasmania. The extent of occurrence of New Holland mouse in QLD, NSW, Victoria and Tasmania is still unknown, although further research currently being undertaken (DAWE 2020). There appears to be little information on the species potential extent of occurrence in SEQ.

Distribution in context to the Project

The species has not been recorded during any Project-associated surveys or during surveys for the nearby TSRC project, although targeted surveys have not been carried out. Two records (2000) exist in the Helidon Hills 6 km to the northeast of the eastern end of the Project. Further records (from 2000, 2001 and 2012) occur 15 km to 30 km north of these records between Lockyer National Park and Crows Nest (refer Figure 4.14 in Appendix B). Two other records exist at Main Range National Park from 1997 more than 50 km southeast of the Project disturbance footprint. DAWE (2020) species habitat mapping indicates the species or species habitat as likely to occur in the Project disturbance footprint.

Recovery plans/threat abatement plans

There is no Commonwealth adopted recovery plan or threat abatement plans applicable to this species.

The DAWE Approved Conservation Advice (DEWHA 2010b) notes the following potentially threatening processes identified for Australian habitat as relevant to New Holland mouse:

- Loss and modification of habitat due to urban and agricultural development
- *Phytophthora* is thought to be a threat to the species habitat
- Introduced predators including Red fox (*Vulpes vulpes*) cat (*Felis catus*) and dog (*Canis familiaris*)
- Inappropriate fire management and invasive weed species
- Climate change impacts to habitat alteration and fragmentation

The following threat abatement plans have been identified as being relevant for this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d)
- *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi.* (DotEE 2018).

Important populations and habitat critical to the survival of the species

There are no important populations or definition of Habitat critical to the survival of the species in any available literature for the species. The Project disturbance footprint intersects habitat associated with the northernmost population of the species (in the Lockyer Forest Reserves) and therefore may be considered to potentially impact an 'important population'.

In the absence of any other habitat definition for the species this assessment has defined *Habitat critical to the survival of the species* by applying a 1 km buffer on known records that intersect 'potential habitat' for the species (refer Appendix A for methodology). Predictive habitat mapping indicates that the Project may impact 156.25 ha of *potential habitat* in which this species may occur (refer Table 5.4 and habitat figure in Appendix G). The Project disturbance footprint is not considered to comprise *Habitat critical to the survival of the species*. This includes substantial habitat located within the Toowoomba Range where the species has not been recorded previously and may be an overestimation of the potential occurrence of the species. The occurrence of the preferred heath understorey within the MNES study area has not been documented.

Impacts and mitigation measures associated with this species are identified within Table 5.7. The following significant impact assessment (refer Table 5.39) under the MNES guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.39 Assessment against the significant impact criteria - New Holland mouse

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population of a species	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint. Although there are no records within the MNES study area the species has been recorded in the wider area to the northeast of the eastern extent of the Project (north of Helidon). The nearest records (2000) located 6 km northeast of the Project disturbance footprint. It is uncertain to what extent habitat within the footprint may be suitable for the species. It is noted the area is subject to substantial existing disturbance in the vicinity of the Project disturbance footprint (the adjacent QR West Moreton System rail corridor and the Toowoomba Bypass). Pre-construction surveys (as per State survey guidelines – it is noted there are no DAWE guidelines relevant to the species) will be carried out where suitable habitat for this species is identified within the final Project disturbance footprint. Provisions to protect the species will be in place within the Project Flora and Fauna Sub-plan should individuals be located within the disturbance footprint (refer Table 5.7). Should the species be found individuals will be relocated from the area of disturbance by qualified fauna spotter-catchers as close as possible to where the species was collected and in suitable habitat. It is noted that the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the population by providing access to otherwise inaccessible areas during a bushfire event. The Project is predicted to impact 156.25 ha of potential habitat for the species, although this likely an overestimation as it includes habitat within the Toowoomba Range where the species has not been recorded previously. Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint to the north where the species is known to occur. It is considered unlikely the Project will lead to a long-term decrease in the size of an important population of the species.
Reduce the area of occupancy of an important population	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint although it is unknown if the species occurs. Pre-construction surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final construction footprint. The Project is predicted to impact 156.25 ha of potential habitat for the species, although this likely an overestimation as it includes habitat within the Toowoomba Range where the species has not been recorded previously. Should the species be found to occur there is potential the Project will reduce the area of occupancy of an important population of the species.
Fragment an existing important population into two or more populations	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint. The Project is linear but impacts areas which are already subject to extensive fragmentation. The project is co-located with the west Moreton system at Gowrie and east of Lockyer creek and west of Helidon. The alignment crosses through the more elevated area within the Toowoomba Range via a tunnel allowing unimpeded movement above this area. Several viaducts along the alignment within the Toowoomba Range will also allow substantial movement opportunities across the Project. It is considered unlikely that the Project will fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	The Project is predicted to impact 156.25 ha of *potential habitat* for the species, although this likely an overestimation as it includes habitat within the Toowoomba Range where the species has not been recorded previously. There is no *Habitat critical to the survival of the species* present (as defined for this assessment). The Project is located within an area already subject to substantial disturbance. As such The Project is considered unlikely to adversely affect habitat critical to the survival of New Holland mouse.
Disrupt the breeding cycle of an important population	There is potential for habitat supporting an 'important population' to occur within the Project disturbance footprint. The species breeding pattern in QLD remains unknown. In NSW the species may breed from August through to Autumn although breeding may be irruptive dependent on local weather conditions. It is uncertain if the species occurs in the Project disturbance footprint. Pre-clearance surveys (as per DAWE survey guidelines) will be carried out where suitable habitat for this species is identified within the final construction footprint. Should the species be found to occur there is some potential for the Project to disrupt the breeding cycle of an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	It is uncertain if the species occurs in the Project disturbance footprint. The Project is predicted to impact 156.25 ha of *potential habitat* for the species, although this likely an overestimation. Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint to the northeast where the species is known to occur. Predictive mapping indicates there is 1,716 ha of identical habitat located within the immediate surrounds of the MNES study area. It is considered unlikely the Project will impact the availability or quality of habitat to the extent that the species is likely to decline.

Criterion	Assessment against significance criteria
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	There are no particular weed or pest species identified as relevant to New Holland mouse. *Phytophthora cinnamomi* is considered a potential threat to the species habitat. Project-associated surveys observed feral predators including cats (a significant predator of small mammals) as present in the area. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction, *Phytophthora cinnamomi* outbreaks and associated diseases resulting from Project activities (refer Table 5.7). The Plan will consider relevant guidelines to control *Phytophthora cinnamomi* and Myrtle rust (e.g. DotE 2015b) associated with Project activities. This will include at a minimum vehicle washdown procedures and contractor education (including procedures regarding cleaning clothing). This will be particularly important during any revegetation activities in the vicinity of New Holland Mouse habitat. Revegetation plant species will be obtained from a reliable source that is certified free of these pathogens. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	Recovery strategies listed in the Approved Conservation Advice for *Pseudomys novaehollandiae* (New Holland mouse) (DEWHA 2010b) include: ■ Mitigate the loss, disturbance or modification of important habitat ■ Control exotic flora ■ Reduce feral animal predation or competition ■ Implement appropriate fire management regimes ■ Manage and mitigate disease, fungi and parasites ■ Provide conservation information to communities and interest groups. There is no reason for the Project to substantially interfere with the recovery strategies outlined above. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The Biosecurity Management Plan will control introduced predators and weeds associated with Project infrastructure, and ensure *Phytophthora cinnamomi* is not introduced to the area as a result of Project activities. Should the species occur any impact will be minor, and is considered unlikely to interfere substantially with the recovery of the species.
Assessment of potential for significant residual impacts	The Project may result in the clearance of 156.25 ha of *potential habitat* predicted to occur in the footprint. This is largely located within the Toowoomba Range where the species has not been recorded previously. A conservative approach has been applied to the assessment and based on the nine-part test for significance the Project has some potential to have a significant residual impact on New Holland mouse.

Grey-headed flying-fox (*Pteropus poliocephalus*)

Ecology and distribution

The Grey-headed flying-fox is a canopy-feeding species that eats fruit and nectar. This species utilises a range of vegetated habitats, including rainforests, open forests, closed and open woodlands, *Melaleuca* swamps and *Banksia* woodlands. In an urban setting, this species is known to feed on commercial fruit crops, and on introduced tree species. Roost sites are generally located near water bodies. This species is known to roost in vegetation ranging from rainforest, Melaleuca stands, mangroves and riparian vegetation. The species has a high level of roost site fidelity, although new sites have been known to be colonised (DAWE 2020). The species travels to foraging areas usually located within 15 km of the roost site (Tidemann 1998), although they are capable of travelling up to 50 km when local foraging resources change (Eby 1991).

Nectar and pollen from *Eucalyptus*, *Corymbia, Angophora, Melaleuca*, and *Banksia* species are considered the primary food source for Grey-headed flying foxes. This species is known to supplement its diet with a wide range of rainforest fruits and introduced species (Duncan et al. 1999). Mating is known to occur in the early autumn months, after which time the larger camps begin to separate, reforming in late spring/early summer when food resources become more abundant. Males and females typically separate in October, when the young are born.

The Grey-headed flying-fox occurs in the coastal belt of Eastern Australia, typically ranging from Rockhampton in central QLD to Melbourne in Victoria. It is noted that only a small portion of this range is used at any one time, as the species selectively forages where resources are available. The availability of food resources have a direct influence on the occurrence and relative abundance within the Grey-headed flying foxes distribution in various seasons and years (DAWE 2020). As such, the species is known to make seasonal movements between camps. Dispersal from large breeding camps in the Brisbane area to regional areas occurs in winter (Nelson 1965).

Distribution in context to the Project

The species was not identified during Project-associated surveys, including roost sites. Five records (AoLA) exist for this species from within the Toowoomba Range from 2004 to 2011 (refer Appendix B). Four of these (from 2007 and 2011) are associated with a flying-fox roost site located 540 m south of the Project disturbance footprint (to the east of the New England Highway) (refer Figure 4.3). There is no recent data collected from this site. There are a number of database records in the surrounds largely to the south in Toowoomba but also to the north on Murphy's Creek and the Highfields area (refer Figure 4.6 in Appendix B). The species main distribution extends from Rockhampton south to Victoria and South Australia. The Project disturbance footprint is not at the limit of the species range. Based on quarterly flying-fox data collected by DES in the SEQ region there are two Flying-fox camps located within 15 km of the Project which regularly comprise Grey-headed flying-fox: Spring Street in Toowoomba (8.5 km south); and Jackson Close in Highfields (5 km north).

The *Referral guideline for management actions in grey-headed and spectacled flying-fox camps* (DotE 2015c) identifies 'nationally important' camps for Grey-headed flying-fox as:

- Camps that have contained ≥ 10,000 Grey-headed flying-foxes in more than one year in the last 10 years, or
- Have been occupied by more than 2,500 Grey-headed flying-foxes permanently or seasonally every year for the last 10 years.

Neither of the identified camps have sustained numbers of Grey-headed flying-fox analogous to the definition of a 'nationally important' camp based on the available data (collected from 2007 to November 2019).

Recovery plan/threat abatement plans

There is currently a draft *National recovery plan for the Grey-headed flying-fox (Pteropus poliocephalus*) (DotEE 2017a) awaiting adoption by DAWE. The draft Plan identifies the following threatening processes as applicable to the species:

- Loss of roosting and foraging sites (particularly winter foraging habitat)
- Human animal conflict, particularly in rural areas where flying-foxes can impact fruit orchards and in urban areas where roosts are perceived to impact local residents. This is a particular issue applicable to flying-fox camps in urban areas.
- Heat stress during extreme heat waves
- Entanglement in backyard netting and electrocution on power lines
- Potential threats include the impacts of climate change (particularly with reference to extended heat waves) and zoonotic diseases.

Important populations/Habitat critical to the survival of the species

Important populations are not identified in the draft *National recovery plan for the Grey-headed flying-fox (Pteropus poliocephalus*) (DotEE 2017a). The species distribution extends from Rockhampton south to Victoria and South Australia. The Project disturbance footprint is not at the limit of the species range. This is a highly mobile species and the linear nature of the Project is not expected to impact dispersal or breeding capacity.

The Plan does not specifically identify habitat critical to the survival of the species but does recommend management of habitat associated with a number of tree species located within the MNES study area including *Eucalyptus tereticornis, E. crebra, E. siderophloia, Corymbia citriodora citriodora,* and *Grevillea robusta*. Vegetation communities associated with the Project disturbance footprint generally comprise at least one of these species. The species will also feed on fruiting tree species in vine forest communities within the MNES study area. All vegetation within the alignment is considered 'potential habitat' for the species. Predictive impact assessment has taken a conservative approach for this species and included all remnant and regrowth vegetation communities within a 15 km radius of the known regular roost sites for the species that are local to the MNES study area as Habitat critical to the survival of the species.

Impacts and mitigation measures associated with this species are identified within Table 5.7. The predictive assessment estimates 201.19 ha of Habitat critical to the survival of the species (<15 km from known roost sites) may be impacted under the current disturbance footprint (refer Table 5.4 and habitat figure in Appendix G). Assessment against the significant impact criteria for vulnerable species is shown in Table 5.40.

Table 5.40 Matters of national environmental significance significant residual impact criteria – Grey-headed flying-fox

Criteria	Assessment against significance criteria (vulnerable species)
Lead to a long-term decrease in the size of an important population of the species	There are no 'important populations' defined for this species. The species was not observed within the MNES study area during Project surveys and no roost sites were observed in the vicinity. There are records within the MNES study area south of the Project disturbance footprint. The species has been commonly recorded in the wider area surrounding the Project, largely to the south. There are at least two camp locations regularly used by the species located within 15 km of the MNES study area. The camps in Toowoomba and Highfields are located 8.5 km south and 5 km north of the Project disturbance footprint respectively. The Project will not conceivably impact these sites. A study by Law and Eby 2008 (ranking the feeding habitats of Grey-headed flying foxes for conservation management) noted that the during winter productive areas are concentrated in coastal floodplains, coastal dunes and inland slopes of SEQ. In addition, the study noted that the majority of winter habitats are heavily cleared, poorly conserved and recognised as endangered vegetation communities. The Project encompasses habitat located on the inland slopes of the edge of SEQ and as such may pose some risk to the species (i.e. loss of foraging habitat in particular winter and spring is a key threat to the species). Important winter and spring habitats include vegetation communities that contain *Eucalyptus tereticornis, E. crebra, E. melliodora, E. pilularis, Corymbia citriodora, Grevillea robusta or Melaleuca quinquenervia*) with several of these species known from the MNES study area. The species will sporadically utilise these resources based on local flowering patterns, with the species known to have a high degree of annual variation in the occurrence at a local scale. Foraging habitat for Grey-headed flying-fox occurs across the Project disturbance footprint encompassing 201.19 ha of *Habitat critical to the survival of the species* (as defined for this assessment). Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint (including 2,790 ha within the MNES study area) and the species will forage in heavily modified habitats such as urban gardens. The species is only likely to utilise the area seasonally based on local flowering patterns. As outlined in Section 5.1.2 the Project will result in edge effects, changes to biological viability of soil or from the deposition of dust, which may result in the degradation of foraging habitat. However, the extent of these impacts will vary spatially and temporally across the Project disturbance footprint. Given there are no 'important populations' identified for Grey-headed flying-fox it is considered unlikely the Project will lead to a long-term decrease in the size of an important population of the species.

Criteria	Assessment against significance criteria (vulnerable species)
Reduce the area of occupancy of an important population	There are no 'important populations' defined for this species. The Project will not impact local roost sites the species is known to regularly use. Foraging habitat for Grey-headed flying-fox occurs across the Project disturbance footprint encompassing 201.19 ha of *Habitat critical to the survival of the species* (as defined for this assessment). Nevertheless, there is abundant similar habitat in the region surrounding the Project disturbance footprint (including 2,790 ha within the MNES study area) and the species will forage in heavily modified habitats such as urban gardens. The species is only likely to utilise the area seasonally based on local flowering patterns. Given there are no 'important populations' identified for Grey-headed flying-fox it is considered unlikely the Project will reduce the area of occupancy of an important population of the species.
Fragment an existing important population into two or more populations	The species is highly mobile and the Project is not considered to represent a barrier to movement for the species. It is considered unlikely that the Project will fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of the species	Foraging habitat for Grey-headed flying-fox occurs across the Project disturbance footprint encompassing 201.19 ha of *Habitat critical to the survival of the species* (as defined for this assessment). It is noted this is a conservative approach given there is there is abundant suitable habitat for the species in the area surrounding the Project and the wider SEQ region. As such the Project will adversely affect habitat critical to the survival of the Grey-headed flying-fox.
Disrupt the breeding cycle of an important population	There are no 'important populations' defined for this species. The Project will not impact local roost sites (potentially used as breeding locations) the species is known to regularly use. The recovery plan for the species notes that roosting requirements are not well understood, nor are the impacts on the species of loss of long-term sites which may be selected to meet specific requirements. There are two flying-fox camps located within 15 km of the Project which regularly comprise Grey-headed flying-fox. The camps in Toowoomba and Highfields are located 8.5 km south and 5 km north of the Project disturbance footprint respectively. The recovery plan notes that flying-foxes are prone to abort foetuses and mass abortions and premature births are known to occur in the wild in response to environmental stress. The nearest camp is 5 km away from the Project and there is negligible risk of this scenario occurring as a result of the Project. It is considered unlikely the Project will disrupt the breeding cycle of an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Foraging habitat for Grey-headed flying-fox occurs across the Project disturbance footprint encompassing 201.19 ha of *Habitat critical to the survival of the species* (as defined for this assessment). The operational rail corridor will not be rehabilitated/landscaped with woody vegetation, however there will be an opportunity to rehabilitate temporary construction areas and riparian zones. However; there is abundant suitable habitat for the species in the area surrounding the Project and the wider SEQ region (including 2,790 ha within the MNES study area). The species occurs across a wide area from central QLD south to Victoria. As outlined in Section 5.1.2 the Project will result in edge effects, changes to biological viability of soil or from the deposition of dust, which may result in the degradation of foraging habitat but is unlikely to lead to a decline in the species. However, the extent of these impacts will vary spatially and temporarily across the Project disturbance footprint. Given the mobility of the species it is unlikely that any habitat will be isolated, with the species known to utilise heavily modified environments including urban gardens and commercial orchards. It is considered unlikely the Project will impact the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	There are no particular weed or pest species identified as relevant to Grey-headed flying-fox. Several weed species were identified across the MNES study area, in abundance at some sites during Project EIS surveys. *Lantana* species (including *L. camara* and *L. montevidensis*) were common throughout the MNES study area with severe infestations at some sites. Project-associated surveys have recorded 17 species listed as restricted matters under the Biosecurity Act with 10 of these listed as WoNS. Other Project-associated surveys have also noted areas of heavy infestations of weed species under the Act (ELA 2019a). Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.

Criteria	Assessment against significance criteria (vulnerable species)
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	The draft recovery Plan for the species includes the following recovery objectives: ■ Identify, protect and enhance roosting habitat and native foraging habitat critical to the survival of the species ■ Determine population trends in Grey-headed flying-foxes so as to monitor the species' national distribution and conservation status ■ Increase public awareness and understanding of Grey-headed flying-foxes and build community capacity to coexist with flying-foxes and minimise the impacts on urban settlements from existing camps without resorting to dispersal ■ Improve the management of Grey-headed flying-fox camps in sensitive areas and support research activities that will improve the conservation status and management of the species. ■ Significantly reduce levels of deliberate Grey-headed flying-fox destruction associated with commercial horticulture ■ Assess and reduce the impact on Grey-headed flying-foxes of electrocution on power lines, and entanglement in netting and on barbed-wire (DotEE 2017a) The Project will impact foraging habitat which is a relatively minor portion of the habitat available within the surrounding landscape. No roost sites are located within or adjacent to the Project. None of the other recovery objectives are applicable to the Project. The Project is considered unlikely to interfere substantially with any of the recovery objectives listed above and will not interfere with the recovery of the species.
Assessment of potential for significant residual impacts	Under the current Project disturbance footprint there may a requirement to up to 201.19 ha of *Habitat critical to the survival of the species* (as defined for this assessment). A conservative approach has been applied to the assessment of habitat within the Project disturbance footprint which may not reflect actual impacts on the species. Nevertheless, based on the nine-part test for significance the Project is likely to have a significant residual impact on Grey-headed flying-fox.

Black-breasted button-quail (*Turnix melanogaster*)

Ecology and distribution

Black-breasted button-quail is restricted to rainforests and forests, mostly in areas with 770 to 1,200 mm rainfall per annum in areas characterised by highly fertile soils. They prefer drier low closed forests, particularly semi-evergreen vine thicket, low microphyll vine forest, araucarian microphyll vine forest and araucarian notophyll vine forest. They may also be found in low, dense Acacia thickets and, in vegetation behind coastal sand dunes. In SEQ, the Black-breasted button-quail has been recorded on rare occasions in open eucalypt forest. This species also heavily utilises areas infested with *Lantana camara*, particularly where this produces a dense leaf-litter below a thigh woody shrub layer. A dense leaf litter layer is required for foraging and possibly also roosting. Their principal food is invertebrates gathered from the leaf litter on the forest floor, however, seeds may also be consumed (Hughes and Hughes 1991; Smith and Mathieson 2004). The species foraging method leaves distinctive signs ('platelets') in foraging areas which can be used to identify the species presence. The species is relatively sedentary although migratory movements may occur at night in response to resource availability.

Breeding occurs from September to April/May and between three and five eggs are laid. Nests consist of a scrape in the ground, lined with leaves, grass or moss. Nests are typically well-concealed and placed in the buttress root of a tree or sapling, the base of a fern or under a low bush or grass tussock (DAWE 2020; Smyth and Young 1996).

Black-breasted button-quails are distributed across SEQ from near Byfield in the north to the Border Ranges rainforests in the south, generally east of the Great Dividing Range (refer Figure 5.5); although there are records up to 300 km inland at locations at Palmgrove National Park and Barakula State Forest in QLD. In north-eastern NSW, they are restricted to the Northern Rivers and Tablelands as far south as Dorrigo (Marchant and Higgins 1993; Mathieson and Smith 2009).

Distribution in context to the Project

The species has not been recorded during any Project-associated surveys (including searches for foraging platelets) but was recorded during surveys for the nearby TSRC project (although the location of this record has been restricted due to probity issues). There are a number of records (AoLA) from the Toowoomba area, many of which are very old. There are two database records from within the Project disturbance footprint in the Gowrie area one of which is from 1901. The other record does not have an associated collection date and has a high spatial uncertainty. The nearest recent records are also from the Gowrie area (1999 and 1.8 km north of the Project disturbance footprint) and Redwood Park at the base of the Toowoomba Range (2006 and 5 km south). There are two 2018 records 9 km south in the Toowoomba Range and Lockyer Valley although the location of these records have been generalised to protect the species location. There is a large cluster of records to the northeast in the Ravensbourne National Park area (approximately 18 km north of the eastern extent of the Project) which includes relatively recent records from the 2000s. The closest of these is from 1995 and 16 km north of the eastern extent of the Project (refer Figure 5.6 in Appendix B).

Recovery plans/threat abatement plans

The *National recovery plan for the black-breasted button-quail* (Mathieson and Smith 2009) identifies the following threatening processes as applicable to the species:

- Habitat loss caused by urban, timber harvesting and agricultural land use
- Habitat degradation caused by grazing from livestock and introduced herbivores such as deer and pigs (*Sus scrofa*)
- Inappropriate fire regimes
- Predation by feral species such as Red fox (*Vulpes vulpes*), cat (*Felis catus*) and dog (*Canis lupus familiaris*).

The following threat abatement plans have been identified as being relevant for this species:

- *Threat abatement plan for predation by feral cats* (DotE 2015d)
- *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa)* (DotEE 2017b)
- *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi.* (DotEE 2018).

Important populations and habitat critical to the survival of the species

The overall population is estimated at 5000 individuals although this has a high error margin and is based on little baseline information (Garnett et al 2011). The *National recovery plan for the black-breasted button-quail Turnix melanogaster* (Mathieson and Smith 2009) identifies important populations from the Yarraman-Nanango, the Jimna-Conondale Range, Great Sandy Region, and populations in Palmgrove National Park and Barakula State Forest. *Habitat critical to the survival of the species* is defined as including semi-evergreen vine thickets, low microphyll vine forest, Araucarian microphyll vine forest, and Araucarian notophyll vine forest. This habitat has been identified within the Project disturbance footprint.

The Project is predicted to impact 9.18 ha of *Habitat critical to the survival of the species* in which this species may occur (refer Table 5.4 and habitat figure in Appendix B). This comprises habitat within the Toowoomba Range. Impacts and mitigation measures associated with this species are identified within Table 5.7.

The following significant impact assessment (refer Table 5.41) under the MNES guidelines (DotE 2013a) has been informed by the information detailed above.

Table 5.41 Matters of national environmental significance significant residual impact criteria - Black-breasted button-quail

Criterion	Assessment against significance criteria
Lead to a long-term decrease in the size of an important population of a species	The species has not been recorded during any Project-associated surveys but was recorded during surveys for the nearby TSRC project. The nearest reliable records of the species are from the Gowrie area (1999) and in the Toowoomba Range 2006) 5 km south of the Project. There is no important population identified in the Project area or the Toowoomba Range. Pre-construction surveys (as per DAWE guidelines) will be carried out where suitable habitat for this species is identified within the final Project disturbance footprint, including the vine thicket communities in close proximity to the eastern tunnel portal(refer habitat figure in Appendix G). It is considered very unlikely the Project will result in direct mortality of individuals of the species. Any individuals occurring within the Project disturbance footprint are expected to move away from the area naturally. It is noted that the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit any population present by providing access to otherwise inaccessible areas during a bushfire event. The Project is predicted to impact 9.18 ha of *Habitat critical to the survival of the species*. The Project is a linear development and there is extensive identical habitat in the immediate surrounds and throughout the wider region that will not be impacted. The Project is considered unlikely to result in a long-term decrease in the size of a population.
Reduce the area of occupancy of an important population	The species has not been recorded during any Project-associated surveys but was recorded during surveys for the nearby TSRC project. The nearest reliable records of the species are from the Gowrie area (1999) and in the Toowoomba Range 2006) 5 km south of the Project. There is no important population identified in the Project area or the Toowoomba Range. The Project is predicted to impact 9.18 ha of *Habitat critical to the survival of the species*. The Project has potential to reduce the area of occupancy of a local population, although it is not considered as an important population (as defined in the recovery plan for the species).
Fragment an existing important population into two or more populations	The species has not been recorded during any Project-associated surveys but was recorded during surveys for the nearby TSRC project. The nearest reliable records of the species are from the Gowrie area (1999) and in the Toowoomba Range 2006) 5 km south of the Project. There is no important population identified in the Project area or the Toowoomba Range. The section of the Project located within the Toowoomba Range lies roughly adjacent to the existing TSRC. Impacts to connectivity in the range are minimised through the proposed tunnel (extending for 1 km in this area) and the incorporation of several viaducts within the Project design. The species is relatively mobile and is known to move between patches at night. The Project is considered unlikely to fragment an existing population.
Adversely affect habitat critical to the survival of the species	The species is known to occur in the area. The Project is predicted to impact 9.18 ha of *Habitat critical to the survival of the species* (as identified in the recovery plan for the species) located in the Toowoomba Range area. As such, the Project will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	The species has not been recorded during any Project-associated surveys but was recorded during surveys for the nearby TSRC project. The nearest reliable records of the species are from the Gowrie area (1999) and in the Toowoomba Range 2006) 5 km south of the Project. There is no important population identified in the Project area or the Toowoomba Range. Pre-clearance surveys will be carried out (as per DAWE guidelines) where suitable habitat for this species is identified. This species breeds in late winter to autumn (August to May). Where possible the Project will avoid clearing/construction activities in sensitive habitat during the breeding season. The Project is considered has potential to disrupt the breeding cycle of individuals but is considered unlikely to disrupt the local population as a whole.

Criterion	Assessment against significance criteria
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	The fragmented distribution of this species occurs across SEQ and north-east NSW. The Project is predicted to impact 9.18 ha of *Habitat critical to the survival of the species*. A further 385 ha of identical habitat is located within the immediate surround of the MNES study area. As outlined in Section 5.1.2 the Project will result in edge effects, changes to biological viability of soil or from the deposition of dust, which may result in the degradation of foraging habitat but is unlikely to lead to a decline in the species. However, the extent of these impacts will vary spatially and temporarily across the Project disturbance footprint. It is noted the Project may be a point source for bush fires (construction and operation) though the risk is considered to be low. The Project may also benefit the species (should it be found to occur) by providing access to otherwise inaccessible areas during a bushfire event. The Project is considered unlikely to decrease the availability of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat	Relevant threat abatement/recovery plans for Black-breasted button-quail include management measures to address the impact of feral cats, dogs and Red fox. Although none of these species have been identified within the MNES study area they are all likely present. Weeds are not considered a threat to the species. It is known to utilise Lantana (*Lantana camara*) which is present in the area including areas with dense infestations. Weed and pest control measures will be incorporated into the Biosecurity Management Plan to control the introduction and spread of weed and pest species across the Project disturbance footprint and surrounds covering both construction and operation activities. The plan will be in place for the life of the Project and will minimise the potential for weed invasion and may in the long-term improve habitat condition within vegetation communities located adjacent to Project infrastructure. Pest measures will ensure feral predators (i.e. wild dogs/dingo and cat) are controlled in areas associated with Project activities. The Project is considered unlikely to result in invasive species becoming established in this species' habitat.
Introduce disease that may cause the species to decline	The Biosecurity Management Plan will incorporate the management of invasive species which will assist in the prevention of pest plant introduction and associated diseases resulting from Project activities. Project equipment sourced from overseas will be quarantined as required under State and Commonwealth legislation. The Project is considered unlikely to introduce disease that may cause the species to decline.
Interfere substantially with the recovery of the species	Recovery objectives listed in the *National recovery plan for the black-breasted button-quail* (Mathieson and Smith 2009) include: ■ Define monitoring strategies and assess the current status throughout its range and a clear definition of the habitats occupied by the species ■ Protect key ecosystems and habitat that support populations of black-breasted buttonquail from human induced threatening processes ■ Maintain or improve the extent, condition (quality) and connectivity of Black-breasted button-quail habitat ■ Reduce the impacts of introduced predators and competitors ■ Increase understanding of the ecology of the species There is no reason for the Project to substantially interfere with the conservation actions outlined in above. While the Project may be a potential point source of ignition for fires this is considered likely to be a rare event and the provision of adjacent access roads for the Project will enhance access for bushfire control in the wider landscape. The Project Biosecurity Management Plan will control introduced predators and weeds associated with Project infrastructure. The Project will impact habitat for the species and somewhat reduce connectivity in the area. Nevertheless, any impact on the species is likely to be minor and is considered unlikely to substantially interfere with the recovery of the species.
Assessment of potential for significant residual impacts	The Project will result in the clearance of 9.18 ha of *Habitat critical to the survival of the species* predicted to occur in the footprint. Based on the nine-part test detailed in this assessment the Project is considered likely to cause significant residual impacts on Black-breasted button-quail.

5.4 Biodiversity offsets for significant residual impacts

Residual impacts are those impacts that remain after the successful implementation of the avoidance hierarchy and mitigation measures identified in Section 5.2. The significance of residual impacts reflects the effectiveness of the proposed mitigation measures but allows for the identification of areas where further management measures may be required.

The significance ratings of most potential impacts identified in Section 5.1 will be reduced after the implementation of mitigation measures, including the avoidance, minimisation and mitigation strategies. In addition, the implementation of the mitigation measures identified in Section 5.2 and Section 5.3.2 will considerably reduce the significance of these impacts potentially resulting from the Project's activities.

Although terrestrial and aquatic ecological MNES will be avoided where practicable and potential impacts will be minimised and mitigated to the greatest extent practical (refer Table 5.5), in some instances the magnitude and significance ratings will remain unchanged following the implementation of the mitigation measures.

There is the potential for some Project activities to have a cumulative, irreversible and/or permanent impact upon some terrestrial MNES species, even after the implementation of all mitigation measures, including rehabilitation. In these cases, the residual impact to *Habitat critical to the survival of the species* or *Important habitat* will require offset should the residual impact be considered significant in accordance with the *EPBC Act Matters of National Environmental Significance Significant Impact Assessment 1.1* (DotE 2013a) (refer Sections 5.3.3, 5.3.4 and 5.3.5.

The EPBC Act Offsets Policy states: 'Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation measures. These remaining, unavoidable impacts are termed 'residual impacts'. Offsets will be required to compensate for the significant residual impacts on threatened species as a result of the Project (refer Section 5.3). An Environmental Offset Strategy for the Project has been prepared and included in Appendix I.

A 'significant impact' is defined as 'an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts' (DotE 2013a).

An offset is likely to be required for MNES that experience a significant residual impact which may include areas containing *Habitat critical to the survival of a species* or *Important habitat* for EPBC Act listed species.

An assessment of the relevant threatened species to the Project has been undertaken in accordance with the relevant significant impact criteria within the MNES Guidelines (refer Sections 5.3.3, 5.3.4 and 5.3.5). Analysis indicates that the Project will potentially have a significant residual impacts on the following threatened species:

- Brush sophora (*Sophora fraseri*) (refer Table 5.21)
- Spotted-tail quoll (*Dasyurus maculatus maculatus*) (refer Table 5.28)
- Collared delma (*Delma torquata*) (refer Table 5.31)
- Red goshawk (*Erythrotriorchis radiatus*) (refer Table 5.32)
- Swift parrot (*Lathamus discolor*) (refer Table 5.26)
- Koala (*Phascolarctos cinereus*) (refer Table 5.37)
- Grey-headed flying-fox (*Pteropus poliocephalus*) (refer Table 5.40)
- Australian painted snipe (*Rostratula australis*) (refer Table 5.27)
- Black-breasted button-quail (*Turnix melanogaster*) (refer Table 5.41)

The current identified extent of significant residual impact to each specific threatened species is quantified in Table 5.33. Further ecological surveys are currently being undertaken to verify the mapping and address some of the gaps in the data (e.g. changes to the alignment since the surveys), with the outcomes of the surveys to be used to update the SRI assessments outlined in Section 5.3.3, Section 5.3.4 and Section 5.3.5 including the extent of the impacts. It is noted the extent of significant residual impacts identified overlap substantially.

Table 5.42 Quantification of anticipated significant residual impacts to matters of national environmental significance

Sensitive environmental receptor (MNES)	Identified Significant residual impact
Brush sophora (*Sophora fraseri)*	2.36 ha
Spotted-tail quoll (*Dasyurus maculatus maculatus*)	24.46 ha
Collared delma (*Delma torquata*)	197.41 ha
Red goshawk (*Erythrotriorchis radiatus*)	84.79 ha
Swift parrot (*Lathamus discolor*)	8.54 ha
Koala (*Phascolarctos cinereus*)	189.01 ha
Grey-headed flying-fox (*Pteropus poliocephalus*)	201.19 ha
Australian painted snipe (*Rostratula australis*)	8.9 ha
Black-breasted button-quail (*Turnix melanogaster*)	9.18 ha

ARTC's Environmental Offset Delivery Strategy – Qld (Strategy) is contained in Appendix I. This Strategy informs the development of offset delivery components including an Environmental Offset Delivery Plan and Offset Area Management Plans. A Detailed Environmental Offset Delivery Plan and Offset Area Management Plans will be developed and implemented by ARTC prior to construction commencement subject to the approval under the EPBC Act.

The Environmental Offset Delivery Plan will:

- Quantify the significant residual impact of the Project on MNES
- Detail offsets to address significant residual impacts for MNES
- Include:
  - Details of milestones to establish the offset
  - Evidence that significant residual impacts can be offset
  - The offset delivery mechanisms, comprising one or more of: land-based offsets, direct benefit management plans, offset transfers or offset payments
  - Identification of land required to provide the offset
  - A legally binding mechanism that ensures protection and management of land-based offset areas.

6 Commitments

The approach outlined in this report is considered to be adequate to address the controlling provisions relevant to the Project. The report describes the particular aspects of the environment relevant to these matters and addresses the relevant sections of the EIS ToR.

As the Project moves into the detailed design and construction phases, more focused and comprehensive ecological surveys in accordance with the Commonwealth's survey guidelines will be undertaken under the Flora and Fauna Sub-plan. The surveys will aim to address any changes to the Project design and footprint, along with informing the design and construction, including specific measures to avoid, mitigate, minimise impacts on a particular species, along with ongoing monitoring activities.

The surveys will also have the added benefit in addressing some of the recommendations in conservation advices, recovery plans and threat abatement plans including:

- Surveys may identify extent and quality of habitat
- Identify new populations and knowledge of the species ecology
- Surveys may be designed to monitor known populations for certain species
- The Project is also a mechanism to engage the public about a species.

As part of these surveys, ARTC will look to collaborate and supplement existing studies being undertaken by local councils, environmental groups and government agencies.

During detailed design ARTC will also finalise the location and design of fauna movement structures across the Project alignment, targeting key locations (for example, in the Toowoomba Range). ARTC will work with the relevant stakeholders including DAWE, DTMR, local councils, DES and where applicable local environmental groups to finalise the location and design of any crossing structures. This will be especially important in areas of future development or complementary to any ecological corridor strategies within the MNES study area, including those associated with the Koala Strategy.

Environmental offsets will be provided where Project works are found to have a significant residual impact on flora and fauna that are MNES (and in some instances also MSES), along with any TECs following the results of the targeted surveys for MNES species outlined above.

An Environmental Offsets Delivery Plan will be prepared in consultation with DAWE and relevant State agencies (DAF and/or DES) and submitted to the relevant authority for approval. The Environmental Offsets Delivery Plan will detail the following (at a minimum):

- Quantifies the significant residual impact of the Project on matters of State environmental significance
- Quantifies the significant residual impact of the Project on MNES
- Quantifies habitat values of lands associated with matters of MNES requiring offsets as per the relevant assessment guidelines and details the required quantum of offsets as per the DAWE offset calculator
- Details proposed offsets to address significant residual impacts for matters of State environmental significance (except where those matters are also significant residual impacts on matters of national environmental significance)
- Details proposed offsets to address significant residual impacts for MNES
- The Environmental Offsets Delivery Plan will also include:
  - Details of milestones to establish the offset
  - Evidence that significant residual impacts can be offset
  - The offset delivery mechanism(s) comprising one or more of: land-based offsets; direct benefit management plans; offset transfers and/or offset payments
  - Identification of land required to provide the offset
  - A legally binding mechanism that ensures protection and management of land-based offset areas.

7 Cumulative impact assessment

Cumulative impacts were assessed using the methodology identified in Section 3.5, incorporating the projects identified in Table 3.11 and depicted in Figure 3.4. The assessment has been based on MNES occurring within the Project disturbance footprint (refer Table 7.1) and used a conservative approach to assessment of habitat lost (i.e. combines the habitat categories as identified in Table 4.5 to identify the maximum potential habitat loss).

The cumulative impacts of multiple projects occurring in the vicinity of the Project disturbance footprint will likely include the continued loss of biodiversity in the SEQ and Brigalow Belt South bioregions. The major potential impacts identified as a result of the Project are common to all projects throughout the region and are therefore cumulative in nature. Thirteen projects have been identified within the cumulative impact assessment study area, which are either currently underway or are going through the EIS process, all of which will likely result in some extent of:

- Habitat loss and degradation from vegetation clearing/removal
- Fauna species injury or mortality
- Reduction in biological viability of soil to support growth due to soil compaction
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation.

Cumulative impacts range from short-term to long-term. The total impact area for all habitat categories (i.e. Potential, Important and Habitat Critical to the survival of the species) of significant receptors contained within the footprint of the projects occurring within the cumulative impact assessment study area, based on bioregional and State extents, is provided in Table 7.1. The results of the significance assessment of these cumulative impacts are presented in Table 7.2. Total habitat areas have been used to represent a highly conservative estimation of impacts, however the total residual impacts as a result of the current project are expected to be significantly less than those reported within this section.

The greatest potential predicted cumulative impact in terms of habitat loss (including all habitat categories) as a result of the Project and other similar projects that occur within the Project cumulative impact area may be upon the following threatened species:

- Flora and fauna species habitat:
  - Austral cornflower (*Rhaponticum australe*) - cumulative removal of 1,928.35 ha of which the Project contributes up to 3.27 per cent
  - Hawkweed (*Picris evae*) - cumulative removal of 4,587.84 ha of which the Project contributes up to 0.67 per cent
  - Austral toadflax (*Thesium australe*) - cumulative removal of 1,305.94 ha of which the Project contributes up to 2.26 per cent
  - King blue-grass (*Dichanthium queenslandicum*) - cumulative removal of 1,011.72 ha of which the Project contributes up to 0.07 per cent
  - Red goshawk (*Erythrotriorchis radiatus*) - cumulative removal of 253.02 ha of which the Project contributes up to 35.08 per cent

- Grey falcon (*Falco hypoleucos*) - cumulative removal of 6,031.17 ha of which the Project contributes up to 3.51 per cent
- Swift parrot (*Lathamus discolor*) - cumulative removal of 1,370.27 ha of which the Project contributes up to 13.79 per cent
- Koala (*Phascolarctos cinereus*) - cumulative removal of 3,813.38 ha of which the Project contributes up to 6.81 per cent
- Long-nosed potoroo (*Potorous tridactylus tridactylus*) - cumulative removal of 1,148.40 ha of which the Project contributes up to 13.61 per cent
- Grey-headed flying-fox (*Pteropus poliocephalus*) - cumulative removal of 1,842.60 ha of which the Project contributes up to 10.92 per cent
- Condamine earless dragon (*Tympanocryptis condaminensis*) - cumulative removal of 1,204.24 ha of which the Project contributes up to 1.35 per cent

However, in addition there is the potential for cumulative impacts as a result of habitat fragmentation, edge effects and barriers which similar to habitat loss is considered to be of medium significance. The cumulative impacts of the project due to the reduction in biological viability of soil to support growth due to soil compaction is also considered to be of medium significance.

Table 7.1 Cumulative impact assessment of magnitude for ecological matters of national environmental significance

MNES	A. Extent within cumulative impact study area (50 km extent) (ha) (i.e. 1,058,586.32 ha)	B. Extent within cumulative impact Project disturbance footprint (defined projects (Figure 3.4)	C. Extent within cumulative impact Project disturbance footprint (defined projects - Figure 3.4) including the Project disturbance footprint	D. Percentage (%) total disturbance to receptors within Cumulative impact study area	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact Project disturbance footprint	F. Magnitude of contribution to disturbance considering D
Commonwealth significant environmental constraints (EPBC Act)						
Threatened flora habitat:						
Hairy-joint grass (*Arthraxon hispidus*)	53,581.07	86.28	95.46	0.18	9.62	Low
Bunya Mountains bluegrass (*Bothriochloa bunyensis*)	1,230.59	0.00	0.00	0.00	0.00	Negligible
Miniature moss-orchid (*Bulbophyllum globuliforme*)	4,555.77	2.23	4.59	0.10	51.42	Low
Stream clematis (*Clematis fawcettii*)	1,152.03	0.00	0.00	0.00	0.00	Negligible
King blue-grass (*Dichanthium queenslandicum*)	59,601.52	1,011.05	1,011.72	1.70	0.066	Low
Bluegrass (*Dichanthium setosum*)	59,556.90	949.64	950.31	1.60	0.07	Low
Four-tailed grevillea (*Grevillea quadricauda*)	6,904.76	0.62	1.64	0.02	62.20	Low
Blunt-leaved leionema (*Leionema obtusifolium*)	32,616.88	28.63	29.26	0.09	2.15	Low
Wandering pepper-cress (*Lepidium peregrinum*)	3,127.74	4.20	4.20	0.13	0.00	Low
Paspalidium grandispiculatum (A grass)	81,484.98	149.44	305.69	0.38	51.11	Low
Hawkweed (*Picris evae*)	164,632.58	4,555.96	4,587.84	2.79	0.69	Low
Austral cornflower (*Rhaponticum australe*)	56,075.03	1,865.33	1,928.35	3.44	3.27	Low
Waxy sarcochilus (*Sarcochilus hartmannii*)	15,780.90	0.00	0.00	0.00	0.00	Negligible
Blotched sarcochilus (*Sarcochilus weinthalii*)	33,108.06	75.75	78.89	0.24	3.98	Low
Brush sophora (*Sophora fraseri*)	49,832.27	323.88	354.93	0.71	8.75	Low
Austral toadflax (*Thesium australe*)	61,492.87	1,276.42	1,305.94	2.12	2.26	Low

MNES	A. Extent within cumulative impact study area (50 km extent) (ha) (i.e. 1,058,586.32 ha)	B. Extent within cumulative impact Project disturbance footprint (defined projects (Figure 3.4)	C. Extent within cumulative impact Project disturbance footprint (defined projects - Figure 3.4) including the Project disturbance footprint	D. Percentage (%) total disturbance to receptors within Cumulative impact study area	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact Project disturbance footprint	F. Magnitude of contribution to disturbance considering D
Threatened fauna species habitat:						
Birds						
Regent honeyeater (*Anthochaera phrygia*)	148,530.69	203.27	359.52	0.24	43.46	Low
Australasian bittern (*Botaurus poiciloptilus*)	22,809.61	136.94	145.84	0.64	6.10	Low
Curlew sandpiper (*Calidris ferruginea*)	22,828.30	136.94	145.84	0.64	6.10	Low
Red goshawk (*Erythrotriorchis radiatus*)	32,946.83	164.25	253.02	0.77	35.08	Low
Grey falcon (*Falco hypoleucos)*	325,913.65	5,819.58	6,031.17	1.85	3.51	Low
Painted honeyeater (*Grantiella picta*)	22,500.46	44.79	53.33	0.24	16.01	Low
Swift parrot (*Lathamus discolor*)	193,527.36	1,181.26	1,370.27	0.71	13.79	Low
Australian painted snipe (*Rostratula australis*)	23,669.97	134.93	143.83	0.61	6.19	Low
Black-breasted button-quail (*Turnix melanogaster*)	65,372.60	112.67	121.85	0.19	7.53	Low
Mammals						
Spotted-tail quoll (*Dasyurus maculatus maculatus*)	137,328.03	173.80	327.79	0.24	46.98	Low
Greater glider (*Petauroides volans*)	89,021.60	83.81	192.86	0.22	56.54	Low
Brush-tailed rock-wallaby (*Petrogale penicillata*)	12,883.10	0.40	0.40	0.003	0.00	Negligible
Koala (*Phascolarctos cinereus*)	254,993.73	3,553.76	3,813.38	1.50	6.81	Low
Long-nosed potoroo (*Potorous tridactylus tridactylus*)	151,370.64	992.15	1,148.40	0.76	13.61	Low
New Holland mouse (*Pseudomys novaehollandiae*)	112,522.58	176.96	333.21	0.30	46.89	Low
Grey-headed flying-fox (*Pteropus poliocephalus*)	288,823.52	1,640.40	1,842.60	0.64	10.92	Low
Reptiles						
Five-clawed worm-skink (*Anomalopus mackayi*)	6,032.19	155.81	155.81	2.58	0.00	Low
Collared delma (*Delma torquata*)	143,692.54	255.29	452.70	0.32	43.61	Low
Dunmall's snake *(Furina dunmalli*)	5,538.75	207.06	207.06	3.74	0.00	Low

MNES	A. Extent within cumulative impact study area (50 km extent) (ha) (i.e. 1,058,586.32 ha)	B. Extent within cumulative impact Project disturbance footprint (defined projects (Figure 3.4)	C. Extent within cumulative impact Project disturbance footprint (defined projects - Figure 3.4) including the Project disturbance footprint	D. Percentage (%) total disturbance to receptors within Cumulative impact study area	E. Percentage (%) contribution of the Project to disturbance within the cumulative impact Project disturbance footprint	F. Magnitude of contribution to disturbance considering D
Condamine earless dragon (*Tympanocryptis condaminensis*)	45,345.71	1,188.02	1,204.24	2.66	1.35	Low
Fish						
Murray cod (*Maccullochella peelii*)	3,757.79	246.62	249.83	6.65	1.29	Low

Table note:

* There is potential for each of the MNES value impacts to overlap spatially. As a result, addition of disturbance values presented in the above table would not represent a true reflection of the total disturbance footprint

Table 7.2 Significance assessment of cumulative impacts within the cumulative impact area

Receptor(s)	Potential impacts[#]	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
Commonwealth Significant Environmental Constraint (species listed as threatened under the EPBC Act): **Flora**: ■ Hairy-joint grass (*Arthraxon hispidus*) ■ Bunya Mountains bluegrass (*Bothriochloa bunyensis*) ■ Miniature moss-orchid (*Bulbophyllum globuliforme*) ■ Stream clematis (*Clematis fawcettii*) ■ King blue-grass (*Dichanthium queenslandicum*) ■ Bluegrass (*Dichanthium setosum*) ■ Four-tailed grevillea (*Grevillea quadricauda*) ■ Blunt-leaved Leionema (*Leionema obtusifolium*) ■ Wandering pepper-cress (*Lepidium peregrinum*) ■ *Paspalidium grandispiculatum* (A grass) ■ *Picris evae* (A hawkweed) ■ Austral cornflower (*Rhaponticum australe*) ■ Waxy sarcochilus (*Sarcochilus hartmannii*) ■ Blotched sarcochilus (*Sarcochilus weinthalii*) ■ Brush sophora (*Sophora fraseri*) ■ Austral toadflax (*Thesium australe*) **Fauna**: ■ Regent honeyeater (*Anthochaera phrygia*) ■ Australasian bittern (*Botaurus poiciloptilus*) ■ Curlew sandpiper (*Calidris ferruginea*) ■ Red goshawk (*Erythrotriorchis radiatus*) ■ Grey falcon (*Falco hypoleucos*) ■ Painted honeyeater (*Grantiella picta*) ■ Swift parrot (*Lathamus discolor*) ■ Australian painted snipe (*Rostratula australis*) ■ Black-breasted button-quail (*Turnix melanogaster*) ■ Spotted-tail quoll (*Dasyurus maculatus maculatus*)	■ Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	■ Edge effects ■ Habitat fragmentation ■ Barrier effects ■ Reduction in connectivity of biodiversity corridors	2	2	1	3	8	Medium
	■ Fauna species injury or mortality	1	1	1	3	6	Low
	■ Dust and light and contaminant disturbance	1	1	1	3	6	Low
	■ Increase in litter (waste)	1	1	1	3	6	Low
	■ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	3	7	Medium
	■ Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low
	■ Displacement of species from invasion of weed and pest species	1	1	1	3	6	Low

Receptor(s)	Potential impacts[#]	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
▪ Brush-tailed rock-wallaby (*Petrogale penicillata*) ▪ Koala (*Phascolarctos cinereus*) ▪ Long-nosed potoroo (*Potorous tridactylus tridactylus*) ▪ New Holland mouse (*Pseudomys novaehollandiae*) ▪ Grey-headed flying-fox (*Pteropus poliocephalus*) ▪ Five-clawed worm-skink (*Anomalopus mackayi*) ▪ Collared delma (*Delma torquata*) ▪ Yakka skink (*Egernia rugosa*) ▪ Condamine earless dragon (*Tympanocryptis condaminensis*) ▪ Murray cod (*Maccullochella peelii*)							

Table notes:

1. Table 3.12 defines the consequences of the impact significance ratings, as follows:
   Low (sum of relevance factors = 1 to 5): Negative impacts need to be managed by standard environmental management practices. Special approval conditions unlikely to be necessary. Monitoring to be part of general Project monitoring program
   Medium (sum of relevance factors = 6 to 9): Mitigation measure likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required
   High (sum of relevance factors = 10 to 12): Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary

8 Conclusion

The Project was submitted as an EPBC Act referral to the DotEE (EPBC 2017/7882). On 17 March 2017, the Minister for the Environment declared the Project a 'controlled action' requiring the preparation of an EIS. The controlling provision for the Project is listed threatened species and communities.

This MNES Assessment Report has been prepared in accordance with Sections 11.1 – 11.35 of the *Terms of Reference for an environmental impact statement: Gowrie to Helidon Project* issued on 9 August 2017 by the QLD Coordinator-General. It has been prepared as a "stand-alone" document that assesses potential impacts on listed threatened species and communities under the EPBC Act during construction, operation and decommissioning of the Project. This technical report has been prepared for the purpose of supporting the Primary approvals for the Project.

The MNES study area contains three TECs and provides suitable habitat for 38 threatened flora (16) and fauna (22) species listed under the provisions of the EPBC Act. Habitat modelling for these 38 threatened species indicated that there was habitat for only 31 species in Project disturbance footprint, 12 flora species and 19 fauna species. No TECs are present in Project disturbance footprint. These MNES were grouped into high, moderate and low sensitivity categories based on factors including conservation status, exposure to threatening processes, resilience and representation in the broader landscape.

The construction and operation of the Project has the potential to impact on ecological receptors through:

- Habitat loss and degradation from vegetation clearing/removal
- Fauna species injury or mortality
- Reduction in biological viability of soil to support growth due to soil compaction
- Displacement of flora and fauna species from invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation.

In order to determine the significance of potential impacts of the Project upon the identified MNES, sensitivity categories were applied to each of the MNES. The sensitivity of the MNES was grouped into three distinct categories: high, moderate and low. These groupings were based on factors including, but not limited to, legislative status, resilience and representation in the broader landscape. In addition to sensitivity, the magnitude of each potential impact was assigned based on the extent, duration and resultant change to the MNES. The magnitude of impact was grouped into five categories: major, high, moderate, low and negligible. Both the sensitivity of a MNES and the magnitude of the potential impact were used to determine the significance of a potential impact.

The proposed mitigation measures for the Project were considered in order to reduce the initial magnitude and ultimately the significance of the potential impacts upon the listed threatened species and communities. Project mitigation measures include:

- Reducing the disturbance footprint as far as reasonably practical, with the Toowoomba Range tunnel and the viaducts already part of the design
- Development and implementation of a Flora and Fauna Sub-plan as a component of the CEMP

- Development and implementation of a Soil Management Plan, including erosion and sedimentation controls, as a component of the CEMP
- Identification and implementation of fauna movement features and fencing to reduce barrier effects associated with the Project and enable fauna passage
- Development and implementation of a Reinstatement and Rehabilitation Plan and a Landscape and Rehabilitation Management Plan
- Development and implementation of the whole-of-Project draft Outline EMP and CEMP.

Following the implementation of a range of mitigation measures and management plans including, but not limited to, avoidance, minimisation and mitigation, the magnitude of residual impacts to the listed threatened species and communities were predicted to be generally reduced, followed by a subsequent reduction in the significance of the impact. However, one potential impact (i.e. habitat loss from vegetation clearing/removal upon most of the terrestrial MNES) was not predicted to significantly reduce in magnitude of impact following the implementation of Project mitigation measures, resulting in a residual impact to each of the MNES.

The Project has the potential to have a significant residual impacts on the following threatened species with the primary reason for these significant residual impacts being the loss of habitat as a result of the Project, along with barrier effects and habitat fragmentation. The extent of habitat to be impacted by the Project is also outlined.

- Flora
  - Brush sophora (*Sophora fraseri*) – 2.36 ha to *Habitat critical to the survival of the species* and 28.69 ha of *potential habitat*
  - Four-tailed grevillea (*Grevillea quadricauda*) – total potential impact of 1.02 ha to *potential habitat*
  - Hawkweed (*Picris evae*) - total potential impact of 31.88 ha to *potential habitat*
  - *Paspalidium grandispiculatum* (a grass) - total potential impact of 156.25 ha to *potential habitat*
  - Austral cornflower (*Rhaponticum austral*) - total potential impact of 73.98 ha to *potential habitat*
  - Blotched sarcochilus (*Sarcochilus weinthalii*) - total potential impact of 3.14 ha to *potential habitat*
- Fauna
  - Collared delma (*Delma torquata*) – 197.41 ha to *important habitat*
  - Koala (*Phascolarctos cinereus*) – 189.01 ha to *Habitat critical to the survival of the species* and 70.6 ha of *potential habitat*
  - Black-breasted button-quail (*Turnix melanogaster*) – 9.18 ha to *Habitat critical to the survival of the species*
  - Spotted-tail quoll (*Dasyurus maculatus maculatus*) - total potential impact of 24.46 ha to *Habitat critical to the survival of the species* and 129.53 ha of *potential habitat*
  - Red goshawk (*Erythrotriorchis radiatus*) - total potential impact of 84.79 ha to *Habitat critical to the survival of the species* and 3.98 ha of *potential habitat*
  - Swift parrot (*Lathamus discolor*) - total potential impact of 8.54 ha to *Habitat critical to the survival of the species* and 180.47 ha of *potential habitat*
  - Long-nosed potoroo (*Potorous tridactylus tridactylus*) – total potential impact of 156.25 ha of *potential habitat*
  - New Holland mouse (*Pseudomys novaehollandiae*) - total potential impact of 156.25 ha of *potential habitat*
  - Grey-headed flying-fox (*Pteropus poliocephalus*) – total potential impact of 201.19 ha to *Habitat critical to the survival of the species*

- Australian painted snipe (*Rostratula australis*) - total potential impact of 8.9 ha to *Habitat critical to the survival of the species*
- Condamine earless dragon (*Tympanocryptis condaminensis*) – total potential impact of 16.22 ha of *potential habitat*

During the detailed design phase, the expected extent of the clearing will be minimised, along with the implementation of design solutions to mitigate barrier effects (e.g. fauna fencing and fauna passageways which will facilitate the movement of wildlife across the alignment).

Predicted cumulative impacts within 50 km of the Project may potentially include habitat loss from vegetation clearing/removal, fauna species injury or mortality, reduction in biological viability of soil to support growth due to soil compaction, displacement of flora and fauna species due to invasion of weeds and pest species, reduction in connectivity of biodiversity corridors, edge effects, habitat fragmentation, barrier effects, noise, dust, and light impacts and increase in litter (waste) and aquatic habitat degradation. However, the significance of the predicted cumulative impact as a result of the Project and other similar projects that occur within 50 km of the Project boundary are likely to be higher on the following ecological MNES flora and fauna species:

- *Paspalidium grandispiculatum* (a grass)
- *Brush sophora (Sophora fraseri)*
- Regent honeyeater (*Anthochaera phrygia*)
- Collared delma (*delma torquata*)
- Red goshawk *(Erythrotriorchis radiatus)*
- Grey falcon (*Falco hypoleucos*)
- Swift parrot (*Lathamus discolor*)
- Spotted-tail quoll (*Dasyurus maculatus maculatus*)
- Koala (*Phascolarctos cinereus*)
- Long-nosed potoroo (*Potorous tridactylus tridactylus*)
- Grey-headed flying-fox (*Pteropus poliocephalus*).

The MNES identified through the EIS will be subject to further investigations and surveys during the detailed design phase to more accurately determine the magnitude of the significant residual impacts upon the listed threatened species and communities. The specific mitigation measures will then be applied to ensure that the significance ratings of any potential impacts are classified as low as is reasonably practicable. Significant residual impacts will be offset through the development and implementation of an Environmental Offset Delivery Plan and associated Offset Area Management Plans.

There is the potential for some Project activities (e.g. vegetation clearing) to have a cumulative, irreversible and/or permanent impact upon some ecological MNES, even after the implementation of all Project mitigation measures. In these cases, the compensation for the residual impact will need to occur. An Environmental Offset Delivery Plan and Offset Area Management Plans for the Project has been prepared in consultation with the relevant State and Commonwealth agencies and complies with the relevant offsets policies (refer Appendix I). Strategic offsets will be provided in accordance with Commonwealth and State based policies. These will be in the form of direct land-based contributions and financial settlements.

8.1 Post primary approval

Should primary approval be issued, all relevant approval conditions will be fully addressed and adhered to at all Project stages.

ARTC will continue to work with relevant stakeholders and agencies to implement the measures and recommendations of this assessment.

Potential impacts on MNES will be managed and where possible, minimised.

9 References

Accad, A., Neldner, V.J., Wilson, B. and Niehus, R.E. (2008). *Remnant vegetation in Queensland: analysis of remnant vegetation 1997-1999-2000-2001-2003-2005, including regional ecosystem information*. Queensland Herbarium, Environmental Protection Agency, Brisbane.

Adair, R.J. and Groves, R.H. (1998). *Impact of environmental weeds on biodiversity: a review and development of a methodology*, Environment Australia, Canberra.

Amos, P.J. (1982). The potoroo in Queensland. *Queensland Agricultural Journal*. Vol. 108, pp. 5-6.

Arup/Smec Joint Venture (2016). Melbourne to Brisbane Inland Rail, Helidon to Calvert Phase 1 Engineering and Environment - Preliminary Environmental Assessment Report

Atlas of Living Australia (2020). Atlas of Living Australia species dataset search. Available: https://bie.ala.org.au/

Australian Bureau of Statistics (2016). Census of Population and Housing. General Community Profile. ASGS Main Statistical Areas. SA1-SA4 and Non-ABS Structures (LGAs). In: Commonwealth of Australia (ed.).

Australian Government (2019). EPBC Act Protected Matters Search Tool. Commonwealth of Australia Available from: http://www.environment.gov.au/epbc/protected-matters-search-tool

Australian Rail and Track Corporation (2015). *Melbourne-Brisbane Inland Rail Engineering and Technical Services Alignment Refinement Report.* Report to Australian Government.

Australian Rail Track Corporation (2010). Melbourne-Brisbane Inland Rail Alignment Study: Final Report, July 2010. Available **https://inlandrail.artc.com.au/13223/documents/29738**.

Australian Rail Track Corporation (2017a). EPBC Act referral Inland Rail Gowrie to Helidon Project, Queensland. Referral number 2017/7882 – Department of Agriculture, Water and the Environment. Available: **http://epbcnotices.environment.gov.au/_entity/annotation/ee8a1f30-e2f3-e611-a71a-005056ba00a8/a71d58ad-4cba-48b6-8dab-f3091fc31cd5?t=1591149225738**

Australian Rail Track Corporation (2017b). Initial Advice Statement: Inland Rail – Gowrie to Helidon – 15 February 2017.

Australian Standards (2009). AS 4970-2009 Protection of trees on development sites. Sydney: Standards Australia

Australian Wildlife Conservancy (2018). Species Profile – Grey Falcon. Available from: http://www.australianwildlife.org/wildlife/grey-falcon.aspx

Ayers, D. and Wallace, G. (1997). Pipeline trenches: an underutilized resource for finding fauna. Pp. 349-357 in Conservation Outside Nature Reserves, edited by P. Hale and D. Lamb. Centre for Conservation Biology, The University of Queensland, Brisbane.

Bali, R. (2005). Discussion Paper - Compensating for Edge Effects, Ecosense Consulting for the NSW Roads and Traffic Authority, Sydney.

Bamford, M., Watkins, D., Bancroft, W., Tischler, G., & Wahl, J. (2008). Migratory Shorebirds of the East Asian - Australasian Flyway: Population estimates and internationally important sites. [Online]. Canberra, ACT: Department of the Environment, Water, Heritage and the Arts, Wetlands International-Oceania. Available: **http://www.environment.gov.au/biodiversity/migratory/publications/shorebirds-eastasia.html**.

Barker, M. and Borsboom, A. (1997). *Sophora fraseri* Species Management Profile. Department of Environment and Resource Management.

Barrientos, R., Ascensao, F., Beja, P., Pereira, H.M. and Borda de Agua, L (2019). Railway ecology vs road ecology: similarities and differences. European Journal of Wildlife Research, vol. 65:12.

Bennett, A.F. (1987). Conservation of mammals within a fragmented forest environment: the contributions of insular biogeography and autecology. In: Saunders, D.A., G.W. Arnold, A.A. Burbridge and A.J.M. Hopkins, eds. *Nature conservation: the role of remnants of native vegetation*. Page(s) 41-52. Chipping Norton, NSW: Surrey Beatty and Sons.

Bennett, A.F. (1990). *Habitat Corridors. Their Role in Wildlife Management and Conservation*, Department of Conservation and Environment, Melbourne.

Birdlife Australia (2019). The New Atlas database (1998 – present). Electronic dataset.

BirdLife International (2016a). *Anthochaera phrygia*. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/full/22704415/0

BirdLife International (2016b). *Botaurus poiciloptilus*. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22697353/0

BirdLife International (2016c). *Falco hypoleucos*. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22696479/0

Birdsall, J.L., McCaughey, W. and Runyon, J.B. (2012). *Roads Impact the Distribution of Noxious Weeds More Than Restoration Treatments in a Lodgepole Pine Forest in Montana*, U.S.A, *Restoration Ecology*, vol. 20, no. 4, pp. 517 – 523.

Bitterns in Rice Project (2016). Tracking Bunyip Birds (Website). Available: https://www.bitternsinrice.com.au/tracking-bunyip-birds/

Bond, A., and Jones, D. (2008). Temporal trends in use of fauna-friendly underpasses and overpasses. Wildlife Research, vol. 35, pp. 103-112.

Bostock, P.D. & Holland, A.E. (2007). *Census of Queensland flora*, CD-ROM, Queensland Herbarium, Brisbane.

Boyes, B (2004). Biodiversity Recovery Plan for Gatton and Laidley Shires, South-East Queensland 2003-2008, Version 2, 5 March 2004, Lockyer Catchment Association (LCA) Inc., Forest Hill.

Boyes, B. (2001). 'Recovery Plan for the Threatened Species and Ecological Communities of Gatton and Laidley Shires South-East Queensland 2001–2005', Lockyer Landcare Group.

Brickell, C.D., Alexander, C., Cubey, J.J., David, J.C., Hoffman, M.H.A., Leslie, A.C., Malécot, V. & Xiaobai, J. (2016). International Code of Nomenclature for Cultivated Plants. Scripta Horticulturae. 18. ISBN 978-94-6261-116-0.

Brigalow Belt Reptiles Workshop (2010). Proceedings from the workshop for the nine listed reptiles of the Brigalow Belt bioregions. 18-19 August 2010. Queensland Herbarium , Brisbane.

Briggs, J.D. and Leigh, J.H. (1995). *Rare or Threatened Australian Plants 1995 rev. edn*, Collingwood, CSIRO Publishing.

Brummitt, R.K. & Powell, C.E. (1992). Authors of plant names. Royal Botanic Gardens, Kew.

Bureau of Meteorology (2020). Average annual, seasonal and monthly rainfall data. Bureau of Meteorology, Commonwealth of Australia. Canberra. Available from: http://www.bom.gov.au/jsp/ncc/climate_averages/rainfall/index.jsp?period=an&area=qd#maps

Camus, T., Therville, F. and Sanchez, H., (2015). Sydney Metro Northwest Project, *Four Double Shielded TBMs excavate 15 km of Twin Tunnels.* Eurock15, 64th Geomechanics Conference

Caro, T (2005). *Antipredator defences in birds and mammals*, University of Chicago Press, Chicago, Illinois, USA.

Carvalho F., Santos S.M., Mira A., Lourenço R. (2017). 'Methods to Monitor and Mitigate Wildlife Mortality in Railways.' In: Borda-de-Água L., Barrientos R., Beja P., Pereira H. (eds.) *Railway Ecology*. Springer, Cham.

Catling, P.C. and Burt, R.J. (1995). 'Why are red foxes absent from some eucalypt forests in eastern New South Wales.' *Wildlife Research* vol. 22, pp. 535-546.

Chaston, K. and Doley, D. (2006). 'Mineral Particulates and Vegetation: Effects of Coal Dust, Overburden and Flyash on Light Interception and Leaf Temperature, *Clean Air and Environmental Quality*, Vol. 40, pp. 40-44.

Claridge, A.W., Tanton M.T., Seebeck J.H., Cork S.J. and Cunningham R.B. (1992). Establishment of ectomycorrhizae on the roots of two species of Eucalyptus from fungal spores contained in the faeces of the long-nosed potoroo (*Potorous tridactylus*). *Australian Journal of Ecology*. Vol. 17, pp. 207-217.

Clarke, G.M., Grosse, S., Matthews, M., Catling, P.C., Baker, B., Hewitt, C.L., Crowther, D. & Saddlier, S.R. (2000). *Environmental Pest Species in Australia, Australia: State of the Environment, Second Technical Paper Series (Biodiversity),* Department of the Environment and Heritage, Canberra.

Coffin, A.W. (2007). 'From roadkill to road ecology: A review of the ecological effects of roads', *Journal of Transport Geography*, vol. 15, pp. 396 – 406.

Creuzer, J.C., Hargiss, L.M., Norland, J.E., DeSutter, T., Casey, F.X., DeKeyser, E.S. & Ell, M. (2016). 'Does Increased Road Dust Due to Energy Development Impact Wetlands in the Bakken Region?' *Water, Air and Soil Pollution*, vol. 227: 39 (https://doi.org/10.1007/s11270-015-2739-1).

Davidson, C. (1993). *Recovery Plan for the Collared Legless Lizard (Delma torquata).* Department of Environment and Heritage, Brisbane, Queensland.

Debus, S.J.S. & Czechura, G. (1988). 'The Red Goshawk Erythrotriorchis radiatus: a review'. *Australian Bird Watcher,* vol. 12 ,pp. 175-199.

Department of Agriculture and Fisheries (2018). 'Accepted development requirements for operational work that is constructing or raising waterway barrier works'. Queensland Government. Available from: **https://www.daf.qld.gov.au/__data/assets/pdf_file/0006/1476888/adr-operational-waterway-barrier-works.pdf**

Department of Agriculture, Water and the Environment (2020a). Species profile and threats (SPATS) database, Commonwealth Department of the Environment and Energy, Canberra. Available: **http://www.environment.gov.au/sprat**.

Department of Agriculture, Water and the Environment (2020b). Conservation Advice Falco hypoleucos Grey Falcon. Canberra: Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/929-conservation-advice-09072020.pdf.

Department of Environment and Heritage Protection (2014). Protected Plants Assessment Guidelines - Nature Conservation (Wildlife Management) Regulation 2006, Queensland Government. Available: **https://www.qld.gov.au/__data/assets/pdf_file/0030/99903/protected-plants-assessment-guidelines.pdf**

Department of Environment and Heritage Protection (2015). *An Aquatic Conservation Assessment for the riverine and non-riverine wetlands of Southeast Queensland catchments*. Queensland Government. Available from: **https://wetlandinfo.des.qld.gov.au/resources/static/pdf/assessment-monitoring/aquabamm/seq/aca_seq_v1_1_full_20151104.pdf**. [Accessed 2020]

Department of Environment and Heritage Protection (2016a). *Flora survey guidelines – protected plants.* Queensland Government. Available: **https://www.parliament.qld.gov.au/Documents/TableOffice/TabledPapers/2014/5414T4966.pdf**. [Accessed 2020]

Department of Environment and Heritage Protection (2016b) *Walking the Landscape – Lockyer Catchment Map Journal v1.0*. Queensland Government. Available from: **http://qgsp.maps.arcgis.com/apps/MapJournal/index.html?appid=e64a7303aff74f2e83454e6baf35651a**. [Accessed 2020].

Department of Environment and Resource Management (2012). *National recovery plan for the red goshawk Erythrotriorchis radiatus*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Queensland Department of Environment and Resource Management, Brisbane.

Department of Environment and Science (2016a). Census of the Queensland Flora, Queensland Government. Accessed: **https://www.data.qld.gov.au/dataset/census-of-the-queensland-flora-2019**

Department of Environment and Science (2017a). Queensland Springs Database. Queensland Government. Available from: http://qldspatial.information.qld.gov.au/catalogue/custom/index.page.

Department of Environment and Science (2017b). 'Regent Honeyeater'. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/regent_honeyeater.html

Department of Environment and Science (2017b). Condamine earless dragon. Queensland Government. Available: **https://www.ehp.qld.gov.au/wildlife/animals-az/condamine-earless-dragon.html**

Department of Environment and Science (2017c). 'Red Goshawk'. Queensland Government. Available: https://www.ehp.qld.gov.au/wildlife/threatened-species/endangered/endangered-animals/red_goshawk.html

Department of Environment and Science (2017d). 'Koala facts'. Queensland Government, Brisbane. Available from: **https://www.ehp.qld.gov.au/wildlife/koalas/koala-ecology.html**

Department of Environment and Science (2017e). 'Long-nosed potoroo'. Queensland Government. Available: **https://www.ehp.qld.gov.au/wildlife/threatened-species/vulnerable/longnosed_potoroo.html**

Department of Environment and Science (2018) Queensland Government Environmental Offsets Policy Version 1.6. Available from: **https://www.ehp.qld.gov.au/assets/documents/pollution/management/offsets/offsets-policyv1-6.pdf**.

Department of Environment and Science (2019). Wildlife Online Database. Queensland Government. Available from: https://environment.ehp.qld.gov.au/species-search/

Department of Environment and Science (2020a). Flying-fox monitoring program datasets, Queensland Government. Accessed: **https://www.data.qld.gov.au/dataset/flying-fox-monitoring-program**

Department of Environment and Science (2020b). Environmental Reports Online. For the State Planning Policy 2017. Version 6.0. Queensland Government. Available: **https://apps.des.qld.gov.au/report-request/environment/**.

Department of Environment and Science (2020c). Environmental Reports Online. For the State Planning Policy 2017. Version 6.0. Queensland Government. Available: https://apps.des.qld.gov.au/report-request/environment/.

Department of Environment and Science (2020d). South East Queensland Koala Conservation Strategy 2020-2025. Queensland Government, Brisbane. Available from: **South East Queensland (SEQ) Koala Conservation Strategy 2020–2025 (des.qld.gov.au)**

Department of Environment, Land, Water and Planning (2016). *National Recovery Plan for the Spotted-tailed Quoll Dasyurus maculatus*, Australian Government, Canberra.

Department of National Parks, Recreation, Sport and Racing (2013) *Lockyer Area Management Strategy 2013*. Queensland Government, Brisbane. Available from: **https://parks.des.qld.gov.au/managing/plans-strategies/statements/lockyer.html**. [Accessed 2020]

Department of Natural Resources, Mines and Energy (2018). Guide: New vegetation management laws. Available from: https://www.dnrme.qld.gov.au/__data/assets/pdf_file/0010/1396486/new-vegetation-management-laws-guide-2018.pdf.

Department of Sustainability, Environment, Water, Population and Communities (2012). *Approved Conservation Advice for Phascolarctos cinereus (combined populations in Queensland, New South Wales and the Australian Capital Territory)*. Commonwealth of Australia, Canberra. Available: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/197-conservation-advice.pdf**.

Department of Sustainability, Environment, Water, Population and Communities (2011d). Approved Conservation Advice for the Lowland Rainforest of Subtropical Australia. Commonwealth of Australia, Canberra. Available: **http://www.environment.gov.au/biodiversity/threatened/communities/pubs/101-conservation-advice.pdf**.

Department of Sustainability, Environment, Water, Populations and Community (2011a). *Survey guidelines for Australia's threatened fish.* Commonwealth of Australia, Canberra. Available: https://www.environment.gov.au/system/files/resources/6c9817ee-517b-4c13-9d8c-e66a61514f53/files/survey-guidelines-fish.pdf

Department of Sustainability, Environment, Water, Populations and Community (2011b). *The draft referral guidelines for the Brigalow Belt reptiles.* Commonwealth of Australia, Canberra.

Department of Sustainability, Environment, Water, Populations and Community (2011c). *Survey guidelines for Australia's threatened mammals.* Commonwealth of Australia, Canberra.

Department of the Environment (2013a). Matters of National Environmental Significance: Significant impact guidelines 1.1. Commonwealth of Australia, Canberra.

Department of the Environment (2013b). *Approved Conservation Advice for Thesium australe (austral toadflax).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/15202-conservation-advice.pdf.

Department of the Environment (2014a). *EPBC Act referral guidelines for the vulnerable koala*. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala

Department of the Environment (2014b). *Approved Conservation Advice for Sarcochilus weinthalii (blotched sarcochilus).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/12673-conservation-advice.pdf.

Department of the Environment (2015a). *Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act.* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/system/files/resources/c05f5b87-0a99-4998-897e-7072c236cf83/files/migratory-birds-draft-referral-guideline.pdf

Department of the Environment (2015b). 'Arrive Clean, Leave Clean. Guidelines to help prevent the spread of invasive plant diseases and weeds threatening our native plants, animals and ecosystems'. Commonwealth of Australia. Canberra.

Department of the Environment (2015c). *Referral guideline for management actions in grey-headed and spectacled flying-fox camps*, Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/system/files/resources/6d4f8ebc-f6a0-49e6-a6b6-82e9c8d55768/files/referral-guideline-flying-fox-camps.pdf

Department of the Environment (2015d). 'Threat abatement plan for predation by feral cats.' Commonwealth of Australia, Canberra, ACT. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats.

Department of the Environment (2015e). *Conservation Advice Calidris ferruginea curlew sandpiper*. Commonwealth of Australia, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf.

Department of the Environment (2015f). *Conservation Advice Grantiella picta painted honeyeater*. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf.

Department of the Environment (2016a). National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*). Commonwealth of Australia, Canberra.

Department of the Environment (2016b). *Draft referral guidelines for the vulnerable Murray cod (Maccullochella peeli).* Commonwealth of Australia. Canberra. Available: https://www.environment.gov.au/system/files/resources/7a17c9a0-bd7c-4bea-ab6c-965059223aa9/files/draft-referral-guidelines-vulnerable-murray-cod.pdf.

Department of the Environment and Energy (2016). 'Threat abatement plan for competition and land degradation by rabbits'. Commonwealth of Australia, Canberra, ACT. Available: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016.

Department of the Environment and Energy (2017a). *Draft national recovery plan for the Grey-headed flying-fox (Pteropus poliocephalus*), Commonwealth of Australia, Canberra.

Department of the Environment and Energy (2017b). *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017.

Department of the Environment and Energy (2018). *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomic.* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018.

Department of the Environment and Energy (2019a). *Draft national recovery plan for the Australasian bittern (Botaurus poiciloptilus*), Commonwealth of Australia, Canberra.

Department of the Environment and Energy (2019b). *Draft national recovery plan for the Australian painted snipe (Rostratula australis*), Commonwealth of Australia, Canberra.

Department of the Environment and Energy (2020). *Draft guide to nationally protected species significantly impacted by paddock tree removal,* Commonwealth of Australia, Canberra.

Department of the Environment and Heritage. (2006). Map of the Semi-evergreen Vine thickets of the Brigalow belt (North and South) and Nandewar bioregions. Available: http://www.environment.gov.au/system/files/pages/2bb7e3dd-60fe-46bc-aed9-0f45b97a44f7/files/brigalow-nandewar-vine-thickets-map.pdf.

Department of the Environment and Science (2016b). Queensland Biodiversity corridor mapping for SEQ and the Brigalow belt south bioregions. Available: https://environment.des.qld.gov.au/management/planning-guidelines/regional-biodiversity.

Department of the Environment, Water, Heritage and the Arts (2008a). *Approved Conservation Advice for Arthraxon hispidus (Hairy-joint Grass).* Canberra: Department of the Environment, Water, Heritage and the Arts. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/9338-conservation-advice.pdf

Department of the Environment, Water, Heritage and the Arts (2008b). *Approved Conservation Advice for Bothriochloa bunyensis (Satin-top Grass).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/15961-conservation-advice.pdf

Department of the Environment, Water, Heritage and the Arts (2008c). *Approved Conservation Advice for Bulbophyllum globuliforme (Miniature Moss-orchid).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/6649-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008d). Approved Conservation Advice for Clematis fawcetii. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/4311-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008e). Approved Conservation Advice for Dichanthium setosum. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/14159-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008f). *Approved Conservation Advice for Grevillea quadricauda (Four-tailed Grevillea).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64651-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008g). *Approved Conservation Advice for Leionema obtusifolium.* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64925-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008h). *Approved Conservation Advice for Paspalidium grandispiculatum.* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10838-conservation-advice.pdf

Department of the Environment, Water, Heritage and the Arts (2008i). *Approved Conservation Advice for Picris evae*. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10839-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008j). *Approved Conservation Advice for Sarcochilus hartmannii (Waxy Sarcochilus).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/4124-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008k). *Approved Conservation Advice for Sophora fraseri.* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/8836-conservation-advice.pdf

Department of the Environment, Water, Heritage and the Arts (2008l). *Approved Conservation Advice for Stemmacantha australis (Austral Cornflower).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/23949-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2008m). 'Threat abatement plan for predation by the European red fox'. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox.

Department of the Environment, Water, Heritage and the Arts (2008n). *Approved Conservation Advice for Delma torquata (Collared Delma).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1656-conservation-advice.pdf.

Department of the Environment, Water, Heritage and the Arts (2010a). *Survey guidelines for Australia's threatened birds*. Commonwealth of Australia, Canberra. Available: https://www.environment.gov.au/epbc/publications/survey-guidelines-australias-threatened-birds-guidelines-detecting-birds-listed-threatened

Department of the Environment, Water, Heritage and the Arts (2010b). *Approved Conservation Advice for Pseudomys novaehollandiae (New Holland Mouse).* Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/96-conservation-advice.pdf.

Department of Transport and Main Roads (2010). Fauna Sensitive Road Design Manual. Queensland Government. Available: https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Fauna-Sensitive-Road-Design-Volume-2

Department of Transport and Main Roads (2012). *Queensland Level Crossing Safety Strategy 2012-2021.* Queensland Government. Available from: https://www.tmr.qld.gov.au/-/media/Safety/railsafety/QueenslandLevelCrossingSafetyStrategy2012to2021.pdf. [Accessed 2020]

Department of Transport and Regional Services (2006). North-South Rail Corridor Study Executive Report. Prepared for the Department of Transport and Regional Services. Available from: https://investment.infrastructure.gov.au/files/north_south_rail_corridor_study/executive_report.pdf.

Doody, J.S., West, P., Stapley, J., Welsh, M., Tucker, A., Guarino, E., Pauza, M., Bishop, N., Head, M., Dennis, S., West, G., Pepper, A., & Jones, A. (2003). 'Fauna by-catch in pipeline trenches: conservation, animal ethics, and current practices in Australia.' *Australian Zoologist*, vol. 32, pp. 410-419.

Dudgeon, J.M. (1982). *Stratigraphy and palaeobotany of east and west Haldon, Main Range, Southeast Queensland.* Volume 10(2). Department of Geology, The University of Queensland.

Duiker, S.W. (2005). *Effects of Soil Compaction, College of Agricultural Sciences*, Available: http://pubs.cas.psu.edu/FreePubs/pdfs/uc188.pdf.

Duncan, A., Baker, G.B., & Montgomery, N. (1999). *The Action Plan for Australian Bats*. Commonwealth of Australia, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/publications/action/bats/index.html.

Eby, P. (1991). 'Seasonal Movements of Grey-headed Flying-foxes, *Pteropus poliocephalus* (Chiroptera: Pteropodidae), from Two Maternity Camps in Northern New South Wales'. *Wildlife Research*. Vol. 18, pp. 547-559.

Eco Logical Australia (2019a). Protected Plants Flora Survey Report – Gowrie Helidon. Extended Geotechnical Program – Inland Rail. Report prepared for ARTC, 29 May 2019.

Eco Logical Australia (2019b). Gowrie to Helidon Pre-clearance Survey Report. Extended Geotechnical Program – Inland Rail. Report prepared for ARTC, 30 July 2019.

Ellis, W.A.H., Melzer, A., Carrick, F.N., and Hasegawa M. (2002). 'Tree use, diet and home range of the koala (*Phascolarctos cinereus*) at Blair Athol, central Queensland'. *Wildlife Research*. Vol. 29, pp. 303-311.

EMM Consulting (2018). MNES assessment report, geotechnical investigations – Gowrie to Kagaru Inland Rail. Report prepared for ARTC, July 2018.

EMM Consulting (2019). Protected Plants Flora Survey Report – Clearing exemption notification for Toowoomba Range 2019. Report prepared for ARTC, July 2019.

Eyre T.J., Ferguson D.J., Hourigan C.L., Smith G.C., Mathieson M.T., Kelly, A.L., Venz M.F., Hogan, L.D. and Rowland, J. (2018). *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland*. Department of Environment and Science, Queensland Government, Brisbane.

Eyre, T.J., Kelly, A.L., Neldner, V.J., Wilson, B.A., Ferguson, D.J., Laidlaw, M.J. and Franks, A.J. (2014). BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. Queensland Herbarium, Department of Science, Information Technology, Innovation and Arts, Brisbane.

Fahrig, L. (2002). *Effect of habitat fragmentation on the extinction threshold: a synthesis*, *Ecological Applications*, vol. 12, no. 2, pp. 346 – 351.

Farmer, A.M. (1993). 'The Effect of Dust on Vegetation: a Review.' *Environmental Pollution*, Vol. 79, pp. 63-75.

Fitzpatrick, R.W., McKenzie, N. and Maschmedt, D.J. (1999). 'Soil morphological indicators and their importance to soil fertility', in *Soil Analysis: an Interpretation Manual*, (eds) K.T. Peverill, L.A. Sparrow and D.J. Reuter, CSIRO Publishing, Collingwood, VIC.

Forman, R.T.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R., Goldman, C.R., Heanue, K., Jones, J.A., Swamson, F.J., Turrentine, T. & Winter, T.C. (2000). *Road Ecology. Science and Solutions*. Island Press, Washington.

Furrer, R.D., and Pasinelli, G. (2016). Empirical evidence for source-sink populations: a review on occurrence, assessments and implications. *Biological Reviews of the Cambridge Philosphical Society* vol. 91, pp. 782-795.

Garnett S.T., Szabo J. & Dutson G. (2011). The action plan for Australian birds 2010. CSIRO Publishing, Victoria.

Ghent, C. (2018). Mitigating the effects of transport infrastructure development on ecosystems. Consilience: The Journal of Sustainable Development. Vol. 18, pp. 58-68.

Gibbons, P., & Lindenmayer, D.B. (2002) Tree hollows and wildlife conservation in Australia. CSIRO Publishing, Collingwood.

Goldingay, R. & B. Dobner. (2014). *Home range areas of koalas in an urban area of north-east New South Wales.* Australian Mammalogy. Vol. 36, pp. 74-80.

Great Barrier Reef Marine Park Authority (2009). *EAM Risk Management Assessment Framework*. Australian Government. Available: http://www.gbrmpa.gov.au/__data/assets/pdf_file/0008/4949/gbrmpa_EAMRiskManagementFramework.pdf.

Halford, D.A. (1998). '*Survey of threatened plant species in southeast Queensland Biogeographical Region'*, Queensland CRA/RFA Steering committee, Queensland Government.

Hansen, B.D., Fuller, R.A., Watkins, D., Rogers, D.I., Clemens, R.S., Newman, M., Woehler, E.J. & Weller, D.R. (2016). Revision of the East Asian-Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species, Unpublished report for the Department of the Environment. BirdLife Australia, Melbourne.

Harrison, M (2002). '*Bulbophyllum species of Australia', Australian Orchid Review Dec 2001/Jan 2002*, pp. 4–1.

Healthy Land and Water (2019). *Litter in our waters*, Available from: https://hlw.org.au/download-topic/waterways/litter-in-our-waterways/. Accessed: 15 August 2019.

Higgins, P.J., Peter, J.M. and Steele, W.K. (eds.) (2001). Handbook of Australian, New Zealand and Antarctic birds, Vol. 5, Tyrant-flycatchers to chats. Oxford University Press, Melbourne.

Holzapfel, S. (1994). 'A revision of the genus Picris (Asteraceae, Lactuceae) s.l. in Australia', Willdenowia, vol. 24, pp. 97-218.

Hughes, P. and Hughes B. (1991). Notes on the Black-breasted Button-quail at Widgee, Queensland. Australian Bird Watcher. Vol. 14, pp. 113-118.

Ingram, G.J., McDonald, K.R. & Nattrass, A.E.O. (2002). Revised common names for Queensland frogs in Nattrass, A.E.O. (ed) Frogs in the Community: Proceedings of the Brisbane symposium 13-14 February 1999. Queensland Frog Society, Brisbane.

Inland Rail Implementation Group (2015). *Inland Rail Implementation Group Report to the Australian Government – Attachment A: ARTC 2015 Inland Rail Programme Business Case*. Available from: https://s3-ap-southeast-2.amazonaws.com/ehq-production-australia/5de589db79424a8f1344e2e42e171fc205104b99/documents/attachments/000/029/855/original/InlandRailBusinessCase.pdf?1448785278. [Accessed 2020]

International Erosion Control Association (2008). Best Practice Erosion and Sediment Control Document. Available: https://www.austieca.com.au/publications/best-practice-erosion-and-sediment-control-bpesc-document

Jain, P., Naithani, AK. And Singh, TN., (2013). *Performance characteristics of tunnel boring machine in basalt and pyroclastic rocks of Deccan traps – a case study.* Journal of Rock Mechanics and Geotechnical Engineering, Volume 11-003.

Johnson, S (2011). Grey Falcon. Beauty of Birds. Available from: https://www.beautyofbirds.com/greyfalcons.html

Koehn J.D., J.A. McKenzie, D.J. O'Mahony, S.J. Nicol, J.P. O'Connor and W.G. O'Connor. (2009). Movements of Murray cod (*Maccullochella peelii peelii*) in a large Australian lowland river. *Ecology of Freshwater Fish*. Vol. 18, pp. 594-602.

Koehn, J. and Clunie, P. (2010). National Recovery Plan for the Murray Cod *Maccullochella peelii peelii*. Victorian Government Department of Sustainability and Environment (DSE). Melbourne. Available from: https://www.environment.gov.au/system/files/resources/bcc0fbf6-279b-4c52-88c5-42ce4d44b864/files/murray-cod.pdf.

Kutt, A.S., Vanderduys, E.P., Ferguson, D. and Mathieson, M. (2012). 'Effect of small-scale woodland clearing and thinning on vertebrate fauna in a largely intact tropical savanna mosaic', *Wildlife Research*, vol. 39, pp. 366 – 373.

Law, B and Eby, P (2008). Ranking the feeding habitats of Grey-headed flying foxes for conservation management. Report prepared for The Department of Environment and Climate Change (NSW) & The Department of Environment, Water, Heritage and the Arts. Canberra.

Lindenmayer, D.B. & K.L. Viggers (1994). Northern range limits of the long nosed potoroo, Potorous tridactylus. *Memoirs of the Queensland Museum*. Vol. 35, pp. 180.

Loyn, R.H., Runnalls, R.G., Forward, G.Y. and Tyers, J. (1983). Territorial bell miners and other birds affecting populations of insect prey, *Science*, vol. 221, pp. 1411 – 1413.

Makinson, R.O. (2000). Proteaceae 2 - Grevillea. in**:** *Flora of Australia*. 17A, pp. 1-524. Melbourne: ABRS/CSIRO.

Marchant, S. and Higgins, P.J. (eds.) (1993). *Handbook of Australian, New Zealand and Antarctic birds, Vol. 2, Raptors to lapwings*. Oxford University Press, Melbourne.

Mathieson, M.T. and Smith, G.C. (2009). *National recovery plan for the black-breasted button-quail Turnix melanogaster.* Department of Environment and Resource Management, Brisbane.

Matsuki, M., Gardener, M. R., Smith, A., Howard, R. K., Gove, A. (2016). Impacts of dust on plant health, survivorship and plant communities in semi-arid environments. Austral Ecology Vol 41, Iss 4 417-427.

McNeill J., Barrie F.R., & Burdet H.M. (2006). International Code of Botanical Nomenclature (Vienna Code) adopted by the Seventeenth International Botanical Congress Vienna, Austria, July 2005. Regnum Vegetabile. v. 146. Konigstein, Koeltz Scientific Books.

Melville, J., Goebel, S., Starr, C., Keogh, J.S., and Austin, J.J. (2007). Conservation genetics and species status of an endangered Australian dragon, Tympanocryptis pinguicolla (Reptilia: Agamidae). *Conservation Genetics.* Vol. 8, pp. 185-195

Menkhorst, P. & Hynes, E. (2010). *National Recovery Plan for the Brush-tailed Rock-wallaby Petrogale penicillata*. Department of Sustainability and Environment, East Melbourne.

Menkhorst, P. & Knight, F. (2011). *A field guide to the mammals of Australia*. South Melbourne, Vic: Oxford University Press.

Milton, S., Dean, W., Sielecki, L., van der Ree, R. (2015). The function and management of roadside vegetation. in van der Ree, Smith and Grilo (eds.), Handbook of Road Ecology. Wiley, West Sussex.

Moenting, A.E. and Morris, D.W. (2006). Disturbance and habitat use: is edge more important than area?, *Oikos*, vol. 115, pp. 23 – 32.

National Environmental Science Program Threatened Species Research Hub (2019). threatened species strategy Year 3 Scorecard. Australian Government, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened /species/20-birds-by2020. [Accessed 2020]

National Murray Cod Recovery Team (2010). *National Recovery Plan for the Murray Cod Maccullochella peelii peelii*. Department of Sustainability and Environment, Melbourne. Available: https://www.environment.gov.au/system/files/resources/bcc0fbf6-279b-4c52-88c5-42ce4d44b864/files/murray-cod.pdf.

Natural Resource Management Ministerial Council (2009). *National Koala Conservation and Management Strategy 2009-2014.* Department of the Environment, Water, Heritage and the Arts, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/publications/national-koala-conservation-mgt-strategy-2009-2014

Neldner, V.J., Wilson, B.A., Thompson, E.J. and Dillewaard H.A. (2012). Methodology for Survey And Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 3.2.Updated August 2012. Queensland Herbarium, Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane. Available from: http://www.ehp.qld.gov.au/plants/herbarium/publications/pdf/herbarium_mapping_methodology.pdf

Neldner, VJ, Wilson, BA, Dillewaard HA, Ryan, TS and Butler, D. W. (2017). *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 4.0.* Queensland Herbarium, Queensland Department of Science, Information Technology and Innovation, Brisbane.

Nelson, J.E. (1965). 'Movements of Australian flying foxes (Pteropodidae: Megachiroptera)'. *Australian Journal of Zoology*. Vol. 13, pp. 53-73.

New South Wales National Parks and Wildlife Service (2005). Southern Richmond Range draft plan of management. New South Wales Government, Sydney.

Norman Disney and Young (2020). Estimated vibration effects from piling and tunnel boring machine transit on breeding birds. Norman Disney and Young, Auckland. Available from: https://ndy.com/news/vibration-effects-birds

Office of Environment and Heritage (2017a). 'Australasian Bittern – Profile'. New South Wales Government. Available: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10105

Office of Environment and Heritage (2017b). 'Swift Parrot – Profile'. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10455

Office of Environment and Heritage (2017c). 'Red Goshawk – Profile'. New South Wales Government. Available: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10279

Office of Environment and Heritage (2017d). 'New Holland Mouse - Profile.' New South Wales Government. Available: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20253

Office of Environment and Heritage (2017e). Grey Falcon - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10330

Office of Environment and Heritage (2018a). *Wandering pepper-cress- Profile*. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10464.

Office of Environment and Heritage (2018b). Koala - Profile. New South Wales Government, Sydney. Available: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10616.

Olde, P.M. and Marriott, N.R. (1995). *The Grevillea Book, Volume 2*, Kenthurst, NSW, Kangaroo Press.

Oli, M.K. (2004). The fast-slow continuum and mammalian life-history patterns: an empirical evaluation. Basic and Applied Ecology 5: 449-63.

Ottburg, F and Blank, M. (2015). Solutions to the impacts of roads and other barriers on fish and fish habitat. in van der Ree, Smith and Grilo (eds.), Handbook of Road Ecology. Wiley, West Sussex.

Parsons, M., Thoms, M. and Norris, R. (2002). *Australian river assessment system: AUSRIVAS physical assessment protocol*. Environment Australia, Canberra. Available: https://ausrivas.ewater.org.au/protocol/download/protocol-1.pdf

Peck, S. and Hobson, R. (2007). *Survey results and management options for the Collared Delma (Delma torquata) along the proposed Toowoomba Bypass, Toowoomba Range, South-east Queensland, November 2006*. Queensland Parks and Wildlife Service.

Perry, G., Buchanan, B.W., Fisher, R.N., Salmon, M. and Wise, S.E. (2008). 'Effects of artificial night lighting on amphibians and reptiles in urban environments.' In: J.C. Mitchell, R.E. Jung Brown and B. Bartholomew (eds.), *Herpetological Conservation*, Society for the Study of Amphibians and Reptiles.

Pizzey, G. and Knight, F. (2001). *The field guide to the birds of Australia 7th Edition*. Pymble, N.S.W: HarperCollins Publishers.

Pusey, B., Kennard, M., & Arthington, A. (2004). *Freshwater fishes of north-eastern Australia*. CSIRO Pub, Collingwood, Vic.

Queensland Government (2019). Regulated Vegetation Management Map. Queensland Government. Available from: http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

Queensland Rail and Queensland Transport (2003). Gowrie to Grandchester Rail Corridor Study. Available: https://www.tmr.qld.gov.au/Projects/Name/G/Gowrie-to-Grandchester-Rail-Corridor-Study.

Queensland Roads (2008) *Toowoomba Bypass – Range Crossing with Tunnels*. Available from: https://archive.org/details/qrmar08toowoomba. [Accessed 2020]

Radle, A.L. (2007). *Effects of noise on wildlife: a literature review*, Available: http://wfae.proscenia.net/library/articles.

Rhodes, J. R., Beyer, H. L., Preece, H.J. and McAlpine, C.A. (2015). South East Queensland Koala Population Modelling Study. UniQuest, Brisbane, Australia.

Rich, C. and Longcore, T. (eds.) (2006). *Ecological consequences of artificial night lighting*, Island Press, Washington

Richardson, R. (2006). *Queensland Brigalow Belt Reptile Recovery Plan 2008 – 2012,* Report to the Department of the Environment, Water, Heritage and the Arts, Canberra. WWF-Australia, Brisbane.

Robertson, P. & M. Evans (2009). *National Recovery Plan for the Grassland Earless Dragon Tympanocryptis pinguicolla.* ACT Department of Territory and Municipal Services, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-grassland-earless-dragon-tympanocryptis-pinguicolla.

Rowden, P., Steinhardt, D. and Sheehan, M. (2008). 'Road crashes involving animals in Australia', *Accident Analysis and Prevention*, vol. 40, pp. 1865 – 1871.

Rowland, J. (2012). *Painted honeyeater, Grantiella picta. Targeted species survey guidelines.* Queensland Herbarium, Department of Environment and Science, Brisbane.

Saunders. D. and Tzaros, C. (2011). National Recovery Plan for the Swift Parrot *Lathamus discolor*. Birds Australia, Melbourne.

Saunders., D and Heinsohn, R. (2008) Winter habitat use by the endangered, migratory Swift Parrot (Lathamus discolour) in New South Wales. *Emu,* vol. 108, pp. 81-89

Scarlett, N. (2000). *Flora and Fauna Guarantee Action Statement Draft; Winged Pepper-cress Lepidium monoplocoides*, Department of National Resources and Environment, Melbourne.

Schoenjahn, J (2018). *Adaptations of the rare endemic Grey Falcon Falco hypoleucos that enable its permanent residence in the arid zone of Australia*. PhD Thesis. University of Queensland.

Smith, D., van der Ree, R., Rosell, C. (2015). Wildlife crossing structures: an effective strategy to restore or maintain wildlife connectivity across roads. in van der Ree, Smith and Grilo (eds.), Handbook of Road Ecology. Wiley, West Sussex.

Smith, G.C. & Mathieson M. (2004). Black-breasted button-quail. *Wingspan*. September, pp. 34-35.

Smyth, A.K. and Young J. (1996). Observations on the endangered Black-breasted Button-quail *Turnix melanogaster* breeding in the wild. *Emu.* Vol. 96, pp. 202-207.

Stanley, T.D. and Ross, E.M. (1983). *Flora of South-eastern Queensland, vol. 1*, Queensland Department of Primary Industries, Brisbane.

Swift Parrot Recovery Team (2000). *Swift Parrot Recovery Plan 2001-2005* (non-current). Department of Primary Industries, Water and Environment, Hobart. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/swift-parrot/index.html. In effect under the EPBC Act from 26-Mar-2002. Ceased to be in effect under the EPBC Act from 10-Feb-2012.

Taylor, B. and Goldingay, R. (2010). Roads and wildlife: impacts, mitigation and implications for wildlife management in Australia. Wildlife Research. Vol. 37, pp. 320-331.

Thackway, R. and Cresswell, I.D. (1995). An Interim Biogeographic Regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative program. Reserve Systems Unit, Australian Nature Conservation Agency, Canberra.

Thorp, J. and Lynch, R. (2011). The Determination of Weeds of National Significance, National Weeds Strategy Executive Committee, Launceston.

Threatened Species Scientific Committee (2014). *Lepidium peregrinum (a herb) – Commonwealth Listing Advice*. Department of Environment, Water, Heritage and the Arts, Canberra. Available: **http://www.environment.gov.au/biodiversity/threatened/species/l-peregrinum.html**.

Threatened Species Scientific Committee (2015). Conservation Advice *Calidris ferruginea* curlew sandpiper. Canberra: Department of the Environment. Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf**.

Threatened Species Scientific Committee (2016a). Conservation Advice Lathamus discolor *swift parrot*. Department of the Environment, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/744-conservation-advice-05052016.pdf.

Threatened Species Scientific Committee (2016b). *Conservation Advice Tympanocryptis condaminensis Condamine earless dragon.* Department of the Environment, Canberra. Available: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/87888-conservation-advice-05052016.pdf**.

Threatened Species Scientific Committee (2016c). *Conservation Advice Petauroides volans greater glider*. Department of the Environment, Canberra. Available: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-20160525.pdf**.

Threatened Species Scientific Committee (2019a). *Conservation Advice Botaurus poiciloptilus Australasian bittern*. Department of the Environment and Energy, Canberra.

Threatened Species Scientific Committee (2019b). *Conservation Advice Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland).* Canberra: Department of the Environment and Energy. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/66645-conservation-advice-31102019.pdf.

Threatened Species Scientific Committee. (2013). *Listing advice for Dichanthium queenslandicum*. Australian Government, Canberra. Available: http://www.environment.gov.au/biodiversity/threatened/species/pubs/14159-listing-advice.pdf.

Threlfall, C.G., Law, B., and Banks, P.B. (2013). 'The urban matrix and artificial light restricts the nightly ranging behaviour of Gould's long-eared bat (*Nyctophilus gouldi*).' Austral Ecology, vol. 38, pp. 921–930.

Tidemann, C.R. (1998). 'Grey-headed Flying-fox, *Pteropus poliocephalus*'. In: Strahan, R, (ed.) *The Mammals of Australia*. New Holland Publishers. Frenchs Forest.

van der Grift, E., van der Ree, R., Jaeger, J. (2015). 'Guidelines for evaluating the effectiveness of road mitigation measures', in van der Ree, Smith and Grilo (eds.), *Handbook of Road Ecology*. Wiley, West Sussex.

van der Ree, R, Ward, SJ, and Handasyde, KA (2004). 'Distribution and conservation status of possums and gliders in Victoria.' In *The Biology of Australian Possums and Gliders* (eds R.L Goldingay and SM Jackson), pp. 91-110. Surrey Beatty and Sons, Sydney.

van der Ree, R., Clarkson, D.T., Holland, K., Gulle, N., Budden M. (2008). Review of Mitigation Measures used to deal with the Issue of Habitat Fragmentation by Major Linear Infrastructure, Report for Department of Environment, Water, Heritage and the Arts, Commonwealth of Australia, Canberra.

Van der Ree, R., Gagnon, J., Smith, D. (2015a). Fencing: a valuable tool for reducing wildlife-vehicle collisions and funnelling fauna to cross structures. in van der Ree, Smith and Grilo (eds.), *Handbook of Road Ecology*. Wiley, West Sussex.

Van der Ree, R., Smith, D., Grilo, C. (2015b). *Handbook of Road Ecology*. Wiley, West Sussex

Van der Ree, R., Tonjes, S., Weller, C. (2015c). Ensuring the completed road project is designed, built and operated as intended, in van der Ree, Smith and Grilo (eds.), *Handbook of Road Ecology*. Wiley, West Sussex.

van der Ree, R., van der Grift, E., Mata, C. and Suarez, F. (2007). 'Overcoming the barrier effect of roads – how effective are mitigation strategies?' ICOET Proceedings (Chapter 7 – Wildlife and Terrestrial Ecosystems), pp. 423 – 431.

Van dyck, S. and Lawrie, B. (1997). 'The New Holland mouse *Pseudomys novaehollandiae* (Rodentia: Muridae), an addition to the mammal fauna of Queensland', *Memoirs of the Queensland Museum*, vol. 42, pp. 367-376.

VicRoads (2012). Fauna sensitive road design guidelines.VicRoads, Melbourne. Available from: file:///C:/Users/Brett.Taylor3/Downloads/VICROADS_n1571864_VicRoads_Fauna_Sensitive_Road_Deisgn_Guidelines_Final.PDF

Weller, C (2015). Construction of roads and wildlife mitigation measures: pitfalls and opportunities. in van der Ree, Smith and Grilo (eds.), Handbook of Road Ecology. Wiley, West Sussex.

Wilson, A. and Lindenmayer, D.B. (1995). *Wildlife Corridors and the Conservation of Biodiversity: A Review*, National Corridors of Green Program, Green Australia Ltd., Canberra

Wilson, S and Swan, G (2017). *A complete guide to reptiles of Australia (5th ed).* New Holland Publishers, Chatswood, N.S.W.

Woinarski, J.C.Z., Burbidge, A.A. and Harrison, P.L. (2014). *The action plan for Australian mammals*, CSIRO Publishing, Collingwood, Victoria.

Woinarski, J.C.Z., McCosker, J.C., Gordon, G., Lawrie, B., James, C.D., Augusteyn, J., Slater, L. & Danvers, T. (2006). 'Monitoring change in the vertebrate fauna of central Queensland, Australia, over a period of broad-scale vegetation clearance, 1973–2002', *Wildlife Research*, vol. 33, pp. 263 – 274.

Young, P.A.R, Wilson, B.A., McCosker, J.C., Fensham, R.J., Morgan, G. and Taylor, P.M. 1999. Brigalow belt. In P Sattler and R Williams (eds), *The conservation status of Queensland's bioregional ecosystems*, Environmental Protection Agency, Brisbane.

APPENDIX J

INLAND RAIL

Matters of National Environmental Significance

Appendix A Predicted habitat and TEC modelling methodology

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

IR_1536

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Inland Rail Gowrie to Helidon EIS

Appendix A – Predictive habitat modelling methodology

Australian Rail Track Corporation

Reference: 3200

Contents

1 Introduction 1

1.1 Background 1
1.2 Context 1
1.3 Review of existing databases and literature 2

2 Species and communities included within the predictive habitat mapping model 5
3 Predictive habitat modelling input datasets 10
4 Predictive habitat modelling categories 11

4.1 Flora and fauna species 11

5 Predictive habitat models and general assumptions associated with their development 13

5.1 Flora and fauna habitat models 13

6 References 56
7 Bibliography 57

7.1 Flora species 57
7.2 Fauna species – conservation significant species 65

Tables

Table 1.1 Database and document review summary
Table 1.2 Assessments and reports providing ecological information for areas associated with the Project
Table 2.1 Conservation significant flora species identified from database searches
Table 2.2 Conservation significant fauna species identified from database searches
Table 5.1 EPBC Act threatened (EPBC Act controlling provisions) flora species habitat assumptions used to map areas of occurrence within the matters of national environmental significance study area
Table 5.2 EPBC Act threatened (EPBC Act controlling provisions) fauna species habitat assumptions used to map areas of occurrence within the matters of national environmental significance study area

1 Introduction

1.1 Background

For the purposes of the Inland Rail Project (Gowrie to Helidon) (the Project) predictive habitat models for flora and fauna have been prepared. These models are designed to map the potential areas that are likely to be analogous to habitat associated with the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth (Cth)) (EPBC Act) threatened species that have been identified as potentially occurring within the broader MNES study area during the review of literature and publicly accessible databases associated with the Project EIS investigations. This mapping has the following objective:

- To provide predictive habitat modelling for EPBC Act listed flora and fauna species to:
  - Identify areas of potential habitat for EPBC Act listed species
  - Facilitate the calculation of potential disturbance areas associated with the Project and to subsequently inform the assessment of significant residual impacts for matters of national environmental significance (MNES).

This document outlines the methodology used for the development of the predictive habitat models and provides the species specific assumptions and mapping requirements needed to reproduce the predictive habitat models for each individual species. The models have been used to prepare maps indicating the potential extent of each threatened species associated with the Project as identified in the Project Environmental Impact Statement (EIS) Terms of Reference (ToR), in addition to those species identified from the desktop review phase of the Project EIS. The methodologies presented here represent a conservative approach to mapping and apply the conservative approach (adopting the precautionary principle) to the identification of habitat for each specific matter.

The approach adopted is designed to be dynamic and will evolve in response to changes to the design and footprint, along with additional ecological information gained from Project activities (e.g. pre-clearing surveys or protected plant surveys in accordance with the relevant flora survey guidelines (i.e. DES 2019) and changes to species status. This flexibility also has benefits such that during the construction stage, it allows management and monitoring of compliance with disturbance limits and environmental offset requirements. That is, the predictive mapping models along with other Project inputs (e.g. fauna 'breeding places' identified during pre-clearing surveys) can be used to identify temporary and permanent no-go zones and track clearing extents against relevant disturbance limits and where applicable, inform additional specific mitigation measures.

1.2 Context

For context with respect to the methodology's compliance with EPBC Act Survey Guidelines for threatened species, the more conservative approach of this methodology surpasses the guideline's expectations. The *"How to use these guidelines"* statement contained within the EPBC Act Survey Guidelines for threatened species, includes the following statement:

"*… Alternatives to a dedicated survey may also be appropriate. For example, a desktop analysis of historic data may indicate that a significant impact is not likely. Similarly, a regional habitat analysis may be used to determine the importance of a site to the listed birds. Proponents should also consider the proposals impact in the context of the species' national, regional, district and site importance to establish the most effective survey technique(s)…*"

This methodology includes analysis of historic and current data gained from a range of sources (as listed in Table 1.1 and Table 1.2) with direct and current survey efforts including dedicated ground truthing surveys of the database mapping and follow-up ecological assessments within the MNES study area as part of the Project geotechnical drilling survey program.

1.3 Review of existing databases and literature

Each predictive habitat model has been developed to deliver a process that is robust, transparent and repeatable. The first stage in developing each of the models involved determining the extent of current distribution for each of the modelled species and an assessment of information related to species habitat requirements.

Ten data sources were accessed to identify MNES species that have potential to occur within the MNES study area. These data sources are listed in Table 1.1.

In addition, multiple ecological assessment were identified which describe MNES values (including species protected under the EPBC Act) within the MNES study area (refer Table 1.2).

Table 1.1 Database and document review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia (AoLA) (2020)	13/05/2020	MNES study area	Ongoing inspection of records of flora and fauna, including threatened species listed under the EPBC Act.
Flying Fox Monitoring Program (DES 2020a)	24/04/2020	MNES study area	Show the location of flying-fox roosts in QLD recorded by the department and include monitoring data of continuously and periodically (seasonally or irregularly) used roosts. The exact location of roosts may vary within a small localised area.
Birdlife Australia (2019)	29/03/2019	MNES study area	Records of avian fauna, including threatened and migratory species listed under the EPBC Act.
EPBC Act Protected Matters Search Tool (PMST) (Australian Government 2019)	25/03/2020	MNES study area	Provides a “predictive” account of MNES identified within a specific area. Includes MNES such as world heritage properties, national heritage places or wetlands of international importance and threatened/migratory species.
Regulated Vegetation Management Map (QLD Government 2019)	25/03/2020	MNES study area	Mapping of REs and High Value Regrowth that provide habitat for TECs and threatened species under the EPBC Act.
Wetland Info database (DES 2020b)	25/03/2020	MNES study area	Provides interactive maps, species records, case studies and legislation associated with QLD wetlands.
Wildlife Habitat Map (DES 2020c)	25/03/2020	MNES study area	Modelled habitat for threatened species listed under the EPBC Act.
Wildlife Online database (DES 2019) incorporating WildNet and Herbrecs datasets	25/03/2020	MNES study area	Records of flora and vertebrate fauna including threatened species listed under the EPBC Act.
QLD Springs Database (QLD Government 2017a)	25/03/2020	Regional extent	The dataset provides a comprehensive catalogue of permanently saturated springs that have fixed locations and any associated surface expression groundwater dependent ecosystems.

Database/data source name	Database search date	Database search areas	Data type
Matters of national environmental significance (MNES) (DAWE 2020)	25/05/2020	MNES study area	Location of MNES, including: ■ Threatened species as listed under the EPBC Act ■ Migratory species listed under the EPBC Act ■ TECs listed under the EPBC Act ■ Critical habitats ■ World Heritage Properties ■ National Heritage Places ■ Wetlands of International Importance (i.e. Ramsar) ■ Great Barrier Reef Marine Park ■ Commonwealth Marine Area ■ Nuclear Areas.

Table 1.2 Assessments and reports providing ecological information for areas associated with the Project

Document title	Reference	Summary of significant findings related to MNES
Australian Rail Track Corporation/Transport - Land/Gowrie to Helidon/Queensland/Inland Rail Gowrie to Helidon Project, QLD (EPBC Referral number 2017/7882)	ARTC (2017a)	■ Provides initial details on how the project is likely to impact upon MNES. This includes identification of potential impacts to threatened flora and fauna species and TECs. ■ Observations of Koala (*Phascolarctos cinereus*) presence (scats) – 16 distinct locations along the alignment (high activity noted in some areas)
Initial Advice Statement: Inland Rail – Gowrie to Helidon – 15 February 2017.	ARTC (2017b)	■ Potential impacts on threatened flora, fauna and ecological communities identified for the project. ■ Confirmation of the presence of Austral Toadflax (*Thesium australe*) as part of the nearby Toowoomba Second Range Crossing (TSRC) investigations ■ The Project will likely impact Koala (*Phascolarctos cinereus*) habitat ■ The need for further detailed targeted surveys for three fauna species was identified; specifically for Koala (*Phascolarctos cinereus*), Collared delma (Delma torquata) and Black-breasted button-quail (*Turnix melanogaster*)
Inland Rail – Gowrie to Kagaru Geotechnical investigations. MNES assessment report – 23 July 2018	EMM (2018a)	■ Identified habitat for Austral toadflax (*Thesium australe*), Hawkweed (*Picris evae*) and Austral cornflower (*Rhaponticum australe*) ■ Evidence of Koala (*Phascolarctos cinereus*) presence (scatches/scats) within alignment ■ Known populations of Collared delma (*Delma torquata*) within alignment associated with findings of the TSRC project
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey report – Toowoomba Range (July 2019)	EMM (2019a)	■ Confirmation of the presence of Brush sophora (*Sophora fraseri*) (two individuals) in the Toowoomba Range area
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey reports (2019) Preclearance survey reports (2018 and 2019)	EMM (2018b, 2018c; 2019b, 2019c, 2019d)	■ No MNES observed

Document title	Reference	Summary of significant findings related to MNES
Inland Rail – Gowrie to Helidon Geotechnical investigations. Protected plant survey report – 29 May 2019 Preclearance survey report (30 July 2019)	Ecological Australia (2019a, 2019b)	▪ Koalas (*Phascolarctos cinereus*) observed as well as evidence of presence (scatches/scats) within MNES study area ▪ Collared delma recorded as well as evidence of presence (skins) within MNES study area ▪ Lowland Rainforest of subtropical Australia threatened ecological community (TEC) confirmed within MNES study area

In addition to the assessment of pre-existing datasets and reports identified above, the Project EIS field team deployed a total survey effort of approximately 340 person hours (i.e. 34 field days) between September 2017 and December 2018 assessing environmental attributes associated with the MNES study area. Data associated with this field analysis aided in the validation and iteration of the predictive habitat mapping outputs.

In addition to previous surveys and site-based investigations, recovery plans were assessed in order to identify areas of high conservation significance or of recognised conservation value for each of the MNES subject to predictive habitat modelling. In addition, the Draft Guide to nationally protected species significantly impacted by paddock tree removal (DoEE 2020) was also assessed to determine species that may be impact by the removal of paddock trees (eg. Koala and Swift parrot).

Of the species identified as potentially occurring in the MNES study area and impacted by the Project activities, eight have a Commonwealth approved recovery program. These species consist of the following:

- Murray cod (*Maccullochella peelii*)
- Condamine earless dragon (*Tympanocryptis condaminensis*)
- Brush-tailed rock-wallaby (*Petrogale penicillata*)
- Spotted-tail quoll (*Dasyurus maculatus maculatus*)
- Black-breasted button-quail (*Turnix melanogaster*)
- Red goshawk (*Erythrotriorchis radiatus*)
- Regent honeyeater (*Anthochaera phrygia*)
- Swift parrot (*Lathamus discolor*)

Three species relevant to this assessment are subject to a Draft recovery program. These species consist of the following:

- Australian painted snipe (*Rostratula australis*)
- Australasian bittern (*Botaurus poiciloptilus*)
- Grey-headed flying-fox (*Pteropus poliocephalus*)

In addition to the recovery plans identified above, draft referral guidelines (including drafts) are applicable to the following species:

- Collared delma (*Delma torquata*)
- Dunmall's snake (*Furina dunmalli*)
- Five-clawed worm-skink (*Anomalopus mackayi*)
- Koala (*Phascolarctos cinereus*)
- White-throated needletail (*Hirundapus caudacutus*)

Information derived from the recovery plans, and referral guidelines were used to derive specific habitat characterisation criteria to inform the predictive habitat modelling process.

2 Species and communities included within the predictive habitat mapping model

A total of 21 conservation significant flora species and 31 conservation significant fauna species listed under the provisions of the EPBC Act and/or NC Act were identified as occurring or potentially occurring within the MNES study area (refer Table 2.1 and Table 2.2). Of these, 16 flora and 21 fauna species are considered to potentially, likely or are known to occur within the MNES study area.

All threatened species identified as potentially occurring within the MNES study area were subject to habitat modelling as outlined within this document.

Table 2.1 Conservation significant flora species identified from database searches

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Asteraceae	*Picris evae*	Hawkweed	V	✓	✓	✓	✓	Likely
Asteraceae	*Rhaponticum australe*	Austral cornflower	V	✓	✓	✓	✓	Likely
Brassicaceae	*Lepidium peregrinum*	Wandering pepper-cress	E		✓		✓	Possible
Fabaceae	*Sophora fraseri*	Brush sophora	V	✓	✓		✓	Likely
Haloragaceae	*Haloragis exalata velutina*	Tall velvet sea-berry	V		✓		✓	Unlikely, species distribution is outside of the MNES study area and habitat unlikely to be present.
Orchidaceae	*Bulbophyllum globuliforme*	Miniature moss-orchid	V		✓		✓	Possible
Orchidaceae	*Sarcochilus hartmannii*	Waxy sarcochilus	V		✓		✓	Possible
Orchidaceae	*Sarcochilus weinthalii*	Blotched sarcochilus	V	✓	✓		✓	Possible
Poaceae	*Arthraxon hispidus*	Hairy-joint grass	V		✓		✓	Possible
Poaceae	*Bothriochloa bunyensis*	Bunya Mountains bluegrass	V	✓	✓	✓	✓	Possible
Poaceae	*Dichanthium queenslandicum*	King blue-grass	E		✓		✓	Possible
Poaceae	*Dichanthium setosum*	Bluegrass	V		✓		✓	Possible
Poaceae	*Paspalidium grandispiculatum*	A grass	V		✓		✓	Possible
Proteacaea	*Grevillea quadricauda*	Four-tailed grevillea	V	✓	✓		✓	Possible
Proteaceae	*Macadamia integrifolia*	*Macadamia nut*	V		✓		✓	Unlikely, species has a coastal distribution. Planted specimens (i.e. not in the wild) may be present but these are considered beyond the intent of the EPBC Act listing
Ranunculaceae	*Clematis fawcettii*	*Stream clematis*	V		✓		✓	Possible
Rutaceae	*Leionema obtusifolium*	*Blunt-leaved leionema*	V				✓	Possible
Rutaceae	*Phebalium distans*	*Mt Berryman phebalium*	CE		✓		✓	Unlikely, outside of its range. Only known from a small area south of the Project
Santalaceae	*Thesium australe*	*Austral toadflax*	V		✓		✓	Likely

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Simaroubaceae	*Samadera bidwillii*	*Quassia*	V		✓		✓	Unlikely, No records in wider area and species occurs between Mackay and Gympie (DAWE 2020)
Surianaceae	*Cadellia pentastylis*	*Ooline*	V		✓			Unlikely, outside of its range. Occurs west of the Great Dividing Range

Table notes:

CE = Critically Endangered E = Endangered
V = Vulnerable ✓ = species present within database record within the MNES study area ^ ToR = Terms of Reference

Table 2.2 Conservation significant fauna species identified from database searches

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Birds								
Accipitridae	*Erythrotriorchis radiatus*	Red goshawk	V	✓	✓		✓	Possible
Apodidae	*Hirundapus caudacutus*	White-throated needletail	V, M	✓	✓	✓		Possible
Ardeidae	*Botaurus poiciloptilus*	Australasian bittern	E		✓		✓	Possible
Columbidae	*Geophaps scripta scripta*	Squatter pigeon (southern subspecies)	V	✓	✓	✓	✓	Unlikely, the species is typically associated with the western slopes of the Great Dividing Range. While there are several records of this species within the broader project context, the majority of these are older and there are no recent records (>1990s) within 5 km of the project disturbance footprint
Dasyornithidae	*Dasyornis brachypterus*	Eastern bristlebird	E				✓	Unlikely, outside of species natural range.
Falconidae	*Falco hypoleucos*	Grey Falcon	V			✓		Known (observed)
Meliphagidae	*Anthochaera phrygia*	Regent honeyeater	CE		✓		✓	Possible
Meliphagidae	*Grantiella picta*	Painted honeyeater	V	✓	✓	✓	✓	Possible
Passeridae	*Poephila cincta cincta*	Southern black-throated finch	E		✓			Unlikely, this species is considered to be locally extinct within SEQ.
Psittacidae	*Cyclopsitta diophthalma coxeni*	Coxen's fig-parrot	E		✓		✓	Unlikely. No records in wider area and no suitable wet forest habitat within or near Project.
Psittacidae	*Lathamus discolor*	Swift parrot	CE		✓		✓	Possible
Rostratulidae	*Rostratula australis*	Australian painted snipe	E	✓	✓	✓		Possible
Scolopacidae	*Calidris ferruginea*	Curlew sandpiper	CE, M		✓		✓	Possible
Scolopacidae	*Numenius madagascariensis*	Eastern curlew	CE, M		✓		✓	Unlikely. Species is essentially a coastal specialist.
Turnicidae	*Turnix melanogaster*	Black-breasted button-quail	V	✓	✓	✓	✓	Possible
Fish								
Pericichthyidae	*Maccullochella peelii*	Murray cod	V		✓		✓	Possible

Family	Species name	Common name	EPBC Act	Data source				Likelihood of occurrence
				Wildlife online	PMST	AoLA	ToR^	
Mammals								
Dasyuridae	*Dasyurus hallucatus*	Northern Quoll	E		✓			Unlikely, outside of species natural range.
Dasyuridae	*Dasyurus maculatus maculatus*	Spotted-tail quoll	E		✓		✓	Possible
Macropodidae	*Petrogale penicillata*	Brush-tailed rock-wallaby	V	✓	✓	✓	✓	Likely
Muridae	*Pseudomys novaehollandiae*	New Holland mouse	V		✓		✓	Possible
Petauridae	*Petauroides volans*	Greater glider	V		✓		✓	Possible
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	✓	✓	✓	✓	Likely
Potoroidae	*Potorous tridactylus tridactylus*	Long-nosed potoroo	V		✓		✓	Possible
Pteropodidae	*Pteropus poliocephalus*	Grey-headed flying-fox	V	✓	✓		✓	Likely
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared pied bat	V		✓		✓	Unlikely. Species never recorded in or near Toowoomba Range.
Vespertilionidae	*Nyctophilus corbeni*	South-eastern long-eared bat	V		✓		✓	Unlikely. Outside of species range and no suitable habitat present.
Reptiles								
Agamidae	*Tympanocryptis condaminensis*	Condamine earless dragon	E		✓		✓	Possible
Elapidae	*Furina dunmalli*	Dunmall's snake	V		✓		✓	Possible
Pygopodidae	*Delma torquata*	Collared delma	V	✓	✓	✓	✓	Likely
Scincidae	*Anomalopus mackayi*	Five-clawed worm-skink	V		✓	✓	✓	Possible
Scincidae	*Coeranoscincus reticulatus*	Three-toed snake-tooth skink	V				✓	Unlikely. Species unknown from Toowoomba range and no suitable wet forest habitat present.
Scincidae	*Egernia rugosa*	Yakka skink	V		✓		✓	Unlikely. Highly modified habitat present in the Gowrie area (species not known to occur in the Toowoomba Range or east) and no records within 60 kilometres (km) of the Project.

Table notes:

E = Endangered V = Vulnerable M = Migratory CE = Critically Endangered ✓= species present within database recorded within the impact MNES study area ^ = ToR = Terms of Reference

3 Predictive habitat modelling input datasets

Predictive habitat modelling was undertaken to identify and map areas that are considered to have the potential to provide habitat for the conservation significant species listed in Table 2.1 and Table 2.2 which have potential to occur within the MNES study area. This modelling provides an additional tool to assess the likely occurrence of species of interest and facilitates impact assessment by allowing for the quantification of area of habitat using GIS analysis.

In addition to the species specific vegetation associations identified within Table 5.1 and Table 5.2, additional GIS layers and field derived information have been utilised to identify areas of habitat within the MNES study area where applicable to a species. These layers include:

- Regional ecosystem datasets (Version 11) (remnant and high value regrowth) and pre-clearing regional ecosystem layers (refer Appendix A for the description of Regional Ecosystems that occur within the MNES study area)
- High resolution aerial photography with site derived datasets (i.e. utilisation of condition data, species records and general observational data pertaining to species habitat where applicable)
- Where available[1], threatened species records from Atlas of Living Australia, the Queensland Department of Environment and Science (DES) species profile and previous ecological investigations
- Field derived datasets related to species sightings/records, habitat suitability and the presence of micro-habitat features
- Topographic and geological information
- Government derived cadastral datasets
- Where applicable distribution and habitat modelling from the State and Commonwealth
- Essential habitat and wildlife habitat mapping
- Watercourses and wetlands datasets
  - Defined watercourses
  - Queensland waterways for waterway barrier works
  - State government wetland mapping, including springs and groundwater dependent ecosystems.

[1] Some species records are confidential

4 Predictive habitat modelling categories

4.1 Flora and fauna species

4.1.1 General context

Each predictive habitat model allowed partitioning of habitat for flora and fauna species using current scientific knowledge (including relevant Commonwealth threatened species listing advice and recovery plans) and pre-existing data derived from historic surveys and State based mapping identified above. The specific habitat assumptions for each species that were subject to predictive mapping are provided in Table 5.1 and Table 5.2.

The species-specific assumptions allowed the following areas to be identified for each threatened species:

- Unlikely habitat
- Potential habitat
- Important habitat (where applicable)
- Habitat critical to the survival of the species (where applicable).

The use of these habitat categories aligns with the Commonwealth Department of Agriculture, Water and Environment's (DAWE's) habitat definitions for species protected under the EPBC Act and terminology used in the DAWE's significant impact assessment guidelines.

An overview of each of these categories is provided in the sections below.

4.1.2 Unlikely habitat

Unlikely habitat consists of areas that do not contain specimen backed records of the particular species (i.e. no point data derived from the positive identification/confirmation of a species in the field) and contain no evidence of habitat values to support the presence or existence of resident individuals or populations of the species. However, it is acknowledged that these areas may provide temporary habitat for species during exceptional circumstances. It is considered that occurrences of the subject species within these areas is an anomaly as these areas are not likely to support the species in the long term.

4.1.3 Potential habitat

Potential habitat consists of areas or locations used by transient individuals or where species may have been recorded but where there is insufficient information/evidence to identify the area as Important habitat or Habitat critical to the survival of the species (i.e. records of the species are considered anomalies as general microhabitat features are not considered to be present from a desktop perspective). Potential habitat also includes habitat that is considered to potentially support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records, where these areas are not considered to fulfil the criteria if "*Habitat Critical to the survival of the species*". Potential habitat may include areas of suboptimal habitat for species. Species specific assumptions that define the Potential habitat category are identified in Table 5.1 and Table 5.2. Impacts to *Potential habitat* are not considered to contribute to significant impact to an MNES as the loss of these areas is not deemed to be significant in accordance with the Commonwealth significant impact criteria. However, impact to Potential habitat have been considered in relation to movement of species and the potential to contribute towards fragmentation and barrier effects, rather than the loss of habitat *per se*.

4.1.4 Important habitat

In line with DAWE's guidelines, areas of Important habitat are regarded as a surrogate for important populations of Brigalow Belt reptiles. Relevant to the current investigations, the following species are classified as Brigalow Belt reptiles and where relevant, Important habitat for these species has been mapped as defined in Section 5 of the *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011b):

- Dunmall's snake (*Furina dunmalli*)
- Collared delma (*Delma torquata*)
- Five-clawed worm-skink (*Anomalopus mackayi*)

Important habitat for Brigalow Belt reptiles is defined in Section 5 of the Draft Referral guidelines for the nationally listed Brigalow Belt reptiles (Commonwealth of Australia 2011) as:

"Suitable habitat for any one of the listed Brigalow Belt reptiles is considered important if it is:

- *habitat where the species has been identified during a survey*
- *near the limit of the species' known range*
- *large patches of contiguous, suitable habitat and viable landscape corridors (necessary for the purposes of breeding, dispersal or maintaining the genetic diversity of the species over successive generations), or*
- *a habitat type where the species is identified during a survey, but which was previously thought not to support the species."*

In addition to the species identified above, the Important habitat category has been used to capture "Priority habitat areas" for the Swift parrot (*Lathamus discolor*) as identified in the *National Recovery Plan for the Swift Parrot (Lathamus discolor)* (Saunders and Tzaros 2011) (where these areas do not fulfil the requirements of *Habitat critical to the survival of the species*).

Species specific assumptions that define the Important habitat category for the above-mentioned species is provided in Table 5.2. Impacts to *Important habitat* are considered to contribute to significant impact to an MNES.

4.1.5 Habitat critical to the survival of the species

Habitat critical to the survival of the species represents habitat with the greatest value for the particular MNES. This habitat category identifies areas that align with "habitat critical to the survival" of a listed threatened species is identified in an approved Recovery Plan for the relevant MNES. However, in instances where there are no Recovery Plans for a specific species, the presence of a specimen backed record (i.e. derived from either desktop assessments or field investigations) is considered to align with this category where breeding and foraging habitat is potentially present unless otherwise stated within the species specific criteria presented within Table 5.1 and Table 5.2. For these species, elevation of habitat to this level adequately accounts for the significance of such areas regardless of the absence of a Recovery Plan and applies the precautionary principle to mapping areas of potentially high value habitat. Species specific assumptions associated with the mapping of Habitat critical to the survival of the species are detailed in Table 5.1 and Table 5.2. Impacts to *Habitat critical to the survival of the species* are considered to contribute to significant impact to an MNES.

5 Predictive habitat models and general assumptions associated with their development

5.1 Flora and fauna habitat models

The predictive habitat models for each of the relevant flora and fauna species was designed to provide a dynamic, robust and predictive GIS layer that could incorporate data from scientific literature and DAWE conservation listing advice/recovery programs, verified government datasets, specimen backed datasets (i.e. data derived from a known/confirmed location of an observed specimen) and field identified records into a single layer that could be used to identify areas that are known, or considered to have the potential to support specific threatened MNES. Development of these layers had the ultimate objective to:

- Predict areas that have the potential to support EPBC Act listed threatened species
- Facilitate the quantification of impacts to inform later stages of the EIS process (e.g. offset liabilities)
- Inform the design with respect to identifying areas of high ecological value which should be avoided or measures implemented to minimise the impacts
- Facilitate the assessment of assessment of significant residual impacts in accordance with the *Matters of National Environmental Significance: Significant impact guidelines 1.1* (DotE 2013).

The habitat modelling was created using ESRI ArcGIS, specifically the ESRI ArcGIS Model Builder which facilitated the development of scripts that allowed for the species-specific development of queries that utilised a range of GIS input datasets (e.g. vegetation communities containing site derived and filed verified information).

The models also incorporated the use of selecting relevant components and performing functions such as buffers and intersects that reflected the preferred habitat of a particular species. As a result of this process output habitat layers were generated for each species according to their individual requirements. The species-specific requirements that were used to generate the species-specific queries used to map potential habitat are identified in Table 5.1 and Table 5.2 . Once produced model outputs were reviewed internally by suitably qualified and experience ecologists to assess that they accurately reflected/identified habitat suitable for supporting the relevant species. If anomalies were identified, GIS iterations were undertaken to produce outputs of greater accuracy. However, it is noted that whilst species that were identified to have potential to occur within the broader region underwent habitat modelling, the results of the modelling did not necessarily identify habitat within the MNES study area for all of the species modelled. Where this occurred, these species (i.e. without identified habitat within the MNES study area) did not undergo impact assessment as part of the Project EIS.

As the predictive habitat models have been designed to identify areas of potential habitat for EPBC Act listed threatened species as stipulated by relevant guidelines, policy statements, conservation listing advice and recovery programs, several assumptions to the model have been made. These assumptions are outlined below.

- Heterogeneous vegetation community polygons – Mapping has been designed to identify maximum areas of disturbance based on a conservative approach. In the case of heterogeneous polygons, if the vegetation community code is contained within the heterogeneous polygon, then the entire polygon was selected and included as part of the habitat mapping. This represents a highly conservative approach to habitat modelling as it has potential to significantly over-estimate habitat in the absence of ground-truthing. This is of importance to species such as those that rely on limited areas of habitat such as Brigalow reptiles[2], which would otherwise be overlooked by the model. Areas of predicted habitat may be removed from mapping if field survey indicates that habitat is not available.

[2] The Draft Referral guidelines for the nationally listed Brigalow Belt reptiles noted that the RE's suitability for reptile habitation is only broadly indicative as RE polygons are mapped at a 2-5 hectare (ha) scale depending on how, where

- Buffers – Buffers have been used when integrating a specimen backed record into the predicted mapping. Generally, a 1 km buffer from the species data point is used (in line with the methodology adopted by the Queensland *Vegetation Management 1999* when identifying *essential habitat* derived from a specimen backed record under state based legislation) which results in some areas being identified as potential habitat despite being developed for other purposes (i.e. irrelevant on the level of development or clearing) and thus unlikely to support the species. This is particularly apt for the Koala, where the buffer results in areas of grazing land being defined as koala habitat despite the absence of koala trees etc. In these areas it is noted that the loss of habitat is not the risk but the potential for barrier impacts for koalas and potentially the Spotted-tail quoll. Deviations from this methodology (where they occur), are identified in Table 5.1 and Table 5.2.
- Habitat critical to the survival of the species – The predictive habitat mapping procedures outlined in this document primarily proposes potential habitat as the preferred habitat requirements for many of the species mapped. This is as a result of their habitat not being fully understood or cannot be easily extrapolated from available datasets or species information (such as applicable species recovery plans or approved conservation advice). In those cases, site derived species records were used to extrapolate preferred habitat by correlating with the underlying GIS layer. For these species, where a species point record and associated 1 km buffer intersect with areas of predicted potential habitat, the area of overlap has been elevated to the Habitat critical to the survival of the species category. The relationship between potential habitat, important habitat, species records and habitat critical to the survival of the species outlined in Table 5.1 (flora) and Table 5.2 (fauna).
- Use of existing specimen backed records to identify habitat associations – In instances where there was insufficient literature to confidently identify areas of potential habitat, specimen backed records were used to identify the associated vegetation association (e.g. preferred vegetation communities and geological components). These point-selected datasets were then assessed to determine that they were consistent with the species habitat requirements. When identified as valid, the point selected data points were incorporated into the predictive mapping "recipe" for the particular species (refer Table 5.1 and Table 5.2). Point selected datasets that were not identified as being able to support the species were rejected from use in further analysis.
- Minimum areas of habitat – Mapping has been designed to identify maximum areas of disturbance and therefore no minimum area of habitat has been identified. The methodology was developed to predict areas of potential habitat. However, the resolution of the mapping is constrained by the data inputs (e.g. vegetation community mapping) and therefore areas that may potentially be identified as habitat will always be contiguous to areas of similar habitat that reflect the minimum resolution for the input dataset (e.g. minimum vegetation community polygon size, etc.).
- Levels of habitat mapping – Potential habitat has primarily been indicated on the predictive mapping. However, where areas identified in relevant recovery plans or referral guidelines have been identified and these areas overlap with areas of predicted Potential habitat category, these areas have been elevated to Habitat critical to the survival of the species or Important habitat (e.g. for Brigalow belt reptiles) in line with the information contained within the relevant species advice/guideline or policy.

and when the mapping was carried out. This means that RE polygons mapped as unsuitable habitat may actually contain 2-5 ha of suitable habitat and vice versa for polygons mapped as suitable.

Table 5.1 **EPBC Act threatened (EPBC Act controlling provisions) flora species habitat assumptions used to map areas of occurrence within the matters of national environmental significance study area**

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Asteraceae	*Picris evae*	Hawkweed	V	*Picris evae* was not identified during any Project-associated field surveys but has been recorded during surveys for the nearby TSRC project. This species has been recorded between 2008 to 2019 within the MNES study area to the north and south of the Project disturbance footprint near Cranley to the north of Toowoomba. A record from 2015 occurs near Gowrie Mountain approximately 3 km southwest of the western section of the alignment. The approved conservation advice for the species does not identify important populations or habitat critical for the species (DEWHA 2008). The overall population is relatively restricted in occurrence and local occurrences within the Project disturbance footprint may therefore be considered as part of an important population. Hawkweed occurs in *Eucalyptus* open woodland with a grassy understorey composed of *Dichanthium* spp. Upper stratum species include *Eucalyptus melliodora*, *Eucalyptus crebra*, *Eucalyptus populnea*, *Eucalyptus albens*, *Angophora subvelutina*, *Allocasuarina torulosa*, and *Casuarina cunninghamiana*.	The following regional ecosystems (REs) (remnant and regrowth) are considered to constitute potential habitat as they are identified as eucalypt open woodland forest with grassy understory communities that contain one or more of the following species *Eucalyptus melliodora*, *E. crebra*, *E. populnea*, *E. albens*, *Angophora subvelutina*, *Allocasuarina torulosa*, and *Casuarina cunninghamiana* on black, dark grey or red-brown soils, reddish clay-loam or medium clay soils: 12.3.3, 12.3.10, 12.3.11, 12.8.14, 12.8.16, 12.8.17, 12.8.19, 12.9-10.7, 12.11.7, 12.11.14, 12.12.7, 12.12.26a, 11.3.2, 11.3.2c, 11.3.10, 11.3.17, 11.3.18, 11.3.21, 11.3.30, 113.36, 11.5.1, 11.5.13, 11.8.5, 11.8.5a, 11.8.8, 11.9.9, 11.9.9a, 11.9.9b, 11.10.12, 11.11.1, 11.12.1c, 11.12.2c. In addition, the following pre-clearance REs are considered to constitute habitat: 11.8.8, 11.8.5 (when it is located along a road reserves on basalt derived soils) in recognition of the species ability to persist in disturbed environments *Note: Any specimen backed records (buffered to a 1km*	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	**Important Habitat**	**Habitat critical to the survival of the species**
				Collections have been made along roadsides and in cultivated areas, such as paddocks, on black, dark grey or red-brown soils (i.e. Landzone 8), reddish clay-loam or medium clay soils.	*radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Asteraceae	*Rhaponticum australe*	Austral cornflower	V	*Rhaponticum australe* was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs but has been recorded in the area for surveys carried out for the nearby TSRC project. Database records indicate this species has occurred within and adjacent to the Project to the west of the tunnel. There is a somewhat recent from 1999 located to the north of Morris Road east of Gowrie. The nearest record outside of the Project footprint is from 2016 occurring approximately 20 m to the north between Draper Road and Gowrie Creek between Kingsthorpe and Gowrie Junction. Two records occur near the western tunnel entrance. Both records are dated from 1999 and are located approximately 85 m from the Project disturbance footprint between E Paulsens Road and Gowrie Creek. The approved conservation advice does not identify important populations or critical habitat for the species. The most significant population of this species occurs	The following REs (remnant and regrowth) are considered to constitute potential habitat as they are identified as eucalypt open woodland forest with grassy understory communities that contain one or more of the following species *Eucalyptus tereticornis* and *Angophora floribunda* on black clay soil derived from basalt: 12.2.3, 12.3.3a, 12.3.3d, 12.3.10, 12.5.2, 12.8.16, 12.8.17, 12.11.14, 11.3.4, 11.3.23, 11.3.38, 11.8.5, 11.8.8 In addition, the following pre-clearance REs are considered to constitute potential habitat when they are contained within a road reserve in recognition of the species ability to persist in disturbed environments: 12.2.3, 12.3.3a, 12.3.3d, 12.3.10, 12.5.2, 12.8.16, 12.8.17, 12.11.14, 11.3.4, 11.3.23, 11.3.38, 11.8.5, 11.8.8 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				in the Toowoomba-Aubigny region which the Project disturbance footprint intersects at its northern extent (DEWHA 2008). The overall population is relatively restricted in occurrence and local occurences within the Project disturbance footprint may therefore be considered as part of an important population. *Rhaponticum australe* grows in eucalypt open forest with grassy understory on roadsides and on road reserves with *Chloris gayana, Cirsium vulgare, Eucalyptus tereticornis* and *Angophora floribunda* on black clay soil.			
Brassicaceae	*Lepidium peregrinum*	Wandering Pepper-cress	E	*Lepidium peregrinum* has not been identified as occurring within or near the MNES study area. Desktop assessments also indicate that there is an absence of specimen backed records within the region. *Lepidium peregrinum* grows in riparian open forest dominated by *Eucalyptus camaldulensis* and *Casuarina cunninghamiana* with a variably dense shrubby understorey of *Hymenanthera dentata, Bursaria spinosa, Acacia fimbriata, Acacia floribunda, Callistemon viminalis* and *Leptospermum brachyandrum*. This species is often most abundant in tussock grassland fringing riparian open forest (*Poa* sp. - *Lomandra longifolia* -	The following REs (remnant) are considered to constitute potential habitat as they are identified as open forest communities that contain one or more of the following species *Eucalyptus camaldulensis, Casuarina cunninghamiana, Hymenanthera dentata, Bursaria spinosa, Acacia fimbriata, Acacia floribunda, Callistemon viminalis* and/or *Leptospermum brachyandrum*: 11.3.2b, 11.3.25, 113.25c, 11.3.25e, 11.3.27 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are*	Not applicable	All areas occupied by the species - Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				Paspalum dilatatum), with some plants scrambling to a height of 2 m in thickets of *Hymenanthera*. It also occurred in shade under shrubs close to the creek bank, where most plants were small, about 30 cm in height	*considered to constitute potential habitat*		
Fabaceae	*Sophora fraseri*	Brush sophora	V	*Sophora fraseri* was not identified during any Project-associated field surveys. Database records indicate the nearest occurrence exists 5 km north of the Project at the eastern end of the alignment (west of Rosewood) dated 1992. A very old record (1930) occurs 5 km south of Helidon at the western end of the alignment. A review of the available literature has not revealed any important populations for *Sophora fraseri*, the species occurs across a relatively wide area, and there are no recent records of the species within 14 km of the Project. The predicted impact area is very minor and will not conceivably impact the species such that it is likely to decline or impact recovery of the species. *Sophora fraseri* grows in moist habitats, often in hilly terrain at altitudes from 60–660 m on shallow soils along rainforest margins in eucalypt forests or in large canopy gaps in closed forest communities	The following REs (remnant vegetation), which are identified as either *rainforest*, or *vine thickets* are considered to constitute potential habitat when they are located within an altitude of 60-660 m: 12.8.9, 12.8.14, 12.8.14a, 12.8.14 x 1, 12.8.21, 12.9-10.1, 12.9-10.5d, 12.9-10.19, 12.11.3, 12.11.3a, 12.11.3b, 12.11.5, 12.11.15a. 12.11.5e, 12.11.5h, 12.11.5j, 12.11.5k, 12.11.25, 12.11.26, 12.11.27. In addition to the above REs, where the following remnant REs (identified as vine forest) occur within an altitude of 60-660 metres (m), a 200 m buffer is to be placed around their perimeter where it intersects with any other RE type are also potential habitat in order to include vineforest margins and transitional zones into the Potential habitat category: 12.3.1, 12.3.17, 12.11.1, 11.3.11, 11.3.40, 11.8.13, 11.10.8, 11.11.5.	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	**Important Habitat**	**Habitat critical to the survival of the species**
					Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat.		
Orchidaceae	*Bulbophyllum globuliforme*	Miniature moss-orchid	V	*Bulbophyllum globuliforme* was not identified during any Project-associated field surveys or for the nearby TSRC project. There are no records close to the MNES study area. There are no historic records of this species within or close to the disturbance footprint. The nearest database records are located approximately 120 km from the Project in Lamington and Border Ranges National Parks to the south-east. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008) has not revealed any important populations or critical habitat for the species. No populations that are important for the long-term survival and recovery of the species have been identified. *Bulbophyllum globuliforme* grows as a epiphyte only on *Araucaria cunninghamii*, colonising the upper branches of mature trees in upland rainforest.	In order for *Araucaria cunninghamii* to provide habitat for *Bulbophyllum globuliforme*, trees must be mature. Therefore, only mature (remnant) vegetation communities were selected The following REs (remnant) are considered to constitute potential habitat: 12.2.3, 12.3.1, 12.3.11a, 12.3.16, 12.3.21, 12.5.13, 12.5.13a, 12.5.13c, 12.8.4, 12.8.13, 12.8.21, 12.9-10.1, 12.9-10.15, 12.9-10.16, 12.11.3, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.12.1, 12.12.13, 12.12.15, 12.12.15a, 12.12.16, 12.12.17, 12.12.18, 11.3.11, 11.11.5, 11.12.4, 11.12.12, 11.12.16d. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Orchidaceae	*Sarcochilus hartmannii*	Waxy sarcochilus	V	*Sarcochilus hartmannii* was not identified during any Project-associated field surveys or for the nearby TSRC project. A single record exists within a 50 km buffer of the Project disturbance footprint located approximately 15 km south of the alignment near Barry Griffith Park. No recovery plan exists for this species. There is no Commonwealth adopted recovery plan for the species. The approved conservation advice for the species does not identify important populations or habitat critical for the species (DEWHA 2008). No populations that are important for the long-term survival and recovery of the species have been identified. The Waxy sarcochilus grows on volcanic rocks, shallow soils and exposed cliffs in sclerophyll forests, rainforest margins or open areas at 500-1000 m altitude. It is also found occasionally at the base of fibrous trunks of trees, including cycads and grasstrees	The following REs (remnant) which are identified as either sclerophyll forests or rainforest margins when occurring at an elevation between 500-1000 m are potential habitat: 12.8.1, 12.8.2, 12.8.8, 12.8.9, 12.8.10, 12.8.1112.8.12, 12.8.24, 12.8.25, 12.12.2, 12.12.3, 12.12.15, 12.12.20, 11.8.1, 11.12.6, 11.12.13, 11.12.19 The following REs are considered potential habitat when they are <u>located directly adjacent</u> to the previously listed REs: 12.2.1, 12.2.2, 12.2.3, 12.3.1, 12.3.1a, 12.3.2, 12.3.16, 12.3.21, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.3, 12.8.4, 12.8.5, 12.8.8, 12.8.9, 12.8.13, 12.8.18, 12.8.21, 12.8.22, 129-10.15, 12.9-10.16, 12.11.1, 12.11.2, 12.11.3, 12.11.4, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.12.1, 12.12.13, 12.12.15, 12.12.15a, 12.12.16, 12.12.17, 12.12.18, 11.3.11, 11.3.11x1, 11.3.14, 11.4.1, 11.5.15, 11.7.1x1, 11.8.3, 11.3.13, 11.9.4, 11.9.4a, 11.9.4c, 11.10.8, 11.11.5, 11.11.5a, 11.11.18, 11.11.21, 11.12.4, 11.12.4a	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	**Important Habitat**	**Habitat critical to the survival of the species**
					Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat		
Orchidaceae	*Sarcochilus weinthalii*	Blotched sarcochilus	V	*Sarcochilus weinthalii* was not identified during any Project-associated field surveys or for the nearby TSRC project. There are two very old database records (1882 and 1957) located 2 km north of the Project disturbance footprint. There are eight records to the east of Toowoomba located 8.5 km south of the Project, the most recent of which is from 2015. To the south-east of Toowoomba are three very old records (103 to 1909) located 11 km south. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature has not revealed any important populations (DotE 2014). No populations that are important for the long-term survival and recovery of the species have been identified. The species has a scattered distribution of isolated populations and occurs in the Toowoomba Range. As such, a local population may be considered as an important population.	The following REs (remnant) which are identified as either rainforest, dry rainforest and drier scrub of sub-coastal ranges and associated foothills inland from the coast constitute potential habitat when occurring at an elevation between 400-700 m: 12.2.1, 12.2.2, 12.2.3, 12.3.1, 12.3.1a, 12.3.2, 12.3.16, 12.3.21, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.3, 12.8.4, 12.8.5, 12.8.8, 12.8.9, 12.8.13, 12.8.18, 12.8.21, 12.8.22, 129-10.15, 12.9-10.16, 12.11.1, 12.11.2, 12.11.3, 12.11.4, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.12.1, 12.12.13, 12.12.15, 12.12.15a, 12.12.16, 12.12.17, 12.12.18, 11.3.11, 11.3.11x1, 11.3.14, 11.4.1, 11.5.15, 11.7.1x1, 11.8.3, 11.3.13, 11.9.4, 11.9.4a, 11.9.4c, 11.10.8, 11.11.5, 11.11.5a, 11.11.18, 11.11.21, 11.12.4, 11.12.4a *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat.*	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				The Blotched sarcochilus occurs in rainforest, dry rainforest and drier scrub of sub-coastal ranges and associated foothills inland from the coast at altitudes of 400–700 m above sea level. In south-east Queensland, the Blotched sarcochilus grows in a number of microphyll and notophyll rainforest types and also occurs in patches of isolated scrub			
Poaceae	*Arthraxon hispidus*	Hairy-joint grass	V	*Arthraxon hispidus* was not identified during any Project-associated field surveys or for the nearby TSRC project. The nearest cluster of database records located approximately 4 km south of the Project disturbance footprint. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008) has not revealed any important populations or critical habitat for the species. No populations that are important for the long-term survival and recovery of the species have been identified. Hairy-joint grass is found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps, as well as woodland. In south-east Queensland, Hairy-joint grass has also been recorded growing around freshwater springs on coastal	The following REs (remnant) which are identified as rainforest edges and wet eucalypt forest are considered to constitute potential habitat: 12.2.1, 12.2.2, 12.2.3, 12.2.4, 12.3.1, 12.3.1a, 12.3.2, 12.3.16, 12.3.21, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.3, 12.8.4, 12.8.5, 12.8.8, 12.8.9, 12.8.13, 12.8.18, 12.8.21, 12.8.22, 129-10.15, 12.9-10.16, 12.11.1, 12.11.2, 12.11.3, 12.11.4, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.12.1, 12.12.13, 12.12.15, 12.12.15a, 12.12.16, 12.12.17, 12.12.18, 11.3.11, 11.3.11x1, 11.3.14, 11.4.1, 11.5.15, 11.7.1x1, 11.8.3, 11.3.13, 11.9.4, 11.9.4a, 11.9.4c, 11.10.8, 11.11.5, 11.11.5a, 11.11.18, 11.11.21, 11.12.4, 11.12.4a. In addition, the following REs (remnant) which are identified as woodland near a watersource are considered to constitute potential habitat when they are	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				foreshore dunes, in shaded small gullies, on creek banks, and on sandy alluvium in creek beds in open forests, and also with bog mosses in mound springs.	located within 100 m (i.e. create a buffer, which will be used to "cleave" larger REs to create new polygons) of a watercourse (stream order 3 and above): 12.2.6, 12.2.11, 12.3.3, 12.3.7, 12.3.10, 12.3.12, 11.2.1, 11.3.2, 11.3.3, 11.3.4a, 11.3.6, 11.3.7, 11.3.8, 11.3.9, 11.3.10, 11.3.13, 11.3.14, 11.3.15, 11.3.16, 11.3.17, 11.3.18, 11.3.23, 11.3.27, 11.3.28, 11.3.29, 11.3.35, 11.3.36, 11.3.37, 11.3.39. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Poaceae	*Bothriochloa bunyensis*	Bunya Mountains bluegrass	V	*Bothriochloa bunyensis* was not identified during any Project-associated field surveys or for the nearby TSRC project. Database records indicate this species occurs within the MNES study area at Blue Mountain Heights dated 2004 (2.2 km from aboveground disturbance associated with the Project). The next closest record occurs 5 km to the south in Toowoomba dated 2005. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008) has	The following REs (remnant) which are identified as grassland or woodland with grassy understorey when they occur at an elevation between 600-1100 m are considered to constitute potential habitat on soils derived from basal: 12.8.14, 12.8.15, 12.8.19, 12.8.27, 11.8.10, 11.8.11 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				not revealed any important populations or critical habitat for the species. No populations that are important for the long-term survival and recovery of the species have been identified. Bunya Mountain bluegrass occurs on relatively fertile krasnozem (dark brown) soils derived from basalt on upper slopes and hill crests at altitudes of 600-1100 m, in grassland or woodland with a grassy understorey			
Poaceae	*Dichanthium queenslandicum*	King blue-grass	E	*Dichanthium queenslandicum* was not identified during any Project-associated field surveys or for the nearby TSRC project. There are no database records within or near the MNES study area. The nearest records from within a 50 km buffer of the alignment occur to the southwest at Pittsworth (30 km from the Project) and to the northwest between Oakey and Dalby. King blue-grass occurs in native grassland communities dominated by *Dichanthium* sp. in heavy basaltic black soils.	The following REs (remnant) are considered to constitute potential habitat as they represent native grassland communities on heavy basaltic black soils: 12.8.27, 11.3.21, 11.3.24, 11.4.4, 11.4.11, 11.8.5, 11.8.5a, 11.8.11, 11.8.11a, 11.9.3, 11.9.11a, 11.9.12, 11.11.17. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)
Poaceae	*Dichanthium setosum*	A Bluegrass	V	*Dichanthium setosum* was not identified during any Project-associated field surveys or for the nearby TSRC project. Database records (AoLA) from 1996 occur within 5 km to the north of the alignment (west of Murphy's Creek). Records from 2009 occur a similar distance to the south of	The following REs (remnant and regrowth) are considered to constitute potential habitat as they represent grassy woodlands on basalt derived soils: 12.8.14, 12.8.19, 12.8.27, 11.3.21, 11.3.24, 11.4.4, 11.4.11, 11.8.5, 11.8.5a,	Not applicable	All areas occupied by the species Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				the Project disturbance footprint to the east of Toowoomba. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008) has not revealed any important populations or critical habitat for the species. No populations that are important for the long-term survival and recovery of the species have been identified. *Dichanthium setosum* is associated with heavy basaltic black soils and stony red-brown hard-setting loam with clay subsoil and is found in moderately disturbed areas such as cleared woodland, grassy roadside remnants, grazed land and highly disturbed pasture. The extent to which this species tolerates disturbance is unknown.	11.8.11, 11.8.11a, 11.9.3, 11.9.11a, 11.9.12, 11.11.17. In addition, road reserves that are mapped as RE (pre-clear) 12.8.14, 12.8.19, 12.8.27, 11.3.21, 11.3.24, 11.4.4, 11.4.11, 11.8.5, 11.8.5a, 11.8.11, 11.8.11a, 11.9.3, 11.9.11a, 11.9.12, 11.11.17. are also potential habitat for this species in recognition of the species ability to persist in disturbed environments *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		(*excluding areas that fall outside of identified vegetation communities*)
Poaceae	*Paspalidium grandispiculatum*	A grass	V	*Paspalidium grandispiculatum* was not identified during any Project-associated field surveys or for the nearby TSRC project. Nevertheless, there are a number of records to the northeast of the Project disturbance footprint. The closest is within approximately 4 km of the Project disturbance footprint and is dated 1997. A review of the available literature has not revealed any important populations or definition of habitat critical to the survival of the	The following REs (remnant and regrowth) are considered to constitute potential habitat as they represent mixed forest with *Corymbia citriodora* on sub-coastal, old loamy and sandy plains and mixed open forest often with *Corymbia trachyphloia*, *Corymbia citriodora*, *Eucalyptus crebra*, *Eucalyptus fibrosa* on quartzose sandstone and native pasture: 12.3.18, 12.5.1, 12.5.3, 12.5.7, 12.5.7a, 12.9-10.2, 12.9-10.3,	Not applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				species including the approved conservation advice for the species (DEWHA 2008). However, given there are database records in close proximity to the Project disturbance footprint and the species has a narrow range of occurrence there is potential for an 'important population' to be impacted by the Project. In Queensland, *Paspalidium grandispiculatum* occurs in mixed forest with *Corymbia citriodora* on sub-coastal, old loamy and sandy plains and mixed open forest often with *Corymbia trachyphloia*, *Corymbia citriodora*, *Eucalyptus crebra*, *Eucalyptus fibrosa* on quartzose sandstone. The species has also been recorded in and in native pasture occurring as a result of land clearing.	12.9-10.5, 12.9-10.5a, 12.9-10.5b, 12.9-10.11a, 12.9-10.12, 12.9-10.12a, 12.9-10.17, 12.9-10.17b, 12.9-10.18, 12.9-10.19, 12.9-10.23, 12.9-10.25, 12.9-10.27, 11.5.2, 11.5.9, 11.10.1, 11.10.2, 11.10.13. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Proteaceae	*Grevillea quadricauda*	Four-tailed grevillea	V	*Grevillea quadricauda* was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs or for the nearby TSRC project. Database records indicate this species has been detected/recorded within approximately 2 km to the north of the eastern section of the Project disturbance footprint to the south of the Lockyer Forest Reserves area dated 2017. There are no important populations or definitions of	The following REs (remnant and regrowth) are considered to constitute potential habitat as they represent dry sclerophyll or eucalypt on gravel loam and sandy soils: 12.3.2, 12.3.2a, 12.3.15, 12.5.1, 12.5.11, 12.9-10.5 In addition, the following REs (remnant and regrowth) are considered to constitute potential habitat when they are located within 200 m (i.e. create a buffer, which will be used to "cleave" larger REs to create	Not applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				habitat critical to the survival of Four-tailed grevillea identified in published information. Nevertheless, given the restricted area of occurrence of the species it may be inferred that the population occurring in the Lockyer Forest Reserves could be considered on the edge of the species range. As such, for the purposes of this assessment the habitat adjacent to this area which is intersected by the eastern extent of the Project is considered as potentially comprising individuals within an 'important population'. *Grevillea quadricauda* occurs on gravelly loam soils or in sandy soils. It inhabits the understorey of dry sclerophyll forest or eucalypt woodland, usually along creeks or drainage lines. Associated plant communities include creek line forest dominated by *Syncarpia glomulifera* and *Lophostemon confertus*.	new polygons) of a watercourse (stream order 3 and above): 12.8.1, 12.9-10.1, 12.9-10.1x1, 12.9-10.14, 12.11.3, 12.11.9x1, 12.12.14, 12.12.6, 11.10.2, 11.12.13 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Ranunculaceae	*Clematis fawcettii*	Stream clematis	V	*Clematis fawcettii* was not identified during any Project-associated field surveys or for the nearby TSRC project. The nearest database records are located approximately 9 km south of the Project disturbance footprint to the east of Toowoomba at Mount Davidson with two records from 1990.	The following REs (remnant and regrowth) are considered to constitute potential habitat when they are located within 200 m (i.e. create a buffer, which will be used to "cleave" larger REs to create new polygons) of a watercourse (stream order 3 and above) as they represent vine forest and eucalypt woodland	Not applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities)

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008) has not revealed any important populations or critical habitat for the species. No populations that are important for the long-term survival and recovery of the species have been identified. *Clematis fawcettii* occurs most commonly in the canopy gaps of drier rainforests near streams. It has been recorded in: ▪ semi-evergreen vine thicket ▪ araucarian microphyll vine forest ▪ occasionally, in complex notophyll vine forest ▪ occasionally, in eucalypt woodland communities that are close to vine thicket or rainforest.	communities adjacent to vine thicket or rainforest: 12.2.1, 12.2.2, 12.2.3, 12.3.1, 12.3.1a, 12.3.16, 12.3.21, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.3, 12.8.4, 12.8.5, 12.8.9, 12.8.13, 12.8.18, 12.8.21, 12.8.22, 12.9-10.1, 12.9-10.15, 12.9-10.16, 12.11.1, 12.11.4, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.12.1, 12.12.13, 12.12.16, 12.12.17, 12.12.18, 11.2.3, 11.3.11, 11.3.11x1, 11.3.40, 11.4.1, 11.5.15, 11.7.1x1, 11.8.3, 11.8.13, 11.9.4, 11.9.4a, 11.9.4c, 11.10.8, 11.11.5, 11.11.5a, 11.11.18, 11.11.21, 11.12.4, 11.12.4a. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Santalaceae	*Thesium australe*	Austral toadflax	V	*Thesium australe* was not identified during any Project-associated field surveys, but has been recorded during surveys for the nearby TSRC project. There are two database records (AoLA) to the east of Toowoomba from 1989 and 2009 located approximately 6 km south of the Project. There is no recovery plan adopted by the Commonwealth for this species. A review of the	The following REs (remnant and regrowth) are considered to constitute potential habitat as they comprise *open forest / woodland with a grassy understory,* or *grasslands* on basalt derived sediments: 12.3.3, 12.8.18, 12.8.27, 11.3.4, 11.3.12, 11.3.24, 11.3.30, 11.3.31, 11.3.38, 11.4.13, 11.8.5, 11.8.8, 11.8.10, 11.8.11, 11.9.3	Not applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities).

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				available literature has not revealed any important populations or critical habitat when referring to the Approved conservation advice for the species (DotE 2013). No populations that are important for the long-term survival and recovery of the species have been identified. Austral toadflax is semi-parasitic on roots of a range of grass species, notably *Themeda triandra* and *Dichanthium* sp. It occurs in shrubland, grassland or woodland, often on damp sites. Vegetation types include open grassy heath dominated by *Leptospermum myrtifolium*, *Hakea microcarpa*, *Callistemon sieberi, Grevillea lanigera*, *Epacris microphylla* and Poa spp.; *Themeda triandra* grassland surrounded by *Eucalyptus* woodland; and grassland dominated by *Cymbopogon refractus*. The species is also known to occur within highly disturbed road reserves within the Toowoomba region which are maintained to control woody weed species.	In addition, the following pre-clearance REs are considered to constitute potential habitat when they are contained within a road reserve on basalt derived soils: 12.3.3, 12.8.18, 12.8.27, 11.3.4, 11.3.12, 11.3.24, 11.3.30, 11.3.31, 11.3.38, 11.4.13, 11.8.5, 11.8.8, 11.8.10, 11.8.11, 11.9.3 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Rutaceae	*Leionema obtusifolium*	Blunt-leaved leionema	V	*Leionema obtusifolium* was not identified during any Project-associated field surveys or for the nearby TSRC project. Two older database records (AoLA) occur 2 km to the east of the Project	The following REs (remnant and regrowth) are considered to constitute potential habitat as they are comprised of eucalypt forest on sandstone:	Not applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to

Family	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	Habitat modelling assumptions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				disturbance footprint near Helidon dated 1964 and 1978. Almost all other historical records for this species exist to the northeast within the Lockyer Forest Reserves area with the most recent dated from 2016 and located 6.6 km northeast of the Project. This species only occurs in a small area of SEQ from Helidon to Ravensbourne. There is no recovery plan adopted by the Commonwealth for this species. A review of the available literature including the approved conservation advice for the species (DEWHA 2008) has not revealed any important populations or critical habitat for the species. However, given there are database records in close proximity to the Project disturbance footprint and the species has a narrow range of occurrence there is potential for an 'important population' to be impacted by the Project. *Leionema obtusifolium* is known from a small area of south-east Queensland, in the Helidon and Ravensbourne areas. L*eionema obtusifolium* occurs in eucalypt forest, often with *Eucalyptus acmenoides* and *Corymbia trachyphloia*, on sandstone substrates.	12.9-10.5, 12.9-10.5a, 12.9-10.17, 12.9-10.17d, 12.9-10.21, *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		the survival of the species (excluding areas that fall outside of identified vegetation communities)

Table notes:

CE = Critically endangered E = Endangered V = Vulnerable C = Least concern

Table 5.2 **EPBC Act threatened (EPBC Act controlling provisions) fauna species habitat assumptions used to map areas of occurrence within the matters of national environmental significance study area**

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Birds	*Erythrotriorchis radiatus*	Red goshawk	V	The Red goshawk prefers forest and woodland with a mosaic of vegetation types, large prey populations (birds), and permanent water. Habitat must be open enough for fast attack and manoeuvring in flight but provide cover for ambushing of prey. They avoid very dense and very open habitats. The species occupies large home ranges estimated to be up to 120 square kilometres (km^2) (females) and 200 km^2 (males). The vegetation types utilised by this species include eucalypt woodland, open forest, tall open forest, gallery rainforest, swamp sclerophyll forest, and rainforest margins. Nests are in tall trees within one km of and often beside permanent water (river, swamp, pool), usually in fairly open, biologically rich forest or woodland. These habitats provide appropriate foraging conditions for the large Red goshawk, and a diversity and abundance of the medium to large birds taken as food. SEQ is likely the southern extent of the species distribution. There are scattered records from the Lockyer Valley and Toowoomba areas although recent intensive surveys targeting the species did not observe any individuals (Seaton 2014).	The following Regional Ecosystems are considered to be potential habitat in the Toowoomba Range/Helidon Hills area (i.e isolated fragments are unlikely to represent habitat): 12.2.4, 12.3.1, 12.3.1a, 12.3.2, 12.3.3, 12.3.3a, 12.3.3c, 12.3.4, 12.3.5, 12.3.7, 12.3.16, 12.3.17, 12.3.18, 12.3.19, 12.3.21, 12.5.1, 12.5.2x1, 12.5.5, 12.7.2, 12.8.1, 12.8.2, 12.8.8, 12.8.10, 12.8.11, 12.8.12, 12.8.23, 12.9-10.1, 12.9-10.1x1, 12.9-10.2, 12.9-10.4a, 12.9-10.5, 12.9-10.11, 12.9-10.14, 12.9-10.14a, 12.9-10.14b, 12.9-10.18, 12.9-10.18b, 12.9-10.29, 12.11.2, 12.11.3b, 12.11.6, 12.11.16, 12.11.16x1, 12.12.2, 12.12.2a, 12.12.15, 12.12.15a, 12.12.15b, 12.12.20, 11.2.4, 11.3.2b, 11.3.3c, 11.3.11,11.3.18, 11.3.26, 11.3.40, 11.8.5, 11.8.13, 11.8.15, 11.10.8, 11.9.7, 11.10.5, 11.11.5, 11.11.6, 11.11.7x1, 11.11.15, 11.11.15c, 11.12.1, 11.12.1a, 11.12.5,	Not applicable	The *National recovery plan for the Red goshawk (Erythrotriorchis radiatus)* (DERM 2012) describes habitat critical to the survival of this species comprises all required habitat elements including 'sites for nesting, food resources, water, shelter, essential travel routes, dispersal, buffer areas, and sites needed for the future recovery' As such, for this assessment any potential habitat when it is contained within 1 km of a stream order 3 watercourse (or above) or a lacustrine or palustrine RE or Water body.

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	**Important Habitat**	**Habitat critical to the survival of the species**
					Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat		
Birds/ Falconidae	Falco hypoleucos	Grey falcon	V	However, during drought younger individuals are believed to disperse towards the east coast (Marchant and Higgins 1993). Preferred habitats include open woodland, shrubland, grassland, and pastoral land on alluvial floodplains and flats, clay plains, sandy plains, dunefields and wetlands. Grey falcons hunt from large standing trees in the landscape, with prey species primarily consisting of flocking, ground-feeding granivores (NSW Scientific Committee 2009). Nests of other falcons and corvids are renovated. Suitable nest trees are live and usually adjacent to watercourses or waterholes.	The following REs (remnant and regrowth) are considered to be potential habitat: 11.3.2, 11.3.3, 11.3.4, 11.3.5, 11.3.6, 11.3.7, 11.3.9, 11.3.10, 11.3.12, 11.3.13, 11.3.15, 11.3.16, 11.3.20, 11.3.21, 11.3.23, 11.3.24, 11.3.25, 11.3.27, 11.3.28, 11.3.30, 11.3.31, 11.3.32, 11.3.33, 11.3.34, 11.3.36, 11.3.38, 11.3.39, 11.4.2, 11.4.4, 11.4.5, 11.4.6, 11.4.10, 11.4.11, 11.4.12, 11.4.13, 11.5.2, 11.5.6, 11.5.8, 11.5.9, 11.5.10, 11.5.11, 11.5.12, 11.5.13, 11.5.14, 11.5.17, 11.5.18, 12.3.3, 12.3.4, 12.3.5, 12.3.6, 12.3.7, 12.3.10, 12.3.11, 12.3.19, 12.5.2, 12.5.4, 12.5.8 and 12.5.10. In addition to the communities identified above, all non-remnant areas that are located within 1km of a Stream Order 3 or greater Watercourse are potential habitat for this species.	No applicable	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities).

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	**Important Habitat**	**Habitat critical to the survival of the species**
					Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute general habitat		
Birds	*Botaurus poiciloptilus*	Australasian bittern	E	The Australasian Bittern occurs in terrestrial freshwater wetlands and, rarely, estuarine habitats. It favours wetlands with tall, dense vegetation, where it forages in still, shallow water up to 0.3 m deep, often at the edges of pools or waterways, or from platforms or mats of vegetation over deep water. The species favours permanent and seasonal freshwater habitats, particularly those dominated by sedges, rushes and/or reeds (e.g. *Phragmites, Cyperus, Eleocharis, Juncus, Typha, Baumea, Bolboschoenus*) or cutting grass (Gahnia) growing over muddy or peaty substrate. This species occurs from Bundaberg in South-east Queensland (SEQ) south to Victoria and west into South Australia. There are few and sparse records from SEQ where the population is estimated to be 3 to 16 individuals (Garnett et al. 2011). In SEQ there are records from the Lockyer Valley associated with large permanent water bodies.	The following mapped vegetation community/wetland areas are considered to constitute potential habitat: Lacustrine REs, lacustrine water bodies, palustrine REs, palustrine water bodies, riverine REs, riverine water bodies, estuarine REs, estuarine water bodies, marine REs and marine water bodies *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	Under the draft *National recovery plan for the Australasian bittern (Botaurus poiciloptilus)* (DoEE 2019) habitat critical to the survival of this species includes: ■ Any wetland habitat where the species is 'known or likely to occur' (breeding or foraging habitat) within the indicative distribution map within the Draft recovery plan; and ■ Any location with suitable habitat outside the above area that may be periodically occupied by Australasian Bittern. The MNES study area is currently outside of areas mapped within the recovery plan for this species. However, any wetland containing a specimen backed record is considered to constitute Critical habitat for this species.

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Birds	*Anthochaera phrygia*	Regent honeyeater	CE	The Regent honeyeater primarily inhabits inland slopes of the Great Dividing Range, in areas of low to moderate relief with moist, fertile soils. It is most commonly associated with box-ironbark eucalypt woodland and dry sclerophyll forest, but also inhabits riparian vegetation such as she oak (*Casuarina* spp) where it feeds on needle-leaved mistletoe and occasionally breeds. It may occasionally utilise lowland coastal forest, which may act as a refuge when its usual habitat is affected by drought. Tree species with which the Regent honeyeater is most often associated include *Eucalyptus melliodora, Eucalyptus albens, Eucalyptus sideroxylon* away from the coast, and *Eucalyptus robusta* and *Corymbia citriodora* close to the coast. The species prefers mature large trees that produce more flowers, particularly those on fertile soils and in riparian areas (DES 2017). Not identified as occurring during the Project surveys. In SEQ, the Regent honeyeater irregularly and sparsely occurs as individuals or in pairs from the Cooloola Plains in the north to inland areas such as Dalby. It is known to breed in small numbers regularly to the west of Warwick in Durikai State Forest (Garnett et al. 2011).	The following Regional Ecosystems comprise vegetation communities containing the preferred tree species: *Eucalyptus melliodora, Eucalyptus albens, Eucalyptus sideroxylon, Eucalyptus robusta* and *Corymbia maculate,* and are considered as potential habitat 12.2.7c, 12.3.3c, 12.3.3.d, 12.3.11, 12.3.4, 12.5.1, 12.5.7, 12.5.7a, 12.5.7c, 12.8.14, 12.8.16, 12.8.17, 12.8.24, 12.9-10.2, 12.9-10.5, 12.9-10.17, 12.9-10.27, 12.11.5, 12.11.6, 12.11.9, 12.11.25, 12.12.3, 12.12.5, 11.5.9d, 11.7.6, 11.7.7, 11.8.2, 11.8.2a, 11.8.4a, 11.8.8, 11.10.1, 11.11.1, 11.11.3, 11.12.6. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	Under the *National recovery plan for the Regent honeyeater (Anthochaera Phrygia)* habitat critical to the survival of this species includes: ■ Any breeding or foraging areas where the species is considered 'known or likely to occur' as indicated in Figure 1 of the plan The Project is located within the 'may occur' area only. Therefore, for this assessment any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Birds	*Grantiella picta*	Painted honeyeater	V	The Painted honeyeater inhabits mistletoes in eucalypt forests/woodlands, riparian woodlands of Black box and River red gum, box-ironbark-Yellow gum woodlands, Acacia-dominated woodlands, paperbarks, casuarinas, Callitris, and trees on farmland or gardens. The species is often associated with following tree species: *Acacia harpophylla, Acacia homalophylla, Acacia pendula, Allocasuarina luehmannii, Eucalyptus largiflorens* and *Eucalyptus camaldulensis.* The Painted honeyeater prefers woodlands which contain a higher number of mature trees, as these host more mistletoes. It is more common in wider blocks of remnant woodland than in narrower strips, although it has been observed to breed in relatively narrow roadside strips when ample mistletoe fruit is available. The species population is sparsely dispersed across south-east Australia to north-west Queensland and eastern Northern Territory. There are a few scattered coastal records to the north and south of the Project, but the vast majority of records lie on the western slopes of the Great Dividing Range. Coastal records may be considered as vagrant individuals. Rowland (2012) notes non-breeding individuals are recorded occasionally from coastal areas along the eastern seaboard.	The following mapped vegetation communities (REs) are considered potential habitat where they comprise the trees identified under the species habitat requirements: 12.3.3, 12.3.3a, 12.3.3b, 12.3.3d, 12.3.6, 12.3.7, 12.3.7a, 12.3.10, 12.3.11, 12.3.19, 12.5.1, 12.5.2, 12.5.6, 11.3.1, 11.3.1b, 11.3.2b, 11.3.4, 11.3.5, 11.3.16, 11.3.25, 11.3.25b, 11.3.25c, 11.3.25e, 11.3.27i. *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	There is no definition of habitat critical to the survival of this species available. For the purposes of this assessment this habitat includes: ■ Any breeding or foraging areas where the species is likely to occur Therefore, any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities).

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Birds	*Lathamus discolor*	Swift parrot	E	The Swift parrot inhabits dry sclerophyll eucalypt forests and woodlands. It occasionally occurs in wet sclerophyll forests. The Swift parrot predominantly forages within habitats that have been so significantly cleared that they are classified as endangered ecological communities. Nevertheless, they are recorded in a wide range of habitats including parklands in urban areas. These sites may be used opportunistically when resources elsewhere are scarce. This species primarily feeds on nectar and lerp in the canopy. The species is observed to prefer foraging in large mature trees (Saunders and Tzaros 2011). In SEQ/northern NSW (coastal) the Swift parrot is known to preferentially forage on the following tree species: Queensland blue gum (*Eucalyptus tereticornis*), Swamp mahogany (*E. robusta*), Gum-topped box (*Eucalyptus moluccana*), Blackbutt (*Eucalyptus pilularis*), Spotted gum (*Corymbia maculata*), Red bloodwood (*Corymbia gummifera*), and Rough-barked apple (*Angophora subvelutina*) (Saunders and Tzaros 2011). On the western slopes the species is also known to forage in Yellow box (*Eucalyptus melliodora*), Grey box (*Eucalyptus microcarpa*), Mugga ironbark (*Eucalyptus sideroxylon*), and White box (*Eucalyptus albens*) (Saunders and Heinsohn 2008).	The following REs (remnant and regrowth areas) are considered to be potential habitat as they may provide cover for the species but do not provide tree species that are identified as providing feeding resources: 11.2.5a, 11.3.14, 11.3.27d, 11.3.27f, 11.4.3a, 11.5.9 (except 11.5.9.c), 11.8.2 (except 11.8.2a), 11.8.4a, 12.3.5, 12.3.14, 12.5.1, 12.5.7, 12.5.7a, 12.5.7c, 12.8.24, 12.9-10.2, 12.9-10.5, 12.9-10.5a, 12.9-10.7, 12.9-10.17, 12.9-10.17b, 12.9-10.18a, 12.9-10.27, 12.11.5, 12.11.25, 12.12.3, 12.12.5, 12.12.7. It is acknowledged that mature food trees are preferred foraging habitat, however to capture non-mature foraging habitat, the following regrowth RE containing the food trees (i.e. *Eucalyptus tereticornis, Eucalyptus melliodora, Eucalyptus microcarpa, Eucalyptus robusta, Eucalyptus moluccana, Eucalyptus pilularis, Corymbia maculata, Corymbia gummifera, Angophora subvelutina, Eucalyptus sideroxylon, Eucalyptus albens*) are considered to provide potential habitat:	The *National Recovery Plan for the Swift Parrot (Lathamus discolor)* (Saunders and Tzaros 2011) defines important habitat areas (sites used repeatedly between seasons or for prolonged periods) as "priority habitat" for this species. This includes the following: ▪ Brisbane - Bowman Park, Bardon; Rafting Creek Reserve Ken more/Fig Tree Pocket. ▪ Toowoomba - Glen Lomond Park Note: Where these areas provide habitat Critical to the survival of the species, this mapping takes priority over the	The recovery plan does not define 'critical habitat' for this species. Therefore, for this assessment the following REs which contain food trees (i.e. *Eucalyptus tereticornis, Eucalyptus melliodora, Eucalyptus microcarpa, Eucalyptus robusta, Eucalyptus moluccana, Eucalyptus pilularis, Corymbia maculata, Corymbia gummifera, Angophora subvelutina, Eucalyptus sideroxylon, Eucalyptus albens*) have been considered as 'foraging habitat critical to the survival of the species' where they occur in remnant (mature) patches: 11.2.3, 11.3.2, 11.3.3, 11.3.4, 11.3.9, 11.3.11, 11.3.23, 11.3.25, 11.3.25, 11.3.26, 11.3.27a, 11.3.27b, 11.3.27f, 11.3.29, 11.3.36, 11.3.38, 11.5.1, 11.5.2, 11.5.9c, 11.5.13, 11.5.17, 11.5.20, 11.5.21, 11.7.2, 11.7.4, 11.7.5, 11.7.6, 11.8.2a, 11.8.5, 11.8.8, 11.9.2, 11.9.5, 11.9.9, 11.9.13, 11.10.1, 11.10.2, 11.10.11a, 11.11.1, 11.11.3, 11.11.4, 11.11.10, 11.11.15a, 11.12.1, 11.12.3, 11.12.6, 11.12.15, 11.12.26, 12.2.7, 12.3.3, 12.3.4, 12.3.7,

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				The species was not recorded during Project surveys and the nearest reliable database record of Swift parrot is located 2.5 km from the Project disturbance footprint, although it is relatively old (1998).	11.2.3, 11.3.2, 11.3.3, 11.3.4, 11.3.9, 11.3.11, 11.3.23, 11.3.25, 11.3.25, 11.3.26, 11.3.27a, 11.3.27b, 11.3.27f, 11.3.29, 11.3.36, 11.3.38, 11.5.1, 11.5.2, 11.5.9c, 11.5.13, 11.5.17, 11.5.20, 11.5.21, 11.7.2, 11.7.4, 11.7.5, 11.7.6, 11.8.2a, 11.8.5, 11.8.8, 11.9.2, 11.9.5, 11.9.9, 11.9.13, 11.10.1, 11.10.2, 11.10.11a, 11.11.1, 11.11.3, 11.11.4, 11.11.10, 11.11.15a, 11.12.1, 11.12.3, 11.12.6, 11.12.15, 11.12.26, 12.2.7, 12.3.3, 12.3.4, 12.3.7, 12.3.11, 12.3.18, 12.3.19, 12.5.2, 12.5.7b, 12.8.14, 12.8.16, 12.9-10.1, 12.9-10.3, 12.9-10.8, 12.9-10.11, 12.9-10.14, 12.9-10.18a, 12.11.6, 12.11.9, 12.11.14, 12.11.15, 12.11.18a, 12.12.2, 12.12.12, 12.12.23. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	*Important habitat* category	12.3.11, 12.3.18, 12.3.19, 12.5.2, 12.5.7b, 12.8.14, 12.8.16, 12.9-10.1, 12.9-10.3, 12.9-10.8, 12.9-10.11, 12.9-10.14, 12.9-10.18a, 12.11.6, 12.11.9, 12.11.14, 12.11.15, 12.11.18a, 12.12.2, 12.12.12, 12.12.23

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Birds	*Rostratula australis*	Australian painted snipe	E	The Australian painted snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and clay pans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum *Muehlenbeckia* spp. or cane grass or sometimes *Melaleuca* spp. The Australian painted snipe sometimes utilises areas that are lined with trees, or that have some scattered fallen or washed-up timber. Not identified during Project surveys. Scattered but regular records in SEQ including in the Lockyer Valley.	The following vegetation community/wetland areas are considered to constitute potential habitat: Lacustrine REs, lacustrine water bodies, palustrine REs, palustrine water bodies, riverine REs, riverine water bodies, estuarine REs, estuarine water bodies, marine REs and marine water bodies *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	Under the draft *National recovery plan for the Australian painted snipe (Rostratula australis)* (DotEE 2019) habitat critical to the survival of the species includes: ■ Any habitat where the species is known or likely to occur (from map within the Plan). ■ Any location outside the above area that may be periodically occupied by Australian painted snipe when conditions are favourable. The MNES study area occurs within areas mapped as known or likely to support the species as indicated by the Draft Recovery Plan. Therefore all wetland areas identified as Potential habitat within the MNES study area constitute critical habitat for this species.

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Birds	*Calidris ferruginea*	Curlew sandpiper	CE	The Curlew sandpiper primarily occurs on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They are also recorded inland, though less often, including around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters. Occasionally they are recorded around floodwaters. Species occurs around entire Australian coastline. There are scattered records from large permanent waterbodies in the Lockyer Valley but the majority of records from the region are coastal or from inshore islands in Moreton Bay.	The following mapped vegetation community/wetland areas are considered to constitute potential habitat: Lacustrine REs, Lacustrine Water bodies, Palustrine REs, Palustrine Water bodies, Riverine REs, Riverine Water bodies, Estuarine REs, Estuarine Water bodies, Marine REs and Marine Water bodies *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	Species does not breed in the southern hemisphere. There is no definition of critical habitat available for the species. Therefore, for the purposes of this assessment, wetlands containing a specimen backed record are considered to constitute Critical habitat for this species
Birds	*Turnix melanogaster*	Black-breasted button-quail	V	The Black-breasted button-quail primarily occurs in drier low closed forests, particularly semi-evergreen vine thicket, low microphyll vine forest, araucarian microphyll vine forest and *Brachychiton* scrubs that may incorporate bottle trees (*Brachychiton* sp.), brigalow (*Acacia harpophylla)* and belah (*Casuarina cristata*).. They may also be found in low, thickets or woodlands with a dense understorey but little ground cover, typically dominated by *Acacia* spp. The *National Recovery Plan for the Black-breasted button-quail Turnix melanogaster* (Mathieson and Smith	The following is considered to be potential habitat: Any specimen backed records (buffered to a 1 km radius) that fall outside of areas identified as Critical habitat	Not applicable	Habitat considered critical to the survival of the black-breasted button-quail includes: The recovery plan identifies habitat considered critical to the survival of the species as those communities described under the species habitat requirements (SEVT, dry rainforest communities and Brigalow scrubs). As such the following vegetation communities (REs) are Critical habitat:

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				2009) identifies important populations in the following areas: Yarraman-Nanango, the Jimna-Conondale Range, the Great Sandy region, populations in Barakula State Forest and Palmgrove National Park, and all populations in New South Wales. The species was not recorded during Project surveys. The species is known from the surrounding area and is very habitat specific.			11.2.3, 11.3.11, 11.3.11x1, 11.4.1, 11.5.15, 11.7.1x1, 11.8.3, 11.8.6, 11.8.13, 11.9.4, 11.9.4a, 11.9.4c, 11.9.8, 11.9.11, 11.10.2a, 11.10.8, 11.11.5, 11.11.14, 11.11.18, 11.11.21, 11.12.4, 11.12.21, 12.2.1, 12.2.2, 12.2.3, 12.2.4, 12.3.1, 12.3.2, 12.3.15, 12.5.6a, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.1, 12.8.3, 12.8.4, 12.8.5, 12.8.6, 12.8.7, 12.8.8, 12.8.9, 12.8.13, 12.8.18, 12.8.21, 12.8.22, 12.8.23, 12.9-10.15, 12.11.1, 12.11.2, 12.11.4, 12.11.6, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.11.16, 12.12.1, 12.12.2, 12.12.6, 12.12.13, 12.12.16, 12.12.17, 12.12.18 and 12.12.26
Birds	*Hirundapus caudacutus*	White-throated needletail	V	This is an aerial species that uses all airspace for general hunting. The species breeds within the northern hemisphere summer. The species is thought to rarely land when in Australia (during the southern hemisphere summer). Night-time roosting sites are rarely recorded although the species has been observed roosting on trees in sclerophyll forest on a low ridgeline (Tarburton 1993). The species may occur across eastern Australia during the summer months.	All areas located outside of mapped remnant vegetation communities are potential habitat	Under the *Referral guideline for 14 birds listed as migratory species under the EPBC Act (*DoE 2015) important habitat is described as non-breeding habitat – more often over wooded areas. As such all areas mapped as remnant vegetation are	Not applicable

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
						considered as 'important habitat'.	
Mammals	*Dasyurus maculatus maculatus*	Spotted-tailed quoll (southern subspecies)	E	In SEQ, the Spotted-tailed quoll occurs coastally from Bundaberg to the border and inland to Monto and Stanthorpe. The Spotted-tailed quoll prefers mature wet forest habitat, especially in areas with rainfall in excess of 600 millimetres per year (mm/year). Unlogged forest or forest that has been less disturbed by timber harvesting is also preferable. This subspecies has been recorded from a wide range of habitats, including large tracts of vine forest, wet and dry sclerophyl forest and woodland, and is often associated with *Eucalyptus camaldulensis* within the west of its range. Habitat requirements include suitable den sites such as hollow logs, tree hollows, rock outcrops or caves (DAWE 2020). The species requires large home ranges of several hundred hectares (DELWP 2016). No post 1995 records are within 35 km of the Project disturbance footprint. The species was previously known from the wider area.	Species has broad habitat requirements. The following vegetation communities (REs) constitute potential habitat where they occur in areas that **receive at least 600 mm of rainfall annually**: 12.2.1, 12.2.2, 12.2.3, 12.2.4, 12.3.1, 12.3.1a, 12.3.2, 12.3.3, 12.3.11, 12.3.16, 12.3.19, 12.3.21, 12.5.1, 12.5.2, 12.5.13, 12.5.13a, 12.5.13b, 12.5.13c, 12.8.3, 12.8.4, 12.8.5, 12.8.8, 12.8.9, 12.8.13, 12.8.14, 12.8.18, 12.8.16, 12.8.19, 12.8.20, 12.8.21, 12.8.22, 12.8.26, 12.9-10.5, 12.9-10.7, 12.9-10.15, 12.9-10.16, 12.9-10.17, 12.9-10.25, 12.9-10.26, 12.11.1, 12.11.2, 12.11.4, 12.11.5, 12.11.9, 12.11.9x1, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.11.15, 12.11.26, 12.12.1, 12.12.4, 12.12.9, 12.12.11, 12.12.12, 12.12.13, 12.12.14, 12.12.16, 12.12.17, 12.12.18, 12.12.22, 12.12.23, 11.2.3, 11.3.4, 11.3.11, 11.3.11x1, 11.3.25, 11.3.25e, 11.3.40, 11.4.1, 11.5.15, 11.7.1x1, 11.8.3, 11.8.13, 11.9.4, 11.9.4a, 11.9.4c, 11.10.8, 11.11.5,	Not applicable	The *National recovery plan for the Spotted-tail quoll (Dasyurus maculatus)* (DEWLP 2016) identifies habitat critical to the survival of the species as including: ■ large patches of forest with adequate denning resources and relatively high densities of medium-sized mammalian prey As such, for the purposes of this assessment potential habitat that intersects with remnant vegetation patches that are equal to or greater than 200 ha in size are considered critical habitat for this species ((taking into account the species extensive home range requirements).

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	**Important Habitat**	**Habitat critical to the survival of the species**
					11.11.5a, 11.11.18, 11.11.21, 11.12.4, 11.12.4a. *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Mammals	*Petrogale penicillata*	Brush-tailed rock-wallaby	V	This Brush-tailed rock-wallaby prefers rocky habitats, including loose boulder-piles, rocky outcrops, steep rocky slopes, cliffs, gorges and isolated rock stacks. Rocky outcrops appear crucial to current habitat selection by rock-wallabies, however, vegetation structure and composition is also considered to be an important factor. In many parts of their range, rock-wallabies are closely associated with dense arboreal cover, especially fig trees. The vegetation on and below the cliff appear to be important to this species as a source of food and shelter and in some cases, may provide some protection from predation. A range of vegetation types are associated with Brush-tailed rock-wallaby habitat, including dense rainforest, wet sclerophyll forest, vine thicket, dry sclerophyll forest, and open forest. Database records indicate this species has been recorded from the Toowoomba Range 2 km north of the alignment (two records from 1978). To the east of the alignment there is a record north of Helidon from 1996 (3 km east). There is a 1997 and 2004 record located in Helidon Hills to the northeast of the eastern extent of	The following vegetation communities (REs) are potential habitat where they comprise rocky landscapes (land zones 7, 8, 9-10, 11 and 12) and contain **very steep terrain** (i.e. terrain with **a 50% grade**)) likely to provide suitable rocky refuge habitat: 12.7.2, 12.8.1, 12.8.3, 12.8.4, 12.8.5, 12.8.6, 12.8.7, 12.8.8, 12.8.9, 12.8.10, 12.8.13, 12.8.18, 12.8.19, 12.8.21, 12.8.22, 12.8.23, 12.9-10.3, 12.9-10.5, 12.9-10.6, 12.9-10.16, 12.9-10.19, 12.11.1, 12.11.2, 12.11.4, 12.11.6, 12.11.10, 12.11.11, 12.11.12, 12.11.13, 12.11.16, 12.12.1, 12.12.3, 12.12.4, 12.12.5, 12.12.6, 12.12.7, 12.12.8, 12.12.9, 12.12.11, 12.12.12, 12.12.13, 12.12.14, 12.12.15, 12.12.16, 12.12.17, 12.12.18, 12.12.20, 12.12.21, 12.12.22, 12.12.23, 12.12.24, 12.12.25, 12.12.26, 12.12.27, 12.12.28, 11.7.1, 11.7.2,	Not applicable	The *National Recovery Plan for the Brush-tailed Rock-wallaby (Petrogale penicillata)* (Menkhorst and Hynes 2010) describes habitat critical to survival of the species as: ■ Rocky refuge habitat, foraging habitat and commuting routes between the two. Therefore, all areas mapped as potential habitat that intersect with remnant vegetation (Category B vegetation as regulated under the *Vegetation Management Act 1999*) are considered to constitute critical habitat for the species.

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				the alignment (6 km and 12 km northeast). There is no recent evidence of the species occurring in the area. There is potential for suitable habitat for this species to occur in the wider MNES study area, however no potential habitat is located within the Project disturbance footprint	11.7.3, 11.7.4, 11.7.6, 11.8.1, 11.8.2, 11.8.4, 11.8.5, 11.8.8, 11.8.9, 11.8.11, 11.8.12, 11.8.13, 11.8.14, 11.8.15, 11.9.1, 11.9.2, 11.9.3, 11.9.4, 11.9.5, 11.9.6, 11.9.7, 11.9.9, 11.9.10, 11.9.13, 11.9.14, 11.10.1, 11.10.2, 11.10.4, 11.10.5, 11.10.6, 11.10.7, 11.10.8, 11.10.9, 11.10.11, 11.10.12, 11.10.13, 11.11.1, 11.11.2, 11.11.3, 11.11.4, 11.11.5, 11.11.6, 11.11.7, 11.11.8, 11.11.9, 11.11.10, 11.11.11, 11.11.12, 11.11.13, 11.11.14, 11.11.15, 11.11.16, 11.11.17, 11.11.18, 11.11.19, 11.11.20, 11.12.1, 11.12.2, 11.12.3, 11.12.4, 11.12.5, 11.12.6, 11.12.7, 11.12.8, 11.12.9, 11.12.10, 11.12.11, 11.12.12, 11.12.13, 11.12.14, 11.12.17, 11.12.19, 11.12.20, 11.12.21 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		
Mammals	*Pseudomys novaehollandiae*	New Holland mouse	V	The New Holland mouse has been found from coastal areas and up to 100 km inland on sandstone country. The species has been recorded from sea level up to around 900 m above sea level. Soil type may be an important indicator of suitability	The following vegetation communities (REs) are considered to constitute potential habitat as they may comprise habitats in or near where the species has been recorded previously in SEQ:	Not applicable	There is no recognised definition of habitat critical to the survival of the species. For the purpose of this assessment critical habitat is considered to include:

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				of habitat for the New Holland Mouse, with deeper top soils and softer substrates being preferred for digging burrows. The habitat preference in South-East Queensland appears to be limited to tall dry open forest communities with an understorey of heath dominated by *Xanthorrhoea* species. In the Gatton and Laidley Shire area, the New Holland mouse has been recorded in the Blackfellow Creek and Helidon Hills areas and its habitat is associated with Regional Ecosystems 12.5.1, 12.5.6, 12.8.14, 12.8.17, 12.8.19, 12.9-10.5 and 12.9-10.19. Upon its discovery in Queensland in 1997 at Crow's Nest (near Toowoomba), the species associated habitat appeared to differ substantially from that previously known to support the species. Habitat was characterised by **dry open Eucalypt forest** at relatively high elevation (560 m). In addition, there was a **total lack of dense shrubs**, previously thought to be an essential habitat requirement of the species. Two records (2000) exist in the Helidon Hills 6 km to the northeast of the eastern end of the Project. Other records within a 50 km buffer of the Project disturbance footprint occur 15 km to 30 km north of these records between Lockyer National Park and Crows Nest. Records also exist to the south-east of the Project disturbance footprint from 1997 at Main Range National Park.	12.5.1, 12.5.4, 12.5.6, 12.8.1, 12.8.14, 12.8.14a, 12.8.17, 12.8.19, 12.9-10.2, 12.9-10.3, 12.9-10.5, 12.9-10.19, 12.11.5l *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*		▪ Any breeding or foraging habitat in areas where the species occurs Therefore, Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*).
Mammals	*Phascolarctos cinereus*	Koala	V	There are numerous records (AoLA 2020) from the Toowoomba region	The following is considered to be potential habitat:	Not applicable	Under the *EPBC Act referral guidelines for the*

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				including a 2019 record within the MNES study area to the north of the Project. There are a large number of records within the MNES study area from 2018 and 2019 which are associated with Koala tracking surveys carried out by the Department of Transport and Main Roads (DTMR) for the TSRC. The records likely include multiple records of the same individual/s. Koalas naturally inhabit a range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities dominated by *Eucalyptus* species which can be broadly defined as any forest or woodland containing species that are known koala food trees, or shrubland with emergent food trees. Along the Great Dividing Range and the coastal belt throughout the species' range, Koalas inhabit moist forests and woodlands mostly dominated by *Eucalyptus* species. Its diet is restricted mainly to foliage of *Eucalyptus* spp.; however, it may also consume foliage of related genera, including *Corymbia* spp., *Angophora* spp. and *Lophostemon* spp. The Koala is distributed along the east coast of Australia extending from Queensland to NSW. Home range size is dependent on the quality of habitat. In northern NSW home ranges of 37 ha are recorded (Goldingay and Dobner 2014). Koalas are generally sedentary with longer movements largely restricted to dispersing males which may extend	Any specimen backed records (buffered to a 1 km radius) that fall outside of areas identified as Critical habitat (regardless of the level of clearing or development within the area).		*vulnerable Koala* (DotE 2014) critical habitat for Koala can be characterised by areas containing mature and regrowth eucalypt communities. The species has broad habitat preferences that may encompass remnant and non-remnant habitat where suitable eucalypts occur. The following mapped vegetation communities (REs - both remnant and HVR) and unmapped riparian conduits (often featuring large eucalypts where they facilitate koala movement across the landscape) are considered to constitute critical habitat: 12.3.2, 12.3.3, 12.3.3a, 12.3.3b, 12.3.3c, 12.3.3d, 12.3.4, 12.3.4a, 12.3.6, 12.3.7, 12.3.10, 12.3.11, 12.3.11a, 12.5.1, 12.5.2, 12.5.2x1, 12.5.3, 12.5.3a, 12.5.6, 12.8.14, 12.8.14a, 12.8.14x1, 12.8.16, 12.8.17, 12.9-10.4, 12.9-10.7, 12.9-10.7a, 12.9-10.17, 12.9-10.17a, 12.9-10.17b, 12.9-10.17c, 12.9-10.17d, 12.11.5, 12.11.5a, 12.11.5e, 12.11.5h, 12.11.5j, 12.11.5k, 12.11.18, 12.11.18a, 12.12.12, 11.3.2, 11.3.2a, 11.3.2b, 11.3.2c, 11.3.4,

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				several kilometres through lands cleared of vegetation (DAWE 2020). Koala has been detected during Project-associated surveys including one record near Helidon, three records between Laidley and Grandchester and one near Calvert. There are numerous records (including recent) of Koala from the region surrounding the Project including many within the MNES study area.			11.3.4a, 11.3.14, 11.3.17, 11.3.18, 11.3.23, 11.3.25, 11.3.26, 11.3.37, 11.3.38, 11.3.38a, 11.3.39, 11.5.3, 11.5.3a, 11.5.3b, 11.5.4, 11.5.4a, 11.5.13, 11.5.17, 11.8.2, 11.8.2a, 11.8.8, 11.9.7, 11.9.7a, 11.9.10, 11.10.2, 11.10.2a, 11.10.11, 11.10.11a, 11.10.12, 11.11.9, 11.12.3, 11.12.7, 11.10.1, 11.10.1a, 11.10.1b, 11.10.1c, 11.10.1d, 11.10.13a
Mammals	*Potorous tridactylus tridactylus*	Long-nosed potoroo	V	Database records indicate five records occurring within 50 km of the Project, although none of these occurs within the MNES study area. The nearest database record is from 2015 and located 13 km south of the Project in the Toowoomba Range. Other database records occur to the north and northeast including Crows Nest National Park (2012 – 20 km north), Lockyer National Park (1990), Ravensbourne National Park (four records from 1977 to 1986 – 19 km north) and Deongwar State Forest (2014 – 24 km north). There is also a 1991 record from Lockyer National Park (19 km northeast of the eastern extent of the Project). The Long-nosed potoroo (SE Mainland) is sparsely distributed along the coast and Great Dividing Range of SEQ through NSW. There is limited information about the species habitat in Queensland and NSW. There is no consistent pattern to the habitat of the Long-nosed potoroo	The following vegetation communities (REs) are considered to constitute potential habitat as they may comprise a suitable shrubby understorey: 12.2.4, 12.5.1, 12.5.6, 12.5.7, 12.8.1, 12.8.9, 12.8.14, 12.8.16, 12.8.17, 12.9-10.2, 12.9-10.14, 12.9-10.18, 12.9-10.18b, 12.11.6, 12.11.9, 12.12.2, 12.12.20, 11.8.5, 11.8.15, 11.10.3, 11.10.6, 11.11.15, 11.12.20 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	Not applicable	There is no recognised definition of habitat critical to the survival of the species. For the purpose of this assessment critical habitat is considered to include: ■ Any breeding or foraging habitat in areas where the species occurs Therefore, any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute Habitat critical to the survival of the species (*excluding areas that fall outside of identified vegetation communities*)

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				(SE Mainland); it can be found in wet eucalypt forests to coastal heaths and scrubs. (Woinarski et al 2014). The species requires dense low vegetation and ground cover used for shelter and avoiding predators, although it may forage in more open areas. The species is known to utilise Lantana (Lantana camara) thickets for shelter (Lindemayer and Viggers 1994). The main factors would appear to be **access to some form of dense vegetation** for shelter and the presence of an abundant supply of fungi for food. In NSW and Queensland, the Long-nosed potoroo (SE Mainland) has scattered populations east of the Great Dividing Range extending from SEQ through to NSW. Its range is largely coastal extending up to 800 m asl and preferring areas with rainfall exceeding 760 mm.			
Mammals	*Petauroides volans*	Southern Greater glider	V	The greater glider is an arboreal nocturnal marsupial, largely restricted to eucalypt forests and woodlands. It is primarily folivorous, with a diet mostly comprising eucalypt leaves, and occasionally flowers. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows. The distribution may be patchy even in suitable habitat. The greater glider favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species. During the day Greater gliders shelter in tree hollows, with a selection for large hollows in large,	The species main habitat requirement is tall eucalypt woodland/open forests with large tree hollows for shelter. The following remnant vegetation (REs) are considered to constitute potential habitat in remnant habitat only (i.e. where large hollows are much more likely to occur): 12.2.7, 12.2.5, 12.2.6, 12.2.9, 12.3.5, 12.3.6, 12.3.11, 12.3.12, 12.3.14, 12.3.15, 12.5.1, 12.5.2, 12.5.3, 12.5.3a, 12.5.4, 12.5.5, 12.7.2, 12.8.1,	Not applicable	There is no recognised definition of habitat critical to the survival of the species. For the purpose of this assessment critical habitat is considered to include: ■ Any breeding or foraging habitat in areas where the species occurs Therefore, Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as potential habitat (refer previous column) constitute

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				old trees. Home ranges are relatively small (1−4 ha). Within SEQ, the Greater Glider has been reported to feed upon the following species: *Eucalyptus latisinensis, Corymbia intermedia, Eucalyptus drepanophylla, Corymbia trachyphloia* with lesser amounts of *Melaleuca quinquenervia*. The Greater glider occurs in eucalypt forests along the ranges and coastal plains of eastern Australia from central Victoria near Daylesford to the Windsor Tablelands in far northern Queensland. Not recorded during any Project-associated surveys. Older records from the surrounding area but mostly concentrated to the north-east (Ipswich and greater Brisbane).	12.8.8a, 12.8.26, 12.9-10.1, 12.9-10.2, 12.9-10.4, 12.9-10.5, 12.9-10.7a, 12.9-10.7, 12.9-10.12, 12.9-10.17a, 12.9-10.17, 12.9-10.20, 12.9-10.21, 12.11.14, 12.11.17, 12.11.20, 12.11.23, 12.11.24, 12.12.3, 12.12.6, 12.12.11, 12.12.12, 12.12.15, 12.12.21, 12.12.27, 11.3.29, 11.3.30b, 11.5.8, 11.7.4, 11.7.7, 11.10.2, 11.10.13, 11.11.4b, 11.11.15b, 11.11.20, 11.12.5, 11.12.5a, 11.12.8b, 11.12.9, 11.12.9a, 11.12.13a, 11.12.13b, 11.12.20, *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat.*		Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities).
Mammals	*Pteropus poliocephalus*	Grey-headed flying-fox	V	The species was not identified during Project-associated surveys. Five records (AoLA) exist for this species from within the Toowoomba Range from 2004 to 2011. Four of these (from 2007 and 2011) are associated with a flying-fox roost site located 540 m south of the Project disturbance footprint (to the east of the New England Highway). There is no recent data collected from this site. There are a number of database records in the surrounds largely to the south in Toowoomba but also to the north on Murphy's Creek and the Highfields area.	The following is considered to constitute potential habitat: Any vegetation community (RE) located within a **50 km radius of a flying fox camp known to regularly support Grey headed flying-foxes**. Two camps (based on QLD monitoring data) that fit this criteria are known to occur at the following locations: ▪ Toowoomba, Spring Street (-27.601, 151.943)	Not applicable	The *draft National recovery plan for the Grey-headed flying-fox (Pteropus poliocephalus)* (DoEE 2017) does not define habitat critical to the survival of the species but recommends management of habitat associated with a number of tree species that occur in the area including *Eucalyptus tereticornis, E. crebra, E. siderophloia, Corymbia citriodora citriodora,* and *Grevillea robusta*. For the purpose of

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				The Grey-headed Flying-fox requires foraging resources and roosting sites. It is a canopy-feeding frugivore and nectarivore, which utilises vegetation communities including rainforests, open forests, closed and open woodlands, *Melaleuca* swamps and *Banksia* woodlands. It also feeds on commercial fruit crops and on introduced tree species in urban areas. The primary food source is blossom from *Eucalyptus* and related genera but in some areas it also utilises a wide range of rainforest fruits. None of the vegetation communities used by the Grey-headed Flying-fox produce continuous foraging resources throughout the year. As a result, the species has adopted complex migration traits in response to ephemeral and patchy food resources. The Grey-headed Flying-fox roosts in aggregations of various sizes on exposed branches. Roost sites are typically located near water, such as lakes, rivers or the coast. Roost vegetation includes rainforest patches, stands of *Melaleuca*, mangroves and riparian vegetation. Grey-headed Flying-foxes commute daily to foraging areas, usually within 15 km of the day roost site. Grey-headed Flying-foxes are capable of nightly flights of up to 50 km from their roost to different feeding areas as food resources change. At most times of the year there is a complete exodus from the colony site at dusk.	▪ Highfields, Jackson Close (-27.4605, 151.9283).		this assessment critical habitat is considered to include: 100 m buffer surrounding the camps listed below and all mature vegetation within 15 km from a flying fox camp known to regularly support the species: ▪ Toowoomba, Spring Street (-27.601, 151.943) ▪ Highfields, Jackson Close (-27.4605, 151.9283)

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
Ray-finned fishes	*Maccullochella peelii*	Murray cod	V	The Murray cod has the ability to live in a diverse range of habitats, including clear rocky streams to slow flowing, turbid rivers and billabongs. It is demersal and usually found near complex structural cover such as large rocks, snags, overhanging vegetation, overhanging banks and other woody structures. It uses these points to shelter from fast-flowing water. Given the requirement for snags and structural complexity, larger waterways provide habitat of higher quality. The natural distribution of the Murray river cod is restricted to the Murray-Darling drainage system. The nearest database record is from 2014 in a parkland area in Toowoomba which is very likely to be the result of artificial introduction. As such it has been disregarded. The nearest downstream record (2008) is from Oakey Creek near Jondaryan (30 km northwest of the Project). There is a 2009 record further downstream from the Bowenville area (45 km northwest). There are scattered records further downstream of the confluence of the Condamine River and Oakey Creek at Dalby and Chinchilla.	The following is considered to constitute potential habitat when contained within the Murray-Darling drainage system including Gowrie Creek: Areas identified within the water barrier works mapping, risk impact >=4 to select wet RE areas (with a tolerance of within 20 m), where: *Areas identified as Estuarine REs, Estuarine Waterbodies, Marine REs or Marine Waterbodies are to be excluded from the habitat mapping*	Not applicable	Not applicable
Reptiles	*Delma torquata*	Collared delma	V	The **presence of rocks, logs, bark and other coarse woody debris**, and mats of leaf litter (typically 30–100 mm thick) appears to be an essential characteristic of the Collared delma microhabitat and is always present where the species occurs. Whilst Collared delmas are often found associated with small rocks, the	The following vegetation communities (REs) from SEQ are considered as potential habitat based on the presence of potentially rocky habitat on hillslopes: 12.3.3a, 12.5.1, 12.5.1e, 12.8.16, 12.8.17, 12.8.24, 12.9-10.2, 12.9-10.5, 12.9-	The *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011) describe 'important habitat'	Not applicable

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				presence of small rocks is not an Essential habitat characteristic. On the Toowoomba range, the species is most often found in association with ***Eucalyptus crebra* open forest or woodland** with a grassy understorey containing *Lantana montividensis*. An essential habitat component is the **penetration of sunlight to the ground**. Dense thickets of *Lantana camara* (i.e. reduces light penetration to the ground) has been identified as a threatening process to this species. Collared delma was recorded in the Toowoomba Range during Project-associated surveys. The species is also known to occur in the Toowoomba Range as derived from early surveys in 2006 (Peck and Hobson 2007) and more recent studies associated with the TSRC project. There are 2003 database records (AoLA) located within the Project disturbance footprint. There are also two 1995 records approximately 10 km to the northeast in the Lockyer Reserves northeast of Helidon.	10.7, 12.9-10.8, 12.9-10.18, 12.11.8, 12.11.14, 11.3.29, 11.3.30, 11.3.36, 11.5.1, 11.5.9, 11.5.9c, 11.8.4, 11.8.8, 11.8.14, 11.9.9, 11.9.9b, 11.10.1d, 11.10.7, 11.11.1, 11.11.14, 11.11.15, 11.12.1, 11.12.1a, 11.12.7 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	under Section 5 of the guidelines. The entire MNES study area has been identified as habitat in which Collared delma 'may occur' (Map 10 of the Guidelines). The Project is located adjacent to (south of) habitat in which the species is considered as 'known/likely' to occur. Given suitable habitat may occur 'important habitat' has been deemed as occurring in the MNES study area.	
Reptiles	*Anomalopus mackayi*	Five-clawed worm-skink	V	The species shelters at the soil surface where moisture is sufficiently retained under decaying leaf litter, coarse woody debris or artificial debris. The species also lives in cavities in rotting tree bases, logs and in tussock bases. It is known to dig permanent tunnel-like burrows in loose, friable, humic soils in woodlands on slight basalt rises.	The following vegetation communities (REs) from SEQ are considered to constitute potential habitat based on the presence of cracking clay soils: with grassland or grassy woodland featuring *Eucalyptus tereticornis or Eucalyptus populnea*:	The *Draft Referral guidelines for the nationally listed Brigalow Belt reptiles* (DSEWPaC 2011) describe 'important habitat' under Section 5 of the guidelines.	Not applicable

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				On the Darling Downs, the species occurs in Bluegrass (*Dichanthium sericeum*) and/or Mitchell Grass dominated grasslands or mixed grasslands dominated by other grass species. In SEQ, the species may occur in *Eucalyptus tereticornis/ Eucalyptus camaldulensis/ Eucalyptus populnea* grassy woodland/ open forests. In addition, the species has been recorded in areas characterised by *Callitris* sp. woodland. The species **is not likely to be found in soils in which deep cracks do not form**, such as hard-setting brown clays or sandy soils types). The species occurs in the Brigalow Belt and is not known to occur east of Toowoomba.	12.3.10, 11.3.2, 11.3.4, 11.3.15, 11.3.21, 11.3.25, 11.4.4, 11.4.7, 11.4.11, 11.5.17, 11.9.12 *Note: Any specimen backed records (buffered to a 1km radius) that fall outside of the REs identified above are considered to constitute potential habitat*	The MNES study area does not occur in any area where the species 'may' or is 'known/ likely' to occur' (Map 2 of the Guidelines). Therefore, no important habitat occurs in MNES study area.	
Reptiles	*Furina dunmalli*	Dunmall's snake	V	The species was not detected during Project-associated surveys. No database records of the species exist east of Toowoomba (AoLA 2020). DAWE habitat mapping for the species (2020) across the MNES study area indicate the species habitat may occur. Dunmall's snake has been found in a broad range of habitats, an is most often associated with forests and woodlands containing the following species: *Acacia harpophylla, Callitris glaucophylla, Allocasuarina luehmannii* and *Casuarina cristata* on black alluvial cracking clay and clay loams or sandstone derived soils.	The following remnant vegetation communities (REs) from SEQ are considered as potential habitat for the species based on the presence of *Acacia harpophylla, Callitris glaucophylla, Allocasuarina luehmannii* and *Casuarina cristata:* 12.3.10a, 12.8.23, 12.8.26, 12.99-10.6 Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified above are considered to constitute potential habitat.	The *Drat Referral guidelines for the national listed Brigalow Belt reptiles* (DSEQPaC 2011) describe 'Important haitat' under Section 5 of the guidelines. The entire MNES study area has been identified as habitat in which Dunmall's snake 'may occur' (Map 10 of the Guidelines). Therefore, no important habitat	Not applicable

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				The species occurs in the Brigalow Belt and is not known to occur east of Toowoomba.		occurs in the Project as defined in guidelines.	
Reptiles/Agamidae	*Tympanocryptis condaminensis*	Condamine earless dragon	E	Condamine earless dragon was recorded during Project-associated surveys in an existing rail line easement located within the Project footprint approximately 13 km north-east of Millmerran. There are a number of database records north-west of this area, located largely to the north of the Project footprint. The nearest record (2009) is located 1.5 km south of the Project footprint near Brookstead. There are several records (2003 to 2014) variously between 3 km to 4 km to the north of the Project footprint between Brookstead and Pittsworth, with many records located further north. The only other records located south of the Project are from agricultural lands located north of the Pittsworth-Felton Road (15 km south-west of Pittsworth). The Condamine earless dragon occurs in the Condamine River floodplain on black-cracking clay soil that is intensively cropped. Almost all records of the species have been made on one private property, along narrow road reserves or in headlands (thin, less than 10 m wide strips of grassland on paddock verges). Vegetation where this species has been observed is cropland (on private property), and remnant native grassland and exotic grassland (on private property, headlands and road verges).	The following REs (remnant) are considered to constitute potential habitat for the species where they occur within the Condamine River catchment (extends approx.. 20 km south of Millmerran within project footprint) as they have been identified as *Eucalyptus tereticornis/Eucalyptus coolabah/Eucalyptus populnea* woodland on deep cracking clay soils, or *Dichanthium* spp. grassland on cracking clay soils: 11.3.4, 11.3.15, 11.3.21, 11.4.4, 11.8.11, 1.8.15, 11.9.12. In addition, the following pre-clearance REs (non-remnant) are considered to constitute potential habitat when they are contained within a road reserve or within agricultural cropping (as per habitat type mapping): 11.3.4, 11.3.15, 11.3.21, 11.4.4, 11.8.11, 11.8.15, 11.9.12.	Not applicable	Because the species is known from few sites and former habitat has been reduced all known occurrences are considered critical: any specimen backed records (buffered to a 1 km radius) constitute Habitat critical to the survival of the species (excluding areas that fall outside of identified vegetation communities).

Class	Scientific name	Common name	EPBC Act	Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS Habitat modelling instructions		
					Potential Habitat	Important Habitat	Habitat critical to the survival of the species
				Prior to European settlement, the area where the Condamine earless dragon occurs was on natural grassland. This grassland has been extensively cleared or modified and less than one per cent of its pre-European extent remains and is evidence of continuing decline of species extent and quality of habitat. There are no large, non-linear areas of remnant grassland remaining.			

Table notes:

CE = Critically endangered E = Endangered V = Vulnerable NT = Near threatened C = Least concern

6 References

AECOM (2010). Southern Freight Rail Corridor Study (March 2010).

Australian Rail Track Corporation (2016). Australian Rail Track Corporation/Transport - Inland Rail Gowrie to Helidon Project (EPBC referral 2017/7882).

Australian Rail Track Corporation (2017). Initial Advice Statement: Inland Rail, Gowrie to Helidon (01-3200-PD-P00-DE-0006) .

7 Bibliography

7.1 Flora species

Hawkweed (*Picris evae*)

Atlas of Living Australia (2018). *Picris evae*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2887141 [Accessed 27 August 2018].

Bostock, PD and Holland, AE (2007). *Census of Queensland flora*, CD-ROM, Queensland Herbarium, Brisbane.

Department of Environment and Climate Change NSW (2005). *Hawkweed – Profile*. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10627 [Accessed 27 August 2018].

Department of the Environment, Water, Heritage and the Arts. (2008). Approved Conservation Advice for *Bulbophyllum globuliforme* (Miniature moss-orchid). Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/10839-conservation-advice.pdf**. Accessed 8 September 2020

Holzapfel, S (1994). A revision of the genus *Picris* (Asteraceae, Lactuceae) s.l. in *Australia, Willdenowia*, vol. 24, pp. 97-218.

Office of Environment and Heritage (2018). Hawkweed. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10627 [Accessed 27 August 2018].

Sharp, D. (nd). Queensland Herbarium, Department of Science, Information Technology and Innovation (DSITI), Queensland Government.

Threatened Species Scientific Committee (2008). *Approved Conservation Advice for Picris evae (Hawkweed)* Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10839-conservation-advice.pdf [Accessed 27 August 2018].

Austral cornflower (*Rhaponticum australe*)

Atlas of Living Australia (2018). *Rhaponticum australe*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2908264 [Accessed 27 August 2018].

Department of the Environment & Energy (2018). *Rhaponticum australe* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=23949 [Accessed 27 August 2018].

Department of the Environment, Water, Heritage and the Arts. (2008). Approved Conservation Advice for *Rhaponticum australe* (Austral cornflower). Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/23949-conservation-advice.pdf**. Accessed 8 September 2020

Marlow, G. (1998). *Stemmacantha australis* - Description and Ecology. **In:** Menkins, I., ed. *Native Vegetation of the Darling Downs*.

Queensland Department of Natural Resources (2000). *Species Management Manual*. Forest and Fauna Conservation and Ecology Section, Queensland Department of Natural Resources.

Queensland Herbarium (2007). Department of Science, Information Technology and Innovation, Queensland Government.

Threatened Species Scientific Committee (2008). *Approved Conservation Advice for Rhaponticum australe (Austral cornflower)*.

Wandering pepper-cress (*Lepidium peregrinum*)

Atlas of Living Australia (2018). Wandering pepper-cress. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2896651# [Accessed 30 August 2018].

Department of Agriculture, Water and the Environment. (2020) Species Profiles and Threats Database

Hewson H.J. (1982). The genus *Lepidium* L. (Brassicaceae) in Australia. *Brunonia* 4: 217-308.

Office of Environment and Heritage, NSW (2018). Wandering pepper-cress. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10464 [Accessed 30 August 2018].

Queensland Herbarium (2007). *Lepidium peregrinum*, nomination for re-classifying rare wildlife under the Nature Conservation Act 1992. Queensland Government, Environmental Protection Agency, Queensland National Parks and Wildlife Service. (unpublished)

Queensland Herbarium (2009). Specimen label information. [Accessed 30 August 2018].

Scarlett N.H. (1999). The identity of *Lepidium peregrinum* (Brassicaceae), an endangered Australian plant species. *Teleopea* 8: 337-350

Brush sophora (*Sophora fraseri*)

Atlas of Living Australia (2018). *Sophora fraseri.* Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2909150#overview [Accessed 30 August 2018].

Barker, M. and Borsboom, A. (1997). *Sophora fraseri* Species Management Profile. Department of Environment and Resource Management.

Briggs, JD and Leigh, JH (1995), Rare or Threatened Australian Plants 1995 rev. edn, Collingwood, CSIRO Publishing.

Harden, G.J. (2002). '*Sophora*', **In:** Harden GJ (Ed.) *Flora of New South Wales*, vol. 2, University of New South Wales Press, Sydney.

Office of Environment and Heritage, NSW (2018). Brush sophora. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10764 [Accessed 21 August 2018].

Stanley, T.D. and Ross, E.M. (1983). *Flora of southeastern Queensland*, vol. 1, Queensland Department of Primary Industries, Brisbane.

WetlandInfo, Department of Environment and Science, Queensland (2018). *Sophora fraseri.* [Online] Available from: https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/species/?sophora-fraseri [Accessed 30 August 2018].

Miniature moss-orchid (*Bulbophyllum globuliforme*)

Atlas of Living Australia (2018), *Bulbophyllum globuliforme*, accessed 23 August 2018, available https://images.ala.org.au/image/viewer?imageId=050ae1de-9eb1-4f7d-926f-073d9e7ab02c.

Barker, M. (1999). *Bulbophyllum globuliforme*. Species Management Profile, Species Management Manual. Queensland Department of Natural Resources, Brisbane

Briggs, J.D. and J.H. Leigh (1996). Rare or Threatened Australian Plants - Revised Edition. Collingwood: CSIRO Publishing.

Department of the Environment and Energy (2018). *Bulbophyllum globuliforme* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Thu, 23 August 2018

Department of the Environment, Water, Heritage and the Arts. (2008). Approved Conservation Advice for *Bulbophyllum globuliforme* (Miniature moss-orchid). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/6649-conservation-advice.pdf. Accessed 8 September 2020Harrison, M (2002), 'Bulbophyllum species of Australia', Australian Orchid Review Dec 2001/Jan 2002, pp. 4–19.

Jones, D.L. and Clements, M.A. (2001), *Oncophyllum*, a new genus of Orchidaceae from Australia. The Orchadian. 13 (9):421-424.

Jones DL (2006), Native Orchids of Australia, including the island territories. Reed New Holland. Sydney

Nicholls WH (1969), Orchids of Australia. Nelson. Melbourne.

Stanley, T. D. and E. M. Ross (1989). Flora of southeastern Queensland. Volume Three. Brisbane: Qld Department of Primary Industries

Weston, P. H. and K. D. Hill (1993), *Bulbophyllum.* In: Harden, G.J., ed. Flora of New South Wales, Volume Four. 4. Kensington, New South Wales: University of NSW Press.

Waxy sarcochilus (*Sarcochilus hartmannii*)

Atlas of Living Australia (2018), *Sarcochilus hartmannii.* Australia's species Database. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2898379. Accessed 23 August 2018.

Department of the Environment and Energy (2018). *Sarcochilus hartmannii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Thu, 23 August 2018

Department of Environment and Climate Change NSW (2005), Hartman's Sarcochilus – Priority actions (New South Wales Threatened Species Priority Action Statement), viewed 23 August 2018.

Department of the Environment, Water, Heritage and the Arts. (2008). Approved Conservation Advice for *Sarcochilus hartmannii* (Waxy sarcochilus). Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/4124-conservation-advice.pdf**. Accessed 8 September 2020

Stanley, TD and Ross, EM (1989), Flora of southeastern Queensland, vol. 3, Queensland Department of Primary Industries, Brisbane.

Weston, PH (1993), '*Sarcochilus*', In: Harden, GJ Flora of New South Wales, vol. 4, University of New South Wales Press, Sydney.

Blotched sarcochilus (*Sarcochilus weinthalii*)

Atlas of Living Australia (2013). Atlas of Living Australia. Available on the Internet at: http://www.ala.org.au/

Atlas of Living Australia (2018). *Sarcochilus weinthalii,* accessed 23 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890229#.

Department of Environment, Climate Change and Water (2010). Border Ranges Rainforest Biodiversity Management Plan - NSW and Queensland. Sydney South, New South Wales: DECCW.

Department of the Environment (2014). Approved Conservation Advice for *Sarcochilus weinthalii* (blotched sarcochilus). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/12673-conservation-advice.pdf. In effect under the EPBC Act from 11 April 2014.

Department of the Environment (2018). *Sarcochilus weinthalii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 Aug

Office of Environment and Heritage (2018). *Blotched sarcochilus* – profile. Sydney, New South Wales: OEH. Available on the Internet at: http://www.environment.nsw.gov.au/threatenedspecies/

Queensland CRA/RFA Steering Committee (1998). Survey of Threatened Plant Species in South East Queensland Biogeographical Region.

Quinn F, Williams JB, Gross CL and Bruhl J (1995). Report on rare and threatened plants of northeastern New South Wales. Armidale: University of New England

Hairy-joint grass (*Arthraxon hispidus*)

Atlas of Living Australia (2018). Distribution of Hairy-joint grass, accessed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2902385.

Batianoff, GN and Franks, AJ (1998). 'Environmental weed invasions on the southeast Queensland Foredunes

Bostock, PD and Holland, AE (2007). Census of the Queensland Flora, Queensland Herbarium, Brisbane.

Briggs, JD and Leigh, JH (1996). Rare or Threatened Australian Plants, 1995 revised edition, CSIRO Publishing, Collingwood.

Department of Environment and Climate Change NSW (2005). Hairy Jointgrass profile, viewed 24 August 2018, available <http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10066>

Department of the Environment, Water, Heritage and the Arts. (2008). Approved Conservation Advice for *Arthraxon hispidus* (Hairy-joint grass). Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/9338-conservation-advice.pdf**. Accessed 8 September 2020

Harden, GJ (Ed) (1993). Flora of New South Wales, Volume Four, University of NSW Press, Kensington.

Jacobs, SWL and Wall, CA (2007). Arthraxon hispidus (Thunb.) Makino, In: PlantNET - The Plant Information Network System of Botanic Gardens Trust, Sydney, Australia (1999-2007), viewed 23 December 2015, http://plantnet.rbgsyd.nsw.gov.au

Leigh, J, Boden, R and Briggs, J (1984). Extinct and Endangered Plants of Australia, Macmillan, Melbourne.

NSW Government (2005). BioNet, viewed 23 December 2015, <www.bionet.nsw.gov.au>.

Queensland CRA/RFA Steering Committee (1997). Forest taxa at risk, threats, conservation needs and recovery planning in southeast Queensland, Queensland Government and Commonwealth of Australia.

Queensland CRA/RFA Steering Committee (1998). Survey of Threatened Plant Species in South East Queensland Biogeographical Region, Queensland Government and Commonwealth of Australia.

Queensland Herbarium (2008). HERBRECS, Queensland Herbarium, Brisbane.

Bunya Mountains bluegrass (*Bothriochloa bunyensis*)

Atlas of Living Australia (2018). Distribution of *Bothriochloa bunyensis* – Bunya Mountains Bluegrass, viewed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2900237.

Ausgrass (2018). *Bothriochloa bunyensis -Austrobaileya,* viewed 24 August 2018, available http://ausgrass2.myspecies.info/content/bothriochloa-bunyensis.

Department of the Environment, Water, Heritage and the Arts. (2008). Approved Conservation Advice for *Bothriochloa bunyensis* (Bunya Mountains bluegrass). Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/15961-conservation-advice.pdf**. Accessed 8 September 2020

Department of the Environment and Energy (2018). Bothriochloa bunyensis in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for Bothriochloa bunyensis (Satin-top Grass). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/15961-conservation-advice.pdf. In effect under the EPBC Act from 03 July 2008

Fensham, RJ and Fairfax, RJ (1996). 'The grassy balds on the Bunya Mountains, southeastern Queensland: Floristics and conservation issues', Cunninghamia, vol. 4, no. 3, pp. 511–523.

Halford, DA (1998). Survey of Threatened Plant Species in south east Queensland Biogeographical Region, Queensland CRA/RFA Steering Committee.

Sharp, D and Simon, BK (2002). AusGrass: Grasses of Australia, CSIRO Publishing, Melbourne.

King blue-grass (*Dichanthium queenslandicum*)

Accad A, Neldner VJ, Wilson B and Niehus RE (2008). Remnant vegetation in Queensland: analysis of remnant vegetation 1997–1999–2000–2001–2003–2005, including regional ecosystem information. Queensland Herbarium, Environmental Protection Agency, Brisbane.

Atlas of Living Australia (2018). *Dichanthium queenslandicum*. Australia's species Database. Viewed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2901362.

Ausgrass2 (2018). *Dichanthium queenslandicum*, viewed 24 August 2018, available: http://ausgrass2.myspecies.info/content/dichanthium-queenslandicum.

Butler DW (2007). Draft recovery plan for the 'Bluegrass (*Dichanthium* spp.) dominant grassland of the Brigalow Belt Bioregions (north and south)' endangered ecological community, 2007–2011. Report to Department of the Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Department of the Environment and Energy (2018). *Dichanthium queenslandicum* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of Sustainability, Environment, Water, Population and Communities (2013). Approved Conservation Advice for *Dichanthium queenslandicum* (king blue-grass). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/5481-conservation-advice.pdf. In effect under the EPBC Act from 26 February 2013

Fensham, R.J. (1999). Native grasslands of the Central Highlands, Queensland, Australia. Floristics, regional context and conservation. Rangeland Journal 21: 82–103.

Fletcher, M. (2001). Rare and threatened plants of the Central Highlands. Queensland Parks and Wildlife Service, Emerald.

Sharp, D. and Simon B.K. (2002). AusGrass: Grasses of Australia. CD-ROM, Version 1.0 (Australian Biological Resources Study, Canberra, and Environmental Protection Agency, Queensland)

Simon B.K. (1982). New species of Gramineae from southeastern Queensland. Austrobaileya 1: 455–467.

Bluegrass (*Dichanthium setosum*)

Atlas of Living Australia (2018). Distribution of *Dichanthium setosum,* available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2905357 [Accessed 24 August 2018].

AusGrass2 (2018). *Dichanthium setosum,* available: http://ausgrass2.myspecies.info/content/dichanthium-setosum [Accessed 24 August 2018].

Ayers, D, Nash, S, & Baggett, K (Eds) 1996, Threatened Species of Western New South Wales, New South Wales National Parks and Wildlife Service, Hurstville.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Dichanthium setosum*. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/14159-conservation-advice.pdf. In effect under the EPBC Act from 26-Mar-2008.

Department of Environment and Conservation New South Wales (2005). *Dichanthium setosum* – Profile, viewed 11 December 2018, http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10221.

Harden, G.J. (Ed) 1993, Flora of New South Wales, Volume Four, University of New South Wales Press,

Kensington. Henderson, R.J.F. (1997). Queensland Plants Names and Distribution, Queensland Herbarium: Indooroopilly.

NSW Office of Environment and Heritage (2013a). Bluegrass - profile. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10221.

Yu, P., N. Prakash & R.D.B. Whalley (2000). Comparative reproductive biology of the vulnerable and common grasses in Bothriochloa and Dicanthium. In: Jacobs, S.W.L. & J. Everett, eds. Grasses: systematics and evolution. CSIRO Publishing, Collingwood.

A grass (*Paspalidium grandispiculatum*)

Atlas of Living Australia (2018). *Paspalidium grandispiculatum*. Australia's species Database. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2905357 [Accessed 24 August 2018].

Boyes, B. (2001). Recovery Plan for the Threatened Species and Ecological Communities of Gatton and Laidley Shires Southeast Queensland 2001- 2005. Lockyer Landcare Group

Department of the Environment and Energy (2018). *Paspalidium grandispiculatum* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Paspalidium grandispiculatum*. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10838-conservation-advice.pdf. In effect under the EPBC Act from 01 October 2008.

Environmental Protection Agency (2008). Copy of the certified regional ecosystem map for the purpose of the Vegetation Management Act 1999, online RE Maps, Environmental Protection Agency, Brisbane, viewed 8 December 2015

Halford, D. (1998). Survey of Threatened Plant Species in Southeast Queensland Biographical Region. [Online]. Brisbane: Queensland CRA/RFA Steering Committee. Available from: http://www.daff.gov.au/rfa/regions/qld/environment/threatened-plant.

Jacobs, S.W.L. (2004). Paspalidium grandispiculatum. PlantNET - The Plant Information Network System of Botanic Gardens Trust. [Online]. Sydney, Australia. Available from: http://plantnet.rbgsyd.nsw.gov.au. Simon, BK 1982, 'New Species of Gramineae from southeastern Queensland', Austrobaileya, vol. 1, no. 5, pp. 455–467.

Office of Environment and Heritage, NSW (2018). *Paspalidium grandispiculatum* - Profile. Available from: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20151 [Accessed 24 August 2018].

Sharp, D and Simon, BK (2002). AusGrass: Grasses of Australia, ABRS Identification Series, interactive CD ROM, ABRS, CSIRO Publishing, Melbourne.

Simon, B.K. (1982). New Species of Gramineae from southeastern Queensland. Austrobaileya. 1(5):455-467.

Queensland CRA/RFA Steering Committee (1998). Survey of Threatened Plant Species in South East Queensland Biogeographical Region. Available from: http://www.daff.gov.au/rfa/regions/qld/environment/threatened-plant.

Four-tailed grevillea (*Grevillea quadricauda*)

Atlas of Living Australia (2018). *Grevillea quadricauda* (Four-tailed Grevillea). accessed 24 August 2018, available: <https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2913939>.

Department of Environment and Climate Change (2005). Threatened species profile database, Fourtailed Grevillea – profile, viewed 11 March 2015.

Department of the Environment and Energy (2018). *Grevillea quadricauda* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Grevillea quadricauda* (Four-tailed Grevillea). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64651-conservation-advice.pdf. In effect under the EPBC Act from 26 March 2008.

Keith, DA (2004). Ocean shores to desert dunes, the native vegetation of New South Wales and the ACT, Department of Environment and Conservation, Hurstville.

Makinson, RO (2000). '*Proteaceae* 2 – Grevillea', Flora of Australia, vol. 17A, pp. 1-524, ABRS/CSIRO, Melbourne.

New South Wales National Parks and Wildlife Service (2005). Southern Richmond Range draft plan of management, viewed 7 December 2015.

Olde, PM and Marriott, NR (1995). The Grevillea Book, Volume 2, Kenthurst, NSW, Kangaroo Press.

Queensland Land and Resources Tribunal (2005). Hearing of applications and objections, file number AML95/03 ENO96/03, viewed 11 March 2015.

Stream clematis (*Clematis fawcettii*)

Atlas of Living Australia (2018). Clematis fawcettii - Stream clematis, viewed 24 August 2018, available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2889478#gallery.

Bean AR (2009). Personal communication provided on Species Information Sheet, 19 April 2010. Queensland Herbarium, Department of Environment and Resource Management.

Briggs, JD and Leigh JH (1996). Rare or Threatened Australian plants, Centre for Plant Biodiversity Research, CSIRO Division of Plant Industry, Canberra, ACT.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for Clematis fawcettii (Stream Clematis). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/4311-conservation-advice.pdf. In effect under the EPBC Act from 01 October 2008.

Department of the Environment and Energy (2018). Clematis fawcettii in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of Environment and Climate Change NSW (2005). Northern Clematis – Profile, viewed 24 August 2018.

Department of Environment and Climate Change NSW (2007). Forest eucalypt dieback associated with over-abundant Bell Miners and psyllids – preliminary determination, viewed 24 August 2018.

Eichler HJ and Jeanes JA (2007). Clematis. In: 'Flora of Australia, vol. 2' (ed. AJG Wilson). Australian Biological Resources Study. Canberra.

Harden, G.J. (ed) (1990). Flora of New South Wales. Volume One. Kensington, NSW: University of NSW Press.

NSW National Parks and Wildlife Service (2005). The parks and reserves of the Northern Richmond Range – Plan of Management, Department of Environment and Climate Change, viewed 24 August 2018.

Queensland CRA/RFA Steering Committee (1998). Survey of Threatened Plant Species of South East Queensland Biological Region, Department of Environment.

Stanley, TD and Ross, EM (1983). 'Clematis' in Flora of southeastern Queensland, vol. 1, Brisbane, Queensland Dept. of Primary Industry, pp. 169–170.

Blunt-leaved leionema (*Leionema obtusifolium*)

Atlas of Living Australia (2018). *Leionema obtusifolium* - A Leionema, accessed 25 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2900053.

Boyes, B. (2004). Descriptions, Habitat and Threats for the Significant Species and Ecological Communities of Gatton and Laidley Shires, Southeast Queensland, Appendix B to the Biodiversity Recovery Plan for Gatton and Laidley Shires, Southeast Queensland 2003-2008, Version 2, 5 March 2004, Lockyer Catchment Association (LCA) Inc., Forest Hill.

BRI Collection Records (n.d.). Queensland Herbarium specimens.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for Leionema obtusifolium. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64925-conservation-advice.pdf. In effect under the EPBC Act from 16 December 2008.

Department of the Environment and Energy (2018). *Leionema obtusifolium* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Sat, 25 August 2018

Halford, D (1996). Conservation Statement and Draft Recovery Plan for *Phebalium obtusifolium* Paul G.Wilson – Rutaceae, Queensland Herbarium, Brisbane.

Stanley, TD and Ross, EM (1983). Flora of Southeastern Queensland, vol. 1, Queensland Department of Primary Industries, Brisbane.

Queensland Environmental Protection Agency (2007). Future Tenures for SEQFA reserves, viewed 30 June 2008, http://www.epa.qld.gov.au/parks_and_forests/managing_parks_and_forests/forest_transfer_processes_in_queensland/south_east_queensland_forests_agreement_seqfa/future_tenures_for_s eqfa_reserves/.

Wilson, PG (1998). 'New species and nomenclatural changes in *Phebalium* and related genera (*Rutaceae*)', Nuytsia, vol. 12, no. 2, pp. 267-288.

Austral toadflax (*Thesium australe*)

Atlas of Living Australia (2018). *Thesium australe*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2898274#tab_recordsView [Accessed 30 August 2018].

Cohn, J.S. (2004). Effects of slashing and burning on *Thesium australe* R. Brown (Santalaceae) in coastal grasslands of NSW. *Proc. Linn. Soc. NSW*. 125:57-65. Linnean Society of NSW, Kingsford, NSW

Department of the Environment. (2013). Approved Conservation Advice for *Thesium australe* (Austral toadflax). Available from: **http://www.environment.gov.au/biodiversity/threatened/species/pubs/15202-conservation-advice.pdf**. Accessed 8 September 2020

Hunter, J.T., Kingston J. & Croft P. (1999). Vegetation and floristics of Kwiambal National Park and surrounds, Ashford, New South Wales. *Cunninghamia*. 6(2):351-78.

Leigh, J., Boden R. & Briggs J. (1984). *Extinct and Endangered Plants of Australia*. Melbourne, Victoria: Macmillan.

Office of Environment and Heritage, NSW (2018). Austral toadflax. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10802 [Accessed 30 August 2018].

Scarlett, N.H., Branwell, M. & Earl G. (2003). *Flora and Fauna Guarantee Action Statement 56-Austral Toad Flax* Thesium australe. [Online]. Victorian Department of Sustainability and Environment (Vic. DSE). Available from: http://www.depi.vic.gov.au/environment-and-wildlife/threatened-species-and-communities/flora-and-fauna-guarantee-act-1988/action-statements.

7.2 Fauna species – conservation significant species

Red goshawk (*Erythrotriorchis radiatus*)

Atlas of Living Australia (2016). Erythrotriorchis radiatus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:1405a1d4-557c-40ac-9f44-a6d41e9136cd#overview [Accessed 22 August 2018].

Debus, S.J.S. 1991, An annotated list of NSW records of the Red goshawk. Australian Birds. 24:72- 89

Debus, S.J.S. 1993, The status of the Red goshawk (Erythrotriorchis radiatus) in New South Wales. Olsen, P., ed. Australasian Raptor Studies. Page(s) 182-191. ARA-RAOU, Melbourne

Department of Environment and Energy (2018). Erythrotriorchis radiatus (Red Goshawk) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=942 [Accessed 22 August 2018].

Department of Environment and Resource Management (2012). National recovery plan for the red goshawk (*Erythrotriorchis radiatus*). Available from: http://www.environment.gov.au/system/files/resources/115185bc-74f7-40e4-a0af-f46aaa482dc7/files/erythrotriorchis-radiatus.pdf. Accessed: 8 September 2020

Department of Environment and Science (2017). Red Goshawk. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/threatened-species/endangered/endangered-animals/red_goshawk.html [Accessed 22 August 2018].

Ecological Australia (2019). Helidon to Calvert Pre-clearance Survey Report. Extended Geotechnical Program – Inland Rail. Report prepared for ARTC (30 July 2019).

Marchant, S. & P.J. Higgins, eds. 1993, Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

Office of Environment and Heritage (2017). Red Goshawk – Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10279 [Accessed 22 August 2018].

Seaton, R (2014). Survey for the Red Goshawk (*Erythrotriorchis radiatus*) in South East Queensland. The Sunbird. 44(2), 52–59.

Grey falcon (*Falco hypoleucos*)

Atlas of Living Australia (2018). Falco (Hierofalco) hypoleucos. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:5c4c5947-83a6-4a42-b861-8c408cfed4e7 [Accessed 2 September 2018].

Australian Wildlife Conservancy. (2018). Species Profile – Grey Falcon. Available from: http://www.australianwildlife.org/wildlife/grey-falcon.aspx [Accessed 22 August 2018].

BirdLife International (2016). Falco hypoleucos. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22696479/0 [Accessed 22 August 2018].

S, Johnson. (2011). Grey Falcon. Beauty of Birds. Available from: https://www.beautyofbirds.com/greyfalcons.html [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Grey Falcon - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10330 [Accessed 2 September 2018].

White-throated needletail (*Hirundapus caudacutus*)

Atlas of Living Australia (2018). *Hirundapus caudacutus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21205690-54fd-452a-9772-d3e1f8780dff# [Accessed 24 August 2018].

Department of the Environment and Energy (2018). *Hirundapus caudacutus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682 [Accessed 24 August 2018].

Australasian bittern (*Botaurus poiciloptilus*)

Atlas of Living Australia (2018). Botaurus poiciloptilus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:47dca80b-ac7c-4130-bef3-4afb4fad35ab [Accessed 22 August 2018].

Birdlife Australia (2018). Australasian Bittern. Available from: http://www.birdlife.org.au/bird-profile/australasian-bittern [Accessed 22 August 2018].

BirdLife International (2016). Botaurus poiciloptilus. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22697353/0 [Accessed 22 August 2018].

Department of the Environment and Energy (20190. Draft National Recovery Plan for the Australasian Bittern *Botaurus poiciloptilus*. Available from: **https://www.environment.gov.au/system/files/consultations/9a03b781-7f67-4874-a919-cf53cd1eee60/files/draft-recovery-plan-australasian-bittern.pdf**. [Accessed: 8 September 2020]

Garnett ST, Szabo J and Dutson G. (2011). The action plan for Australian birds 2010. CSIRO Publishing, Victoria.

O'Donnell, Colin. (2011). Breeding of the Australasian Bittern (Botaurus poiciloptilus) in New Zealand. ResearchGate. Available from: https://www.researchgate.net/publication/263002340 [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Australasian Bittern – Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10105 [Accessed 22 August 2018].

State Wide Integrated Flora and Fauna Teams (2018). Australasian Bittern. Available from: http://www.swifft.net.au/cb_pages/australasian_bittern.php [Accessed 22 August 2018].

Threatened Species Scientific Committee (2011). Botaurus poiciloptilus in Species Profile and Threats Database. Department of Environment and Energy. Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1001-listing-advice.pdf [Accessed 22 August 2018].

Regent honeyeater (*Anthochaera phrygia*)

Atlas of Living Australia (2018b). Anthochaera (Xanthomyza) phrygia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:af9380ee-2f65-4213-bb6f-ea6baf92ad3e#overview [Accessed 17 August 2018].

Birdlife Australia (2018). Regent Honeyeater. Available from: http://www.birdlife.org.au/bird-profile/regent-honeyeater [Accessed 17 August 2018].

BirdLife International (2016). Anthochaera phrygia. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/full/22704415/0 [Accessed 17 August 2018].

Curtis, Lee K. Dennis, Andrew J. McDonald, Keith R. Kyne, Peter M. Debus, Stephen J.S (2012). Queensland's Threatened Animals. CSIRO.

Department of Environment and Science (2017). Regent Honeyeater. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/regent_honeyeater.html [Accessed 17 August 2018].

Garnett ST, Szabo J and Dutson G. (2011). The action plan for Australian birds 2010. CSIRO Publishing, Victoria.

Painted honeyeater (*Grantiella picta*)

Atlas of Living Australia (2018). *Grantiella picta.* Viewed 17 August 2018, Available: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:de126daa-e11d-42e0-ace6-7873abe6c96b#.

Barea, L. P. (2008). Nest-site selection by the Painted Honeyeater (Grantiella picta), a mistletoe specialist. Emu, 108, 213-220.

BirdLife International (2018) Species factsheet: Grantiella picta. Downloaded from http://www.birdlife.org on 17/08/2018.

Cooney, S. J., Watson, D. M., & Young, J. (2006). Mistletoe nesting in Australian birds: A review. Emu, 106, 1-12.

Department of the Environment (DOE) (2015). Conservation Advice Grantiella picta painted honeyeater. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf. In effect under the EPBC Act from 08-Jul-2015.

Garnett, S., J. Szabo & G. Dutson (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing. Available from: <http://birdsindanger.net/taxatable>.

Higgins, P. J., Peter, J. M., & Steele, W. K. (Eds.). (2001). Handbook of Australian, New Zealand and Antarctic birds: Vol. 5. Tyrant-flycatchers to Chats. Oxford University Press: Melbourne. **ISBN 0195532589**. http://eol.org/pages/919405/details#cite_note-Higgins.2CPeter.2CSteele-2.

Keast, A. (1968). Seasonal movements in the Australian honeyeaters (Meliphagidae) and their ecological significance. Emu, 67, 159-209. <http://eol.org/pages/919405/details#cite_note-Keast-12.>

Nature Conservation Act 1992 (Queensland): September 2017 list)

Oliver, D. L., Chambers, M. A., Parker, D. G. (2003). Habitat and resource selection of the Painted Honeyeater (Grantiella picta) on the northern floodplains regions of New South Wales. Emu, 103, 171-176. http://eol.org/pages/919405/details#cite_note-OliverChambers-13.

Department of Environment and Science (2018). Painted honeyeater – *Grantiella picta*, Wetland*Info*, Queensland, **https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/species/?grantiella-picta** [Accessed 17 August 2018].

Pizzey, G., & Knight, G. (2012). The field guide to the birds of Australia (9th ed.). HarperCollins: Sydney. ISBN 978-0-7322-9193-8. http://eol.org/pages/919405/details#cite_note-Higgins.2CPeter.2CSteele-2.

Rowland, J. (2012). *Painted honeyeater, Grantiella picta. Targeted species survey guidelines.* Queensland Herbarium, Department of Environment and Science, Brisbane.

Simpson, K., & Day, N. (2004). *Field Guide to the Birds of Australia*, 7th ed. Australia: Penguin, 210.

Whitmore, M. J., & Eller, C. M. (1983). Observations at a nest of Painted Honeyeaters. Emu, 83(3) 199 – 202

Swift parrot (*Lathamus discolor*)

Atlas of Living Australia (2018). Lathamus discolor. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:3f12e573-a7b7-45e7-a6e4-aeae9bc3a9ed [Accessed 22 August 2018].

Birdlife Australia (2018). Swift Parrot. Available from: http://www.birdlife.org.au/bird-profile/swift-parrot [Accessed 22 August 2018].

Department of Environment and Energy (2018). Lathamus discolor (Swift Parrot) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=744 [Accessed 22 August 2018].

Department of Environment and Science (2011). Swift parrot. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/swift_parrot.html [Accessed 22 August 2018].

Higgins, P.J. (ed.) 1999, Handbook of Australian, New Zealand and Antarctic Birds. Volume Four - Parrots to Dollarbird. Melbourne: Oxford University Press.

Kennedy, S.J. & A. Overs 2001, Foraging ecology and habitat use of the Swift parrot on the western slopes of New South Wales. Corella. 25:68-74.

Kennedy, S.J. & C.L. Tzaros 2005, Foraging ecology of the Swift parrot *Lathamus discolor* in the box-ironbark forests and woodlands of Victoria. Pacific Conservation Biology. 11:158-173.

Mallick, S., D. James, R. Brereton & S. Plowright 2004, Blue-gums Eucalyptus globulus in north-west Tasmania: an important food resource for the endangered Swift parrot *Lathamus discolor*. *Victorian Naturalist*. 121:36-46.

Office of Environment and Heritage (2017). Swift Parrot - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10455 [Accessed 22 August 2018].

Saunders, D. & Heinsohn, R. (2008), Winter habitat use by the endangered, migratory Swift parrot (Lathamus discolor) in New South Wales. Emu. 108:81-89. CSIRO Publishing.

Saunders, D. 2002, Assessment of Swift parrot Sites near Cessnock, Lower Hunter Valley Region, NSW - including the Hunter Employment Zone. Report prepared in response to porposed developments in the Hunter Employment Zone.

Saunders, D.L. and Tzaros, C.L. (2011) National Recovery Plan for the Swift Parrot Lathamus discolor, Birds Australia, Melbourne.

Australian painted snipe (*Rostratula australis*)

Barrett, G., Silcocks A., Barry S., Cunningham R. & Poulter R. (2003). *The New Atlas of Australian Birds*. Melbourne, Victoria: Birds Australia.

Blakers, M., Davies S.J.J.F. & Reilly P.N. (1984). *The Atlas of Australian Birds*. Melbourne, Victoria: Melbourne University Press.

del Hoyo, J., Elliott A. & Sargatal J. eds. (1996). *Handbook of the Birds of the World. Volume 3, Hoatzin to Auks*. Barcelona: Lynx Edicions.

Department of the Environment & Energy (2018). *Rostratula australis* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from:

http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=77037 [Accessed 22 August 2018].

Department of the Environment & Energy (2019). Draft National Recovery Plan for the Australian Painted Snipe *Rostratula australis*. Available from: https://www.environment.gov.au/system/files/consultations/5e6b3fbf-ef4d-4d0a-b9c8-c8e29bb11afc/files/draft-recovery-plan-australian-painted-snipe.pdf. [Accessed: 8 September 2020].

Garnett, S.T. & Crowley G.M. (2000). *The Action Plan for Australian Birds 2000*. Canberra, ACT: Environment Australia and Birds Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html [Accessed 22 August 2018]

Marchant, S. & Higgins P.J., eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

New South Wales National Parks and Wildlife Service (1999). *Threatened Species Information - Painted Snipe.*

Rogers, D., Hance I., Paton S., Tzaros C., Griffioen P., Herring M., Jaensch R., Oring L., Silcocks A. & Weston M. (2005). The breeding bottleneck: breeding habitat and population decline in the Australian Painted Snipe. In: Straw, P., ed. *Status and Conservation of Seabirds in the East Asian-Australasian Flyway*. Pp. 15-23.

Watkins, D. (1993). A national plan for shorebird conservation in Australia. *RAOU Report Series*. 90.

White, M.E. (1997). *Listen, Our Land Is Crying. Australia's Environment: Problems and Solutions.* Kenthurst, New South Wales: Kangaroo Press.

Curlew sandpiper (*Calidris ferruginea*)

Dann, P. (1999a). Feeding periods and supratidal feeding of Red-necked Stints and Curlew Sandpipers in Western Port, Victoria. *Emu*. 99:218-222.

Dann, P. (1999b). Foraging behaviour and diets of Red-necked Stints and Curlew Sandpipers in south-eastern Australia. *Wildlife Research*. 27:61-68.

Department of the Environment & Energy (2018). *Calidris ferruginea* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=856 [Accessed 22 August 2018].

Gosbell, K, Collins P. & Christie M. (2002). *Wader Surveys in the Coorong & S.E. Coastal Lakes February 2002*. Australasian Wader Studies Group.

Hayman, P., Marchant J. & Prater T. (1986). *Shorebirds. An identification guide to the waders of the world*. London & Sydney: Croom Helm.

Higgins, P.J. & Davies S.J.J.F. eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Lane, B.A. (1987). *Shorebirds in Australia*. Sydney, NSW: Reed.

Department of Environment and Climate Change, NSW (2005). *Taren Point Shorebirds - profile*. NSW DECC. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10800 [Accessed 22 August 2018].

New South Wales National Parks and Wildlife Service (1999). *Threatened Species Information - Painted Snipe.*

Black-breasted button-quail (*Turnix melanogaster*)

Atlas of Living Australia (2018f). *Turnix (Austroturnix) melanogaster*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:03a6ee3f-e227-41e2-b2f3-6f6aea694a83 [Accessed 23 August 2018].

Bennett, S. (1985). The distribution and status of the Black-breasted Button-quail *Turnix melanogaster. Emu*. 85:157-162.

Department of the Environment & Energy (2018). *Turnix melanogaster* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=923 [Accessed 23 August 2018].

Garnett, S.T. & Crowley G.M. (2000). *The Action Plan for Australian Birds 2000*. Canberra, ACT: Environment Australia and Birds Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html.

Hughes, P. & Hughes B. (1991). Notes on the Black-breasted Button-quail at Widgee, Queensland. *Australian Bird Watcher*. 14:113-118.

Marchant, S. & Higgins, P.J. eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings*. Melbourne, Victoria: Oxford University Press.

Pizzey, G. & Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Smith, G.C. & Mathieson M. (2004). Black-breasted button-quail. *Wingspan*. September:34-35.

Smyth, A.K. & Young J. (1996). Observations on the endangered Black-breasted Button-quail *Turnix melanogaster* breeding in the wild. *Emu.* 96:202-207.

Murray cod (*Maccullochella peelii*)

Atlas of Living Australia. (2018). Maccullochella peelii. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:54e10f17-f08c-4f93-b576-681f361ffe56 [Accessed 22 August 2018].

Department of Environment and Energy. (2018). Maccullochella peelii (Murray Cod) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66633 [Accessed 22 August 2018].

Koehn J.D., J.A. McKenzie, D.J. O'Mahony, S.J. Nicol, J.P. O'Connor and W.G. O'Connor. (2009). Movements of Murray cod (Maccullochella peelii peelii) in a large Australian lowland river. Ecology of Freshwater Fish. 18:594-602. John Wiley and Sons A/S.

Murray Darling Basin Authority. (2007). Native Species – Murray Cod (Maccullochella peelii peelii). Available from: https://www.mdba.gov.au/sites/default/files/archived/mdbc-NFS-reports/2202_factsheet_native_murray_cod.pdf [Accessed 22 August 2018].

National Murray Cod Recovery Team (2010). National Recovery Plan for the Murray Cod Maccullochella peelii peelii. Department of Sustainability and Environment, Melbourne. Available from: http://www.environment.gov.au/resource/national-recovery-plan-murray-cod-maccullochella-peelii-peelii [Accessed 22 August 2018].

Australian lungfish (*Neoceratodus forsteri*)

Atlas of Living Australia. (2018). Maccullochella peelii. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:54e10f17-f08c-4f93-b576-681f361ffe56 [Accessed 22 August 2018].

Spotted-tailed quoll (*Dasyurus maculatus maculatus*)

ACT Government (2005). *Spotted-tailed Quoll* (Dasyurus maculatus) - *a vulnerable species, Action Plan No. 30*. Canberra: Environment ACT. Available from: http://www.environment.act.gov.au/cpr/conservation_and_ecological_communities/threatened_species_action_plans. [Accessed 21 August 2018]

Belcher, C.A. (1995). Diet of the tiger quoll *(Dasyurus maculatus)* in East Gippsland, Victoria. *Wildlife Research*. 22:341-357.

Belcher, C.A. (2000). *The Ecology of the Tiger Quoll,* Dasyurus maculatus*, in south-eastern* Australia. Ph.D. Thesis. Melbourne, Victoria: Deakin University.

Belcher, C.A. (2003). Demographics of tiger quoll *(Dasyurus maculatus maculatus)* populations in south-eastern Australia. *Australian Journal of Zoology*. 51:611-626.

Belcher, C.A. & Darrant J.P. (2004). Home range and spatial organization of the marsupial carnivore, *Dasyurus maculatus maculatus* (Marsupialia: Dasyuridae) in south-eastern Australia. Journal of Zoology. 262:271-280.

Belcher, C., Nelson J. & Darrant J. (2007). Diet of the tiger quoll *(Dasyurus maculatus)* in south-eastern Australia. *Australian Journal of Zoology*. 55:117-122.

Catling, P.C., Burt R.J. & Forrester R.I. (1998). Models of the distribution and abundance of ground-dwelling mammals in the eucalypt forests of south-eastern New South Wales. Wildlife Research. 25(5):449-466.

Catling, P.C., Burt R.J. & Forrester R.I. (2000). Models of the distribution and abundance of ground-dwelling mammals in the eucalypt forests of north-eastern New South Wales in relation to habitat variables. Wildlife Research. 27:639-654.

Claridge, A.W., Paull D., Dawson J., Mifsud G., Murray A.J, Poore R. & Saxon M.J. (2005). Home range of the spotted-tailed quoll (*Dasyurus maculatus*), a marsupial carnivore, in a rainshadow woodland. *Wildlife Research*. 32(1):7-14.

Dawson, J.P. (2005). *Impact of wildfire on the* Spotted-tail quoll Dasyurus maculatus *in Kosciuszko National Park*. M.Sc. Thesis. University College (Australian Defence Force Academy), University of New South Wales.

Department of Agriculture, Water and the Environment (2020). *Dasyurus maculatus maculatus (SE mainland population)* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=75184. [Accessed 21 August 2018]

Department of the Environment, Land, Water and Planning (2016). National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus*. Available from: **https://www.environment.gov.au/system/files/resources/2343110b-d2b4-4a1f-b66e-ddfae63c4aa6/files/national-recovery-plan-spotted-tailed-quoll.pdf**.

Edgar, R. & Belcher C. (2008). Spotted-tail quoll, *Dasyurus maculatus* (Kerr, 1792). **In:** Strahan, R., ed. *The Mammals of Australia*. Page(s) 61-62. Carlton, Victoria: Reed New Holland.

Fleay, D. (1940). Breeding of the Tiger Cat. *Victorian Naturalist*. 56:159-163.

Green, R.H. & Scarborough T.J. (1990). The Spotted-tail quoll *Dasyurus maculatus* (Dasyuridae, Marsupialia) in Tasmania. *The Tasmanian Naturalist*. 100:1-15.

Jones, M.E., Oakwood M., Belcher C.A., Morris K., Murray A.J., Woolley P.A., Firestone K.B., Johnson B. & Burnett S. (2003). Carnivore Concerns: Problems, issues and solutions for conserving Australasia's marsupial carnivores. In: Jones, M., Dickman C. & Archer M., eds. Predators with Pouches: The biology of carnivorous marsupials. Page(s) 422-434. Collingwood, Victoria: CSIRO Publishing.

Jones, M.E., Rose R.K. & Burnett S. (2001). Dasyurus maculatus. *Mammalian Species*. 676:1-9. American Society of Mammalogists.

Körtner, G. & Gresser S. (2002). *Impact of fox baiting on quoll populations. Final Report to Environment Australia and the New South Wales National Parks and Wildlife Service.*

Long, K.I. & Nelson J.L. (2004). *(Draft) Recovery Plan for* Dasyurus maculatus *(*Spotted-tail quoll*) 2005-2009*. Canberra: Department of the Environment.

Mansergh, I.M. (1984). The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia with particular reference to Victoria. *Australian Zoologist*. 21:109-122.

Maxwell, S., Burbidge A.A. & Morris K. (1996). *The 1996 Action Plan for Australian Marsupials and Monotremes*. Wildlife Australia, Environment Australia. Available from: http://www.environment.gov.au/resource/action-plan-australian-marsupials-and-monotremes [Accessed 21 August 2018].

Murray, A.J. & Poore R.N. (2004). Potential impact of aerial baiting for wild dogs on a population of spotted-tailed quolls *(Dasyurus maculatus). Wildlife Research*. 31:639-644.

National Parks and Wildlife Service (NPWS) (1999). Spotted-tail quoll, Dasyurus maculatus *(Kerr 1792)*. Hurstville, New South Wales: National Parks and Wildlife Service.

Threatened Species Scientific Committee (2004). Commonwealth Listing Advice on *Dasyurus maculatus maculatus* (Spotted-tail quoll, Spotted-tail quoll, Tiger Quoll). [Online]. Available from: http://www.environment.gov.au/biodiversity/threatened/species/tiger-quoll.html [Accessed 21 August 2018].

Van Dyck, S.M. & Longmore, N.W. (1991). The mammal records. **In:** Ingram, G.J. & Raven, R.J., eds. *Atlas of Queensland's Frogs, Reptiles, Birds & Mammals*. Page(s) 284-336. Brisbane: Queensland Museum.

Watt, A. (1993). Conservation status and draft management plan for *Dasyurus maculatus* and *D. hallucatus* in southern Queensland. Queensland: Department of Environment.

Brush-tailed rock-wallaby (*Petrogale penicillata*)

Atlas of Living Australia 2018b, *Petrogale penicillata.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7a7a2817-26e7-44bd-bb34-1dc9c1ed4d38 [Accessed 21 August 2018].

Bayne, P. (1994). Behaviour of the Brush-tailed rock-wallaby, *Petrogale penicillata*, and the recognition of individuals. *Master of Natural Resources*. M.Sc. Thesis. University of New England.

Bugg, A. (1995). Brush-tailed Rock-wallaby *Petrogale penicillata*. Habitat Assessment using Spatial analysis: The application of Geographic Information Systems and Remote Sensing to Wildlife Survey and Management. *BSc (Hons) Thesis*. Australian National University, Australia.

Capararo, S.M. & Beynon F. (1996). Ground Surveys of Brush-tailed Rock-wallaby (*Petrogale penicillata*) colonies in southern NSW. *Unpublished report to NSW National Parks and Wildlife Service.*

Carter, K & Goldizen A. W. (2003). Habitat choice and vigilance behaviour of brush-tailed rock-wallabies (*Petrogale penicillata)* within their nocturnal foraging ranges. Wildlife Research. 30 4:355-364.

Clancy, T.F. & Close R.L. (1997). The Queensland rock-wallabies - an overview of their conservation status, threats and management. Australian Mammalogy. 19: 169-174.

Close, R.L. (1993). *Brush-tailed rock-wallaby*. Royal Zoological Society Series on NSW Mammals.

Department of Environment and Conservation (2005). Draft Recovery Plan for the Brush-tailed rock-wallaby, *Petrogale penicillata*. Sydney, NSW: Department of Environment and Conservation.

Department of the Environment & Energy (2018). *Petrogale penicillata* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=225 [Accessed 21 August 2018].

Eldridge, M.D.B. & Close R.L. (1992). 'Taxonomy of Rock Wallabies, Petrogale (Marsupialia: Macropodidae). I. A Revision of the Eastern Petrogale with the Description of Three New Species'. Australian Journal of Zoology. 40:605-625.

Eldridge, M.D.B. & Close R.L. (1998). *'Brush-tailed rock-wallaby, Petrogale penicillata'*. R Strahan, ed. The Mammals of Australia (rev. edn). NSW: New Holland Publishers Pty Ltd.

Jarman, P.J. & Phillips C.M. (1989). Diets in a community of macropod species. In: Grigg, G., P. Jarman & I. Hume, eds. Kangaroos, Wallabies and Rat-kangaroos. 1:143-149. Chipping Norton, NSW: Surrey Beatty & Sons.

Joblin, K.P.W. (1983). *Behaviour and ecology of the brushtailed rockwallaby, Petrogale penicillata, in the New England Region*. MNatRes Thesis. M.Sc. Thesis. Department of Ecosystem Management, University of New England, Armidale.

Lee, A.K. & Ward S.J. (1989). *'Life histories of macropodoid marsupials'*. GC Grigg et al, ed. Kangaroos, Wallabies and Rat-kangaroos. 1. Sydney: Surrey Beatty and Sons.

Maxwell, S., Burbidge A.A. & Morris K. (1996). *The 1996 Action Plan for Australian Marsupials and Monotremes*. [Online]. Wildlife Australia, Environment Australia. Available from: http://www.environment.gov.au/resource/action-plan-australian-marsupials-and-monotremes [Accessed 21 August 2018].

Menkhorst, P. and Hynes, E. F. (2010). National recovery plan for the Brush-tailed Rock-wallaby *Petrogale penicillata*. Available from: **https://www.environment.nsw.gov.au/research-and-publications/publications-search/recovery-plan-for-the-brush-tailed-rock-wallaby-petrogale-penicillata**.

Murray, J.V., Low Choy S., McAlpine C.A., Possingham H.P., Goldizen A.W. (2008). The importance of ecological scale for wildlife conservation in naturally fragmented environments: A case study of the Brush-tailed rock-wallaby (*Petrogale penicillata*). Biological Conservation. 141 (1):7-22.

New South Wales National Parks and Wildlife Service (2003). Warrumbungle Brush-tailed rock-wallaby Endangered Population Recovery Plan.

Sharman, G.B. & Maynes G.M. (1983). Rock-wallabies. In: Strahan R., ed. Complete Book of Australian Mammals. Sydney: Angus and Robertson.

Short, J. (1980). Ecology of the Brush-tailed rock-wallaby (*Petrogale penicillata*, Griffith, Smith and Pidgeon). Unpublished Msc Thesis. M.Sc. Thesis. University of Sydney.

Short, J. (1982). Habitat requirements of the Brush-tailed rock-wallaby, *Petrogale penicillata*, in New South Wales. Australian Wildlife Research. 9: 239-246.

Short, J. (1989). The diet of the Brush-tailed rock-wallaby in New South Wales. *Australian Wildlife Research*. 16:Nov-18.

Wong, V. (1993). 'The Brush-tailed rock-wallaby (*Petrogale penicillata*) in western Victoria'. *Victorian Naturalist*. 88:92-102.

Wong, V. (1997). *The Shoalhaven Brush-tailed Rock-wallabies; surveys and monitoring*, Jan-Mar 1997. Unpublished report to the NSW National Parks and Wildlife Service.

New Holland mouse (*Pseudomys novaehollandiae*)

Atlas of Living Australia (2018). Pseudomys novaehollandiae. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:47a50ee8-7678-4d8e-8f8a-e11d12a46ec5 [Accessed 22 August 2018].

Department of Environment and Energy (2018). Pseudomys novaehollandiae (New Holland Mouse, Pookilain) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=96 [Accessed 22 August 2018].

Office of Environment and Heritage (2017). New Holland Mouse - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20253 [Accessed 22 August 2018].

Woinarski, J. & Burbidge, A.A. (2016). Pseudomys novaehollandiae. The IUCN Red List of Threatened Species 2016. Available from: http://www.iucnredlist.org/details/18552/0. [Accessed 26 August 2018].

Southern greater glider (*Petauroides volans volans*)

9Andrews, S. P., Gration, G., Quin, D., & Smith, A. P. (1994). Description and assessment of forestry impacts on fauna of the Urbenville Forestry Management Area. Report for State Forests of New South Wales Austeco Environmental Consultants, Armidale.

Atlas of Living Australia (2018k). *Petauroides volans*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7e891f26-c72e-4b29-98db-1cd10c4eaa6d#overview [Accessed 24 August 2018].

Eyre, T. J. (2002). Habitat preferences and management of large gliding possums in southern Queensland. Ph.D. thesis, Southern Cross University, Lismore.

Henry, S. R. (1984). Social organisation of the greater glider (*Petauroides volans*) in Victoria. In *Possums and Gliders* (eds A. P. Smith & I. D. Hume), pp. 221-228. Surrey Beatty and Sons, Chipping Norton.

Kavanagh, R. P. (1984). Seasonal changes in habitat use by gliders and possums in southeastern New South Wales. In *Possums and Gliders* (eds A. P. Smith & I. D. Hume), pp. 527-543. Surrey Beatty and Sons, Chipping Norton.

Kavanagh, R. P. (2000). Effects of variable-intensity logging and the influence of habitat variables on the distribution of the Greater Glider *Petauroides volans* in montane forest, southeastern New South Wales. *Pacific Conservation Biology* 6, 18-30.

Menkhorst P. & Knight F. (2011). *A Field Guide to the Mammals of Australia, 3rd Edition*. Oxford University Press.

Office of Environment and Heritage, NSW (2017). Greater Glider *Petauroides volans* in the Seven Mile Beach National Park area - profile. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20324 [Accessed 24 August 2018].

Redlands City Council (RCC) (2008). Biodiversity Research Projects: Greater Gliders. Available from: http://www2.redland.qld.gov.au/EnvironmentWaste/EnvironmentPlans/Documents/Greater%20Gliders.pdf [Accessed 24 August 2018].

Threatened Species Scientific Committee (2016). Conservation Advice on greater glider (*Petauroides volans*). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-05052016.pdf [Accessed 24 August 2018].

Tyndale-Biscoe, C. H., & Smith, R. F. C. (1969). Studies on the marsupial glider, *Schoinobates volans* (Kerr). II. Population structure and regulatory mechanisms. *Journal of Animal Ecology* 38, 637-650.

Van Dyck, S. & Strahan R. (2008). *The Mammals of Australia, Third Edition*. Page(s) 880. Sydney: Reed New Holland.

Koala (*Phascolarctos cinereus*)

Atlas of Living Australia. (2018). Phascolarctos cinereus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:e9d6fbbd-1505-4073-990a-dc66c930dad6 [Accessed 22 August 2018].

Crowther, M., D. Lunney, J. Lemon, E. Stalenberg, R. Wheeler, G. Madani, K. Ross & M. Ellis. (2013). Climate-mediated habitat selection in an arboreal folivore. Ecography. 36:001-008.

Department of the Environment (2014). *EPBC Act referral guidelines for the vulnerable koala*. Commonwealth of Australia, Canberra. Available from: **http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala**

Department of Agriculture, Water and the Environment (2020). Phascolarctos cinereus (Koala) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=85104 [Accessed 22 August 2018].

Department of Environment and Science (2017). Koala facts. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/koalas/koala-ecology.html [Accessed 22 August 2018].

Goldingay, R and Dobner, B (2014). 'Home range areas of koalas in an urban area of north-east New South Wales'. *Australian Mammalogy*, vol. 36, pp. 74-80

Martin, R. & K. Handasyde. (1999). The Koala: Natural history, conservation and management. Sydney, NSW: UNSW Press.

Moore, B.D. & W.J. Foley. (2000). A review of feeding and diet selection in koalas (Phascolarctos cinereus). Australian Journal of Zoology. 48:317-333.

Office of Environment and Heritage (2018). Koala - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10616 [Accessed 22 August 2018].

Long-nosed potoroo (*Potorous tridactylus tridactylus*)

Amos, P.J. (1982). The potoroo in Queensland. *Queensland Agricultural Journal*. 108: 5-6.

Atlas of Living Australia (2018k). *Potorous tridactylus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:76cb4b83-1a55-4ff8-98ff-4e7eb6fc0c9b [Accessed 23 August 2018].

Bennett, A.F. (1987). Conservation of mammals within a fragmented forest environment: the contributions of insular biogeography and autecology. In: Saunders, D.A., G.W. Arnold, A.A. Burbridge & A.J.M. Hopkins, eds. *Nature conservation: the role of remnants of native vegetation*. Page(s) 41-52. Chipping Norton, NSW: Surrey Beatty & Sons.

Claridge, A.W., Tanton M.T., Seebeck J.H., Cork S.J. & Cunningham R.B. (1992). Establishment of ectomycorrhizae on the roots of two species of Eucalyptus from fungal spores contained in the faeces of the long-nosed potoroo (*Potorous tridactylus*). *Australian Journal of Ecology*. 17: 207-217.

Department of the Environment & Energy (2018). *Potorous tridactylus* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66645 [Accessed 23 August 2018].

Department of the Environment & Science (2017). Long-nosed potoroo. Available from: https://www.ehp.qld.gov.au/wildlife/threatened-species/vulnerable/longnosed_potoroo.html [Accessed 23 August 2018].

Hughes, R.L. (1962). Reproduction in the macropod marsupial *Potorous tridactylus* (Kerr). *Australian Journal of Zoology*. 10:192-224.

Lindenmayer, D.B. & Viggers K.L. (1994). Northern range limits of the long nosed potoroo, *Potorous tridactylus. Memoirs of the Queensland Museum*. 35:180.

Menkhorst P. & Knight F. (2011). *A Field Guide to the Mammals of Australia, 3rd Edition*. Oxford University Press.

Seebeck, J.H., Claridge A. & Rose R. (2007). *Bettongs, Potoroos and the Musky Rat-Kangaroo*. CSIRO Publishing, Collingwood, Australia.

Van Dyck, S. & Strahan R. (2008). *The Mammals of Australia, Third Edition*. Page(s) 880. Sydney: Reed New Holland.

Woinarski, J.C.Z., Burbidge, A.A. and Harrison, P.L. (2014). *The action plan for Australian mammals*, CSIRO Publishing, Collingwood, Victoria.

Grey-headed flying-fox (*Pteropus poliocephalus*)

Atlas of Living Australia (2018m). *Pteropus poliocephalus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:a2553aed-383a-4c9b-9534-c6058bcee81b# [Accessed 24 August 2018].

Department of the Environment & Energy (2017). Draft Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus*. Available from: https://www.environment.gov.au/system/files/resources/78d5e396-7475-4fc0-8a64-48c86a1cb2b6/files/draft-recovery-plan-grey-headed-flying-fox.pdf. [Accessed: 8 September 2020].

Department of the Environment & Energy (2018). *Pteropus poliocephalus* in Species Profile and Threats Database, Department of the Environment & Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186 [Accessed 24 August 2018].

Duncan, A., Baker, G.B & Montgomery, N. 1999, *The Action Plan for Australian Bats.* [Online]. Canberra: Environment Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/bats/index.html. [Accessed 24 August 2018].

Eby, P. & Lunney, D. 2002, *Managing the Grey-headed flying-fox as a threatened species in NSW*. In: Proceedings of the Royal Zoological Society of New South Wales. Mosman, Sydney: Royal Zoological Society of New South Wales.

Hall, L. & Richards, G. 2000, *Flying Foxes: Fruit and Blossom of Australia*. Sydney: University of New South Wales Press.

Hall, L. 1987, Identification, distribution and taxonomy of Australian flying-foxes (Chiroptera: Pteropodidae). Australian Mammalogy. 10 (2):75-81.

Hall, L.S. 2002, *Management of flying fox camps: what have we learnt in the last twenty five years?* In: Eby, P. & D. Lunney, eds. Managing the Grey-headed flying-fox as a Threatened Species in NSW. Page(s) 215-224. Mosman, NSW; Royal Zoological Society of NSW.

Hariono, B., J. Ng & R.H. Sutton (1992). Lead concentrations in tissues of fruit bats (*Pteropus sp.*) in urban and non-urban areas. *Wildlife Research*. 20.

Martin, L. 2000, Aspects of the Reproductive Biology of the Grey-headed flying-foxes that explain documented population declines, and support a threatened status. In: Proceedings of a Workshop to Assess the Status of the Grey-headed flying-fox in New South Wales. Unpublished report to the NSW Threatened Scientific Committee.

Nelson, J.E. 1965, Movements of Australian flying foxes (Pteropodidae: Megachiroptera). Australian Journal of Zoology. 13:53-73.

Pallin, N. 2000, Ku-ring-gai Flying-fox Reserve: habitat restoration project, 15 years on. Ecological Management and Restoration. 1:10-20.

Ratcliffe, F.N. 1931, *The flying fox (Pteropus) in Australia*. CSIRO Bulletin. 52:1-133.

State of the Environment Advisory Council (1996). *Australia: State of the Environment, 1996.*

Teagle, S. (2002). Flying fox Consultative Committee - Formation, Outcomes and Future Strategies. In: Eby, P. & D. Lunney, eds. *Managing the Grey-headed Flying-fox as a Threatened Species in NSW*. Page(s) 109-116. Mosman, NSW: Royal Zoological Society of NSW.

Tidemann, C. & Vardon, M. 1997, *Pests, pestilence, pollen and pot-roasts: the need for community-based management of flying foxes in Australia*. Australian Biologist. 10(1):77-83. hs Forest: New Holland Publishers Pty Ltd.

Tidemann, C.R. 1998, *Grey-headed flying-fox, Pteropus poliocephalus,* Temminck, 1824. In: Strahan, R., ed. The Mammals of Australia. Frenc.

van der Ree, R., McDonnell, J. Temby, I. Nelson, J. & Whittingham, E. 2005, The establishment and dynamics of a recently established urban camp of flying foxes (*Pteropus poliocephalus*) outside their geographic range. Journal of Zoology. 268:177-185. The Zoological Society of London.

van der Ree, R., McDonnell, M.J. Temby, I. Nelson, J. & Whittingham, E. 2006, The establishment and dynamics of a recently established urban camp of Pteropus ploiocephalus outside their geographic range. Journal of Zoology London. 268:177-185.

Condamine earless dragon (*Tympanocryptis condaminensis*)

Ashdown, R (2014). Condamine earless dragon. Available from: http://ashdown4628.clients.cmdwebsites.com/blog/?p=6941 [Accessed December 2015].

Atlas of Living Australia (2018). Tympanocryptis condaminensis. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:6bce6afb-6a46-47f2-970d-15567172d8be [Accessed 2 September 2018].

Department of Environment and Science (2017). Condamine earless dragon. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/condamine-earless-dragon.html [Accessed 22 August 2018].

Melville, J. Hutchinson, M. Wilson, S. Hobson, R. and Venz, M. (2017). Tympanocryptis condaminensis. The IUCN Red List of Threatened Species 2017. Available from: http://www.iucnredlist.org/details/83494956/0 [Accessed 2 September 2018].

Phipps, G. and Titmus, A. (2006). Husbandry Manual for Bearded Dragons. Available from: http://www.parrotgarden.com.au/wp-content/uploads/2016/05/Bearded_Dragons__Nelson_.pdf [Accessed 2 September 2018].

Threatened Species Scientific Committee (2016). Tympanocryptis condaminensis in Species Profile and Threats Database. Department of Environment and Energy. Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/87888-conservation-advice-05052016.pdf [Accessed 22 August 2018].

Uetz, P. (2011). Tympanocryptis tetraporophora (Australian Earless Lizard). Encyclopedia of Life. Available from: http://eol.org/pages/461641/details#Reproduction [Accessed 22 August 2018].

Dunmall's snake (*Furina dunmalli*)

Atlas of Living Australia (2018). Furina dunmalli. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:9ba2edaa-574b-4c18-8503-d0b658b16cc4 [Accessed 2 September 2018].

Department of Environment and Energy (2018). Furina dunmalli (Dunmall's Snake) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59254 [Accessed 22 August 2018].

Department of Environment and Science (2017). Dunmall's snake. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/dunmalls_snake.html [Accessed 22 August 2018].

Department of Sustainability, Environment, Water, Populations and Community (2011e). *The draft referral guidelines for the Brigalow Belt reptiles,* Department of Sustainability, Environment, Water, Populations and Community, Australian Government, Canberra.Wilson, S (n.d). Dunmall's snake. In. Shy snake is hard to spot. ABC Wide Bay Publication. Available from: http://www.abc.net.au/local/stories/2009/04/21/2548064.htm [Accessed 22 August 2018].

Collared delma (*Delma torquata*)

Brigalow Belt Reptiles Workshop. (2010). Proceedings from the workshop for the nine listed reptiles of the Brigalow Belt bioregions. 18-19 August 2010. Brisbane: Queensland Herbarium.

Davidson, C. (1993). Recovery Plan for the Collared Legless Lizard (Delma torquata). Page(s) 1-10. Brisbane, Queensland: Department of Environment and Heritage.

Department of Environment and Energy (2018). Delma torquata (Adorned Delma/Collared Delma) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1656 [Accessed 22 August 2018].

Department of Sustainability, Environment, Water, Populations and Community (2011e). *The draft referral guidelines for the Brigalow Belt reptiles,* Department of Sustainability, Environment, Water, Populations and Community, Australian Government, Canberra.

Peck, S. & R. Hobson. (2007). Survey results and management options for the Collared delma (Delma torquata) along the proposed Toowoomba Bypass, Toowoomba Range, South-east Queensland, November 2006. Queensland Parks and Wildlife Service.

Porter, R. (1998). A preliminary field investigation of the Collared delma Delma torquata (Reptilia: Pygopodidae). Queensland: Lone Pine Koala Sanctuary.

Richardson, R. (2006). Queensland Brigalow Belt Reptile Recovery Plan 2008 – 2012, Report to the Department of the Environment, Water, Heritage and the Arts, Canberra. WWF-Australia, Brisbane.

Santos. (2012). GLNG Project. Available from: https://www.santos.com/media/3820/significant-species-management-plan-smmp-part-2-p.pdf [Accessed 22 August 2018].

Schell, C and & J. Stark (2017). Personal observations of *Delma torquata* associated with the implementation of the Collared Delma translocation Management Plan for the Toowoomba Second Range Crossing Project.

Five-clawed worm-skink (*Anomalopus mackayi*)

Atlas of Living Australia (2018). *Anomalopus mackayi*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:bcbb3f69-0f90-4b6d-a062-218439a61a51 [Accessed 23 August 2018].

Brigalow Belt Reptiles Workshop (2010). Proceedings from the workshop for the nine listed reptiles of the Brigalow Belt bioregions. 18-19 August. Brisbane: Queensland Herbarium.

Cogger H.G. (2000). *Reptiles and Amphibians of Australia*, (6th edition) Ralph Curtis Books, NSW

Department of the Environment and Energy (2018). *Anomalopus mackayi* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=25934 [Accessed 23 August 2018].

Department of Sustainability, Environment, Water, Populations and Community (2011e). *The draft referral guidelines for the Brigalow Belt reptiles,* Department of Sustainability, Environment, Water, Populations and Community, Australian Government, Canberra.

Ehmann, H. (1992). Encyclopedia of Australian Animals: Reptiles. Angus and Robertson: Sydney

NSW National Parks and Wildlife Service (1999). *Five-clawed Worm-skink - Threatened Species Information*. Available from: http://www.environment.nsw.gov.au/resources/nature/tsprofileFiveclawedWormskink.pdf

Shea, G.M., Millgate M. and Peck S. (1987). A range extension for the rare skink *Anomalopus mackayi. Herpetofauna.* 17 (2):16-19.

Wilson, S.K. and Knowles, D.G. (1988). Australia's Reptiles A Photographic Reference to the Terrestrial Reptiles of Australia. Collins: Sydney.

White-throated needletail (*Hirundapus caudacutus*)

Atlas of Living Australia (2018). *Hirundapus caudacutus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21205690-54fd-452a-9772-d3e1f8780dff# [Accessed 24 August 2018].

Barrett, G., Silcocks A., Barry S., Cunningham R. and Poulter R. (2003). *The New Atlas of Australian Birds*. Melbourne, Victoria: Birds Australia.

Burrows S. (2017). *Hirundapus caudacutus* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21205690-54fd-452a-9772-d3e1f8780dff# [Accessed 24 August 2018].

Cooper, R.P. (1971). High flying swifts. *Australian Bird Watcher*. 4:79-80.

Department of the Environment (2015). *Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act.* Commonwealth of Australia, Canberra. Available from: http://www.environment.gov.au/system/files/resources/c05f5b87-0a99-4998-897e-7072c236cf83/files/migratory-birds-draft-referral-guideline.pdf

Department of the Environment and Energy (2018). *Hirundapus caudacutus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682 [Accessed 24 August 2018].

Higgins, P.J. (ed.) (1999). Handbook of Australian, New Zealand and Antarctic Birds. Volume Four - Parrots to Dollarbird. Melbourne: Oxford University Press.

Tarburton, M.K. (1993). Radiotracking a White-throated Needletail to roost. Emu. 93:121--124.

Appendix A
Regional Ecosystem Descriptions used in the predictive habitat mapping

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

Table A1 Descriptions of Regional ecosystems (Remnant and Regrowth) within the MNES study area

Regional ecosystems (REs)	Description (Regional Ecosystem Description Database Version 11.1)*
11.3.21	Grassland dominated by *Dichanthium sericeum* and/or *Astrebla* spp. (*A. lappacea, A. elymoides* and *A. squarrosa)*. A wide range of other grass and forb species are usually present and may dominant depending on seasonal conditions and management regime. Frequently occurring species include the grasses *Aristida leptopoda, A. latifolia, Bothriochloa bladhii subsp. Bladhii, Brachyachne convergens, Heteropogon contortus, Panicum decompositum, Eriochloa spp., Sporobolus mitchellii* and *Thellungia advena* and the forbs *Abelmoschus ficulneus*, *Corchorus trilocularis, Commelina ensifolia, Euphorbia coghlanii, Ipomoea lonchophylla, Neptunia gracilis, Phyllanthus maderaspatensis, Sida trichopoda* and *Trichodesma zeylanicum* var. *latisepalum*.
11.3.25	*Eucalyptus camaldulensis* or *E. tereticornis* open forest to woodland. Other tree species such as *Casuarina cunninghamiana*, *E. coolabah*, *Melaleuca viminalis*, *Livistona* spp. (in north), *Melaleuca* spp. and *Angophora floribunda* are commonly present and may be locally dominant. An open to sparse, tall shrub layer is frequently present dominated by species including *Acacia salicina*, *A. stenophylla* or *Lysiphyllum carronii*. Low shrubs are present, but rarely form a conspicuous layer.
11.8.11	Grassland dominated by D*ichanthium sericeum, Aristida spp., Astrebla spp*. And *Panicum decompositum* with or without trees such as *Eucalyptus orgadophila*, *E. melanophloia, Corymbia erythrophloia* and *Acacia salicina*, (height 11+/-3 m). However, dominance and cover may vary with seasonal and other environmental conditions. Frequently occurring and sometimes locally dominant, species include the grasses *Bothriochloa ewartiana, Dichanthium sericeum*, *Chrysopogon fallax*, *Heteropogon contortus*, *Enneapogon gracilis*, *Themeda triandra* and *Tragus australianus* and the herbs *Brunoniella australis*, *Evolvulus alsinoides, Galactia tenuiflora* and *Indigofera linnaei*.
11.8.2a	*Eucalyptus tereticornis* and *E. melliodora* woodland occurring on low hills. Occurs on low hills (subregion 31 and 32) formed from basalt. The soils are generally shallow (< 60 cm deep), brown to grey-brown, gradational, clay-loams and clays. Basalt stones and boulders can occur on the surface.
11.8.4	*Eucalyptus melanophloia* and/or E. crebra +/- *E. orgadophila* +/- *Corymbia erythrophloia* grassy open woodland. *Macrozamia moorei* is a conspicuous element of the mid layer in the Central Highlands. Localised patches of *Corymbia citriodora* occur on volcanic plugs such as Minerva Hills. Generally occurs on slopes of mountains and hills formed from Cainozoic igneous rocks usually with shallow stony soils and extensive outcropping.
11.8.5	*Eucalyptus orgadophila* grassy open woodland. *Eucalyptus orgadophila* predominates and forms a distinct but discontinuous canopy sometimes with other sub-dominant species such as *Corymbia erythrophloia*, *E. melanophloia* and occasionally *E. crebra*. Shrubs are usually scarce and scattered although a well-defined shrubby layer does develop in some areas. On the lower slopes at better sites, softwood scrub species may form tall and low shrub layers under the canopy of *Eucalyptus orgadophila*.
11.8.5a	*Eucalyptus orgadophila* woodland with a dense understorey of low trees species including *Geijera parviflora*, *Callitris glaucophylla*, *Pittosporum angustifolium*, *Casuarina cristata*, *Alectryon oleifolius*, *Psydrax odorata* and *Notelaea microcarpa.*
11.8.8	Woodland usually dominated by either *Eucalyptus albens* or *E. crebra*. *Eucalyptus tereticornis* is an associated species that becomes locally dominant on creek lines. Other tree species that may be present include *Callitris baileyi, Angophora subvelutina, Brachychiton populneus, E. melliodora, E. orgadophila, Angophora floribunda, E. moluccana, E. microcarpa, E. biturbinata, E. melanophloia* and *Corymbia clarksoniana*. There is often a sparse low tree layer dominated by similar species to the canopy. The shrub layer is absent or sparse and consisting of species such *as Cassinia laevis, Olearia elliptica, Acacia implexa, Xanthorrhoea glauca* or *Jacksonia scoparia*. The ground layer is usually dominated by grasses of variable composition. Occurs on hilltops and sides formed from Cainozoic basaltic rocks.
12.3.3	*Eucalyptus tereticornis* woodland. *Eucalyptus crebra* and *E. moluccana* are sometimes present and may be relatively abundant in places, especially on edges of plains and higher level alluvium. Other species that may be present as scattered individuals or clumps include *Angophora subvelutina* or *A. floribunda, Corymbia clarksoniana, C. intermedia, C. tessellaris, Lophostemon suaveolens* and *E. melanophloia*. Occurs on Quaternary alluvial plains, terraces and fans where rainfall is usually less than 1,000 millimetres per year (mm/y).
12.3.7	Narrow fringing woodland of *Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *Cunninghamiana* +/- *Melaleuca viminalis*. Other species associated with this RE include *Melaleuca 82ariegate*, *M. trichostachya*, *M. linariifolia*. North of Brisbane *Waterhousea floribunda* commonly occurs and may at times dominate this RE. *Melaleuca fluviatilis* occurs in this RE in the north of the bioregion. *Lomandra hystrix* often present in stream beds. Occurs on fringing levees and banks of rivers and drainage lines of alluvial plains throughout the region

Regional ecosystems (REs)	Description (Regional Ecosystem Description Database Version 11.1)*
12.5.6	*Eucalyptus siderophloia, E. propinqua* and/or *E. pilularis* open forest +/- *Corymbia intermedia, E. microcorys, E. acmenoides, E. tereticornis, E. biturbinata, Lophostemon confertus* with *E. saligna, E. montivaga* at higher altitudes. Occurs on remnant Tertiary surfaces. Usually deep red soils
12.8.9	*Lophostemon confertus* open forest often with vine forest understorey ('wet sclerophyll'). Occurs on Cainozoic igneous rocks. Tends to occur mostly in gullies and on exposed ridges on basalt.
12.8.14	*Eucalyptus eugenioides, E. biturbinata, E. melliodora* +/- E. *tereticornis*, *Corymbia intermedia*, *E. crebra* woodland. *Allocasuarina torulosa* is a common understorey species. Localised occurrences of *Eucalyptus laevopinea*, may occur. Occurs on Cainozoic igneous rocks, especially basalt
12.8.14a	*Eucalyptus moluccana* open forest +/- *E. tereticornis*, *Eucalyptus siderophloia* or *E. crebra*. Understorey generally sparse but can become shrubby in absence of fire. Occurs on Cainozoic igneous rocks.
12.8.17	*Eucalyptus melanophloia* +/- *E. crebra, E. tereticornis, Corymbia tessellaris, C. intermedia* and/or *C. clarksoniana*, *E. melliodora, Angophora subvelutina* grassy woodland. Occurs on Cainozoic igneous rocks, especially basalt.
12.8.21	Low microphyll vine forest and semi-evergreen vine thicket +/- Araucaria cunninghamii. Characteristic species include *Brachychiton rupestris, Flindersia collina, F. australis, Alectryon diversifolius, A. subdentatus, Elattostachys xylocarpa*, Erythroxylum sp. (Splityard Creek L.Pedley 5360), *Psydrax odorata* forma *buxifolia*, *Planchonella cotinifolia*, Croton insularis, Bridelia exaltata and *Bursaria incana*. Occurs on Cainozoic igneous rocks, especially basalt.
12.9-10.2	*Corymbia citriodora* subsp. *variegata* open forest or woodland usually with *Eucalyptus crebra*. Other species such as *Eucalyptus tereticornis*, *E. moluccana*, *E. acmenoides* and *E. siderophloia* may be present in scattered patches or in low densities. Understorey can be grassy or shrubby. Shrubby understorey of *Lophostemon confertus* (whipstick form) often present in northern parts of bioregion. Occurs on Cainozoic and Mesozoic sediments.
12.9-10.5a	*Eucalyptus helidonica*, *Corymbia citriodora* subsp. v*ariegate* open forest +/- *C. trachyphloia* subsp. *Trachyphloia*, *Eucalyptus fibrosa* subsp. *Fibrosa*, *E. dura*, *E. baileyana*, *C. gummifera*, *Angophora woodsiana* and *Lysicarpus angustifolius*. Occurs on quartzose sandstone scarps and crests.
12.9-10.7	*Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland. Occurs on Cainozoic and Mesozoic sediments.
12.9-10.15	Low microphyll vine forest +/- *Araucaria cunninghamii* and semi-evergreen vine thicket. Characteristic species include *Brachychiton rupestris*, *Flindersia collina*, *F. australis*, *Alectryon diversifolius, A. subdentatus, Elattostachys xylocarpa, Erythroxylum* sp. (Splityard Creek L.Pedley 5360), *Psydrax odorata forma buxifolia, Planchonella cotinifolia, Croton insularis, Bridelia exaltata* and *Bursaria incana*. Occurs on Cainozoic and Mesozoic sediments.
12.9-10.17a	Open forest to woodland complex generally with a variety of stringybarks, grey gums, ironbarks and in some areas spotted gum. Canopy trees include *Eucalyptus siderophloia*, *E. propinqua* or *E. major*, *E. acmenoides* or *E. portuensis, E. carnea* and/or *E. microcorys* and/or *Corymbia citriodora* subsp. *ariegate*. Other species that may be present locally include *Corymbia intermedia*, *C. trachyphloia*, *Eucalyptus tereticornis*, *E. biturbinata*, *E. moluccana*, *E. longirostrata*, *E. fibrosa* subsp. *Fibrosa* and *Angophora leiocarpa*. *Lophostemon confertus* or Whipstick *Lophostemon confertus* often present in gullies and as a sub-canopy or understorey tree. Mixed understorey of grasses, shrubs and ferns. Hills and ranges of Cainozoic and Mesozoic sediments.

APPENDIX

J

INLAND RAIL

Matters of National Environmental Significance

Appendix B Species and community profiles

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

IR_1536

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Inland Rail Gowrie to Helidon EIS

Species and Community Profiles

Australian Rail Track Corporation

Reference: 3200

Contents

1 Flora species 1

1.1 Austral cornflower (*Rhaponticum australe*) 1
1.2 Austral toadflax (*Thesium australe*) 3
1.3 Blotched sarochilus (*Sarcochilus weinthalii*) 7
1.4 Bluegrass (*Dichanthium setosum*) 10
1.5 Brush sophora (*Sophora fraseri*) 15
1.6 Bunya Mountains bluegrass (*Bothriochloa bunyensis*) 20
1.7 Four-tailed grevillea (*Grevillea quadricauda*) 22
1.8 Hairy-joint grass (*Arthraxon hispidus*) 26
1.9 Hawkweed (*Picris evae*) 29
1.10 King blue-grass (*Dichanthium queenslandicum*) 34
1.11 Leionema (*Leionema obtusifolium*) 37
1.12 Queensland nut tree (*Macadamia integrifolia*) 40
1.13 Miniature moss-orchid (*Bulbophyllum globuliforme*) 43
1.14 Mt. Berryman phebalium (*Phebalium distans*) 46
1.15 Ooline (*Cadellia pentastylis*) 49
1.16 *Paspalidium grandispiculatum* 53
1.17 Quassia (*Samadera bidwillii*) 56
1.18 Queensland nut tree (*Macadamia integrifolia*) 59
1.19 Stream clematis (*Clematis fawcettii*) 63
1.20 Tall velvet sea-berry (*Haloragis exalata* subsp. *velutina*) 68
1.21 Wandering pepper-cress (*Lepidium peregrinum*) 71
1.22 Waxy sarcochilus (Sarcochilus hartmannii) 74

2 Fauna species – Conservation significant species – Fish 79

2.1 Murray cod (*Maccullochella peelii*) 79

3 Fauna species – Conservation significant species – Reptiles 84

3.1 Collared delma (*Delma torquata*) 84
3.2 Condamine earless dragon (*Tympanocryptis condaminensis*) 88
3.3 Dunmall's snake (*Furina dunmalli*) 91
3.4 Long-legged worm-skink (*Anomalopus mackayi*) 93
3.5 Three-toed snake-tooth skink (*Coeranoscincus reticulatus*) 97
3.6 Yakka skink (*Egernia rugosa*) 100

4 Fauna species – Conservation significant species – Mammals 104

4.1 Brush-tailed rock-wallaby (*Petrogale penicillata*) 104
4.2 Greater glider (*Petauroides volans*) 110
4.3 Grey-headed flying-fox (*Pteropus poliocephalus*) 114
4.4 Koala (*Phascolarctos cinereus*) 118
4.5 Large-eared pied bat (*Chalinolobus dwyeri*) 122
4.6 Long-nosed potoroo (SE mainland) (*Potorous tridactylus tridactylus*) 126
4.7 New Holland mouse (Pseudomys novaehollandiae) 130
4.8 Northern quoll (*Dasyurus hallucatus*) 134
4.9 Southeastern long-eared bat (*Nyctophilus corbeni*) 139
4.10 Spotted-tail quoll (southeastern mainland population) (*Dasyurus maculatus maculatus*) 143

5 Fauna species – Conservation significant species – Birds 150

5.1 Australasian bittern (*Botaurus poiciloptilus*) 150
5.2 Australian painted snipe (*Rostratula australis*) 155

5.3 Black-breasted button-quail (*Turnix melanogaster*) 159
5.4 Black-throated finch (*Poephila cincta cincta*) 164
5.5 Coxen's fig-parrot (*Cyclopsitta diophthalma coxeni*) 169
5.6 Curlew sandpiper (*Calidris ferruginea*) 174
5.7 Eastern bristlebird (*Dasyornis brachypterus*) 179
5.8 Eastern curlew (*Numenius madagascariensis*) 183
5.9 Painted honeyeater (*Grantiella picta*) 186
5.10 Red goshawk (*Erythrotriorchis radiatus*) 191
5.11 Grey falcon (*Falco hypoleucos*) 194
5.12 Regent honeyeater (*Anthochaera phrygia*) 197
5.13 Squatter pigeon (*Geophaps scripta scripta*) 201
5.14 Swift parrot (*Lathamus discolor*) 205
5.15 White-throated needletail (*Hirundapus caudacutus*) 209

6 Threatened ecological communities 213

6.1 Coolibah – Black box woodlands of the Darling Riverine Plains and the Brigalow belt south bioregions 213
6.2 Lowland rainforest of subtropical Australia 215
6.3 Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland 218
6.4 Poplar Box Grassy Woodland on Alluvial Plains 221
6.5 Semi-evergreen vine thickets of the Brigalow Belt (north and south) and Nandewar Bioregions 223
6.6 Weeping Myall woodlands 228
6.7 White box-yellow box-Blakely's red gum grassy woodland and derived native grassland (also known as Box-gum grassy woodland and derived grassland) 231

Figures

Figure 1.1 Distribution range of the Austral cornflower
Figure 1.2 Distribution range of the Austral cornflower in relation to the Project
Figure 1.3 Distribution range of the Austral toadflax
Figure 1.4 Distribution range of the Austral toadflax in relation to the Project
Figure 1.5 Distribution range of Blotched sarcochilus
Figure 1.6 Distribution range of the Blotched sarcochilus in relation to the Project
Figure 1.7 Distribution range of bluegrass
Figure 1.8 Distribution range of the bluegrass in relation to the Project
Figure 1.9 Distribution range of the Brush sophora
Figure 1.10 Distribution range of the Brush sophora in relation to the Project
Figure 1.11 Bunya Mountains bluegrass (Bothriochloa bunyensis)
Figure 1.12 Distribution range of Bunya Mountains bluegrass
Figure 1.13 Distribution range of the Bunya Mountains bluegrass in relation to the Project
Figure 1.14 Distribution range of the Four-tailed grevilia
Figure 1.15 Distribution range of Four-tailed grevilia in relation to the Project
Figure 1.16 Distribution range of Hairy-joint grass
Figure 1.17 Distribution range of Hairy-joint grass in relation to the Project
Figure 1.18 Distribution range of the Hawkweed
Figure 1.19 Distribution range of Hawkweed in relation to the Project
Figure 1.20 Distribution range of King blue-grass
Figure 1.21 Distribution range of King blue-grass in relation to the Project
Figure 1.22 Distribution range of Leionema
Figure 1.23 Distribution range of Leionema in relation to the Project
Figure 1.24 Distribution range of Queensland nut tree
Figure 1.25 Distribution range of Queensland nut tree in relation to the Project
Figure 1.26 Occurrence record of Miniature moss-orchid

Figure 1.27 Distribution range of Miniature moss-orchid in relation to the Project
Figure 1.28 Distribution range of Mt. Berryman phebalium
Figure 1.29 Distribution range of Mt. Berryman phebalium in relation to the Project
Figure 1.30 Distribution range of Ooline
Figure 1.31 Distribution range of Ooline in relation to the Project
Figure 1.32 Distribution range of *P. grandispiculatum*
Figure 1.33 Distribution range of P. grandispiculatum in relation to the Project
Figure 1.34 Distribution range of the Quassia
Figure 1.35 Distribution range of Quassia in relation to the Project
Figure 1.36 Distribution range of Queensland nut tree
Figure 1.37 Distribution range of Queensland nut tree in relation to the Project
Figure 1.38 Stream clematis (*Clematis fawcettii*)
Figure 1.39 Distribution range of Stream clematis
Figure 1.40 Distribution range of Stream clematis in relation to the Project
Figure 1.41 Distribution range of the Tall velvet sea-berry
Figure 1.42 Distribution range of the Tall velvet sea-berry in relation to the Project
Figure 1.43 Wandering pepper-cress (*Lepidium peregrinum*)
Figure 1.44 Distribution range of the Wandering pepper-cress
Figure 1.45 Distribution range of the Wandering pepper-cress in relation to the Project
Figure 1.46 Distribution range of Waxy sarcochilus
Figure 1.47 Distribution range of Waxy sarcochilus in relation to the Project
Figure 2.1 Distribution range of Murray cod
Figure 2.2 Distribution range of Murray cod in relation to the Project
Figure 3.1 Distribution range of the Collared delma
Figure 3.2 Distribution range of the Collared delma in relation to the Project
Figure 3.3 Distribution range of the Condamine earless dragon
Figure 3.4 Distribution range of the Condamine earless dragon in relation to the Project
Figure 3.5 Distribution range of the Dunmall's snake
Figure 3.6 Distribution range of the Dunmall's snake in relation to the Project
Figure 3.7 Distribution range of the Long-legged worm-skink
Figure 3.8 Distribution range of the Long-legged worm-skink in relation to the Project
Figure 3.9 Distribution range of the Three-toed snake-tooth skink
Figure 3.10 Distribution range of the Three-toed snake-tooth skink in relation to the Project
Figure 3.11 Distribution range of the Yakka skink
Figure 3.12 Distribution range of the Yakka skink in relation to the Project
Figure 4.1 Distribution range of the Brush-tailed rock-wallaby
Figure 4.2 Distribution range of the Brush-tailed rock-wallaby in relation to the Project
Figure 4.3 Distribution range of the Greater glider
Figure 4.4 Distribution range of the Greater glider in relation to the Project
Figure 4.5 Distribution range of the Grey-headed flying-fox
Figure 4.6 Distribution range of the Grey-headed flying-fox in relation to the Project
Figure 4.7 Distribution range of Koala
Figure 4.8 Distribution range of Koala in relation to the Project
Figure 4.9 Distribution range of the Large-eared pied bat
Figure 4.10 Distribution range of the Large-eared pied bat in relation to the Project
Figure 4.11 Distribution range of the Long-nosed potoroo (SE Mainland)
Figure 4.12 Distribution range of the Long-nosed potoroo (SE Mainland) in relation to the Project
Figure 4.13 Distribution range of New Holland mouse
Figure 4.14 Distribution range of New Holland mouse in relation to the Project
Figure 4.15 Distribution range of the Northern quoll
Figure 4.16 Distribution range of the Northern quoll in relation to the Project
Figure 4.17 Distribution range of the Southeastern long-eared bat
Figure 4.18 Distribution range of the Southeastern long-eared bat in relation to the Project
Figure 4.19 Distribution range of the Spotted-tail quoll (southern subspecies)
Figure 4.20 Distribution range of the Spotted-tail quoll (southern subspecies) in relation to the Project

Figure 5.1 Distribution range of the Australasian bittern
Figure 5.2 Distribution range of the Australasian bittern in relation to the Project
Figure 5.3 Distribution range of the Australian painted snipe
Figure 5.4 Distribution range of the Australian painted snipe in relation to the Project
Figure 5.5 Distribution range of the Black-breasted button-quail
Figure 5.6 Distribution range of the Black-breasted button-quail in relation to the Project
Figure 5.7 Distribution range of the Black-throated finch
Figure 5.8 Distribution range of the Black-throated finch in relation to the Project
Figure 5.9 Coxen's fig-parrot (*Cyclopsitta diophthalma coxeni*)
Figure 5.10 Distribution range of the Coxen's fig-parrot
Figure 5.11 Distribution range of the Coxen's fig-parrot in relation to the Project
Figure 5.12 Distribution range of the Curlew sandpiper
Figure 5.13 Distribution range of the Curlew sandpiper in relation to the Project
Figure 5.14 Distribution range of the Eastern bristlebird
Figure 5.15 Distribution range of the Eastern bristlebird in relation to the Project
Figure 5.16 Distribution range of the Eastern curlew
Figure 5.17 Distribution range of the Eastern curlew in relation to the Project
Figure 5.18 Distribution range of the Painted honeyeater
Figure 5.19 Distribution range of the Painted honeyeater in relation to the Project
Figure 5.20 Distribution range of Red goshawk
Figure 5.21 Distribution range of Red goshawk in relation to the Project
Figure 5.22 Distribution range of the Grey falcon
Figure 5.23 Distribution range of the Grey falcon in relation to the Project
Figure 5.24 Distribution range of the Regent honeyeater
Figure 5.25 Distribution range of the Regent honeyeater in relation to the Project
Figure 5.26 Distribution range of the southern Squatter pigeon
Figure 5.27 Distribution range of the southern Squatter pigeon in relation to the Project
Figure 5.28 Distribution range of Swift parrot
Figure 5.29 Distribution range of Swift parrot in relation to the Project
Figure 5.30 Distribution range of the White-throated needletail
Figure 5.31 Distribution range of the White-throated needletail in relation to the Project
Figure 6.1 Distribution range of Coolibah TEC
Figure 6.2 Distribution range of Lowland rainforest TEC
Figure 6.3 Distribution range of Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland TEC
Figure 6.4 Distribution range of Poplar Box Grassy Woodland
Figure 6.5 Distribution range of Semi-evergreen vine thicket TEC
Figure 6.6 Distribution range of Weeping Myall woodland TEC
Figure 6.7 Distribution range of White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC

1 Flora species

1.1 Austral cornflower (*Rhaponticum australe*)

1.1.1 Status

EPBC Act – Vulnerable

1.1.2 Biology and ecology

1.1.2.1 Characteristic

Austral cornflower (*Rhaponticum australe)* is an erect perennial herb that grows to 60 cm in height (refer Photograph 1.1). The branches are slightly woolly. Leaves are oblanceolate and toothed to deeply pinnatifid. The lower leaves are up to 18 cm long and 6 cm wide, reducing in size up the stem. The upper leaves are few, small and nearly sessile (DotEE 2018).



Photograph 1.1 Austral cornflower (*Rhaponticum australe*)

Source: Queensland Herbarium (2007)

1.1.2.2 Known distribution

Austral cornflower is currently confined to Queensland. The species was known to previously occur in NSW and Victoria but is now presumed extinct in those states. The current distribution of *R. australe* extends from Allora (north of Warwick) to Callide (northwest of Biloela), Queensland (TSSC 2008) (refer Figure 1.1).



Figure 1.1 **Distribution range of the Austral cornflower**

Source: ALA (2018)

1.1.2.3 Distribution in relation to the project

Rhaponticum australe was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs, but has been recorded in the area for surveys carried out for the nearby TSRC Project. The location of these records cannot be ascertained at this time due to probity issues associated with the project. Database records (AoLA) indicate this species has occurred within and adjacent to the Project to the west of the tunnel. There is a somewhat recent from 1999 located to the north of Morris Road east of Gowrie. The nearest record outside of the Project footprint is from 2016 occuring approximately 20 m to the north between Draper Road and Gowrie Creek between Kingsthorpe and Gowrie Junction. Two records occur near the western tunnel entrance. Both records are dated from 1999 and are located approximately 85 m from the disturbance footprint between E Paulsens Road and Gowrie Creek. Other nearby database records within a 50 km radius of the Project occur at Kingsthorpe, Gowrie Mountain and Puzzling Gully. Database records extend from Jondaryan to the north-west of the Project disturbance footprint, to Pittsworth and Allora to the south-west and south and Laidley east of the Project (refer Figure 1.2).

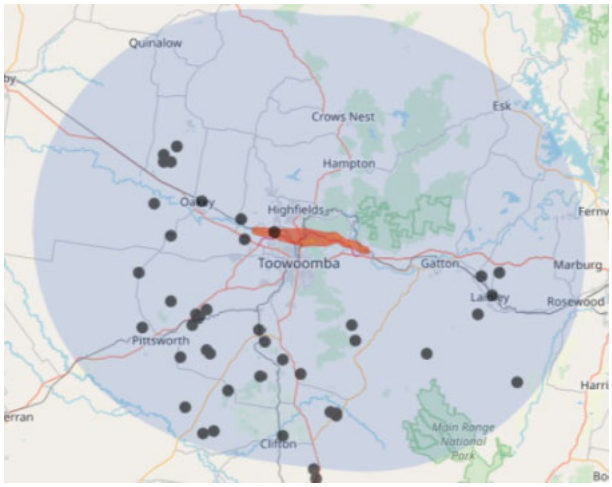


Figure 1.2 **Distribution range of the Austral cornflower in relation to the Project**

Source: ALA (2020)

1.1.2.4 Biology and reproduction

The flowering and fruiting period for Austral cornflower typically occurs in Spring, through to Autumn. The dead flowering stems can remain on the plant for several months after the seeds have dispersed (DotEE 2018; Marlow 1998).

1.1.3 Habitat

Austral cornflower typically grows in Eucalypt open forests, with grassy understory. This species often occurs on roadsides and on road reserves alongside Rhodes grass *(Chloris gayana*), Spear thistle *(Cirsium vulgare*), Queensland blue gum *(Eucalyptus tereticornis*) and Rough-barked apple *(Angophora floribunda*) on black clay soil derived from basalt. This species is considered to be a poor competitor and prefers habitat where grass competition has been reduced by fire, or other forms of disturbance. However, Austral cornflower is unlikely to benefit from disturbance that allows the development of a dense cover of exotic grasses (QDNR 2000).

1.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Austral cornflower:

- Woodland clearing for agriculture and urban development and livestock grazing has caused the local extinction of the Austral Cornflower in Victoria and NSW
- The invasion of exotic grass species into Austral Cornflower habitat may also threaten extant populations. As most populations occur on highly disturbed roadsides, they must compete with introduced species (DotEE 2018).

1.1.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species.

1.1.6 References

Atlas of Living Australia (2018). *Rhaponticum australe*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2908264 [Accessed 27 August 2018].

Department of the Environment and Energy (2018). *Rhaponticum australe* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=23949 [Accessed 27 August 2018].

Marlow, G. (1998). *Stemmacantha australis* - Description and Ecology. **In:** Menkins, I., ed. *Native Vegetation of the Darling Downs*.

Queensland Department of Natural Resources (2000). *Species Management Manual*. Forest and Fauna Conservation and Ecology Section, Queensland Department of Natural Resources.

Queensland Herbarium (2007). Department of Science, Information Technology and Innovation (DSITI), Queensland Government.

Threatened Species Scientific Committee (2008). *Approved Conservation Advice for Rhaponticum australe (Hawkweed)*.

1.2 Austral toadflax (*Thesium australe*)

1.2.1 Status

EPBC Act – Vulnerable

1.2.2 Biology and ecology

1.2.2.1 Characteristic

Austral toadflax is a small, straggling herb growing to 40 cm tall. Leaves are pale green to yellow-green, somewhat succulent, 1 to 4 cm long and 0.5 to 1.5 mm wide (refer Photograph 1.2). Flowers are minute and white, emerging where the leaves meet the stems and appearing in spring. The fruit is small and nut-like, developing in summer. This species is often hidden amongst grasses and herbs (OEH 2017).



Photograph 1.2 **Austral toadflax (*Thesium australe*)**

Source: Hunter (2018)

1.2.2.2 Known distribution

Austral toadflax occurs in NSW, the Australian Capital Territory (ACT), Queensland and Victoria (refer Figure 1.3). It is also known from eastern Asia. Its current distribution is sporadic but widespread, occurring between the Bunya Mountains in southeast Queensland to northeast Victoria and as far inland as the southern, central and northern tablelands in NSW and the Toowoomba region (ALA 2018; OEH 2017; Scarlett et al. 2003).



Figure 1.3 **Distribution range of the Austral toadflax**

Source: ALA (2018)

1.2.2.3 Distribution in relation to the project

Thesium australe was not identified during any Project-associated field surveys, but has been recorded during surveys for the nearby TSRC Project. The location of this record cannot be ascertained at this time due to probity issues associated with the project. There are two database records (AoLA) to the east of Toowoomba from 1989 and 2009 located approximately 6 km south of the Project. To the south-west of Toowoomba there is a 2000 and 2004 record located approximately 11 km south. There are a number of records further south of Toowoomba. To the north there are many records from 2012 in Pechey State Forest (20 km north of the Project). To the east there are older records (1985) near Forest Hill (22 km from the Project) and to the west there is a 2000 record at Bowenville (refer Figure 1.4).

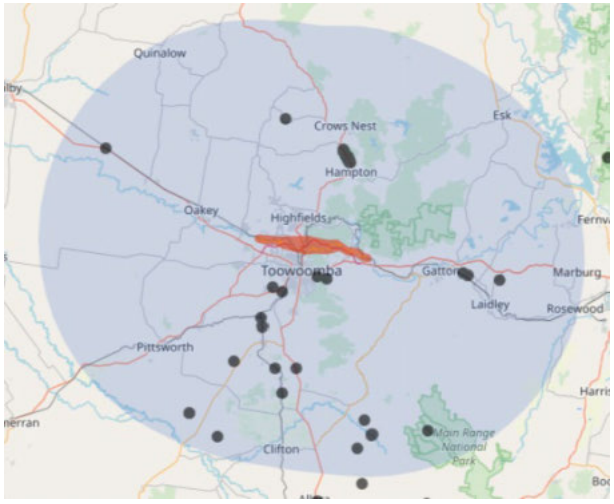


Figure 1.4 **Distribution range of the Austral toadflax in relation to the Project**

Source: ALA (2020)

1.2.2.4 Biology and reproduction

Austral toadflax flowers and fruits throughout the year on the coast, and during summer at higher altitudes. In subalpine and tableland climates, the species dies back to rootstock during winter and resprouts in spring. In coastal areas, the species persists all year round and may live for longer than two years. The existence of buds near the soil surface allows the species to resprout after disturbance. It is observed to germinate well after fire; however fire is not essential for germination (Cohn 2004; Scarlett et al. 1994).

1.2.3 Habitat

It is semi-parasitic on the roots of certain grass species; occurring in shrubland, grassland or woodland, often on damp sites. It occurs in subtropical, temperate and subalpine climates over a wide range of altitudes. It occurs on soils derived from sedimentary, igneous and metamorphic geology on a range of soils, including black clay loams to yellow podzolics and peaty loams (Leigh et al.1984; Hunter et al. 1999; Cohn 2004).

Vegetation types include open grassy heath dominated by Swamp myrtle (*Leptospermum myrtifolium*), Small-fruit hakea (*Hakea microcarpa*), Alpine bottlebrush (*Callistemon sieberi*), Woolly grevillea (*Grevillea lanigera*), Coral heath (*Epacris microphylla*) and *Poa* spp.; Kangaroo grass grassland surrounded by Eucalypt woodland; and grassland dominated by Barbed-wire grass (*Cymbopogon refractus*) (Leigh et al. 1984; Hunter et al. 1999).

1.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Austral toadflax:

- Lack of fire/disturbance
- Existing and intensified grazing by livestock, native herbivores and feral herbivores
- Residential, infrastructure and agricultural development

- Weed invasion
- Infrastructure (road and rail) maintenance (Cohn 2004; NSW OEH 2018; Scarlett et al. 2003).

1.2.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2016). *Threat abatement plan for competition and land degradation by rabbits*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.

1.2.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for competition and land degradation by rabbit relevant to Austral toadflax include:

- Preventing plant regeneration
- Overgrazing and general damage to plant species
- Reversing the normal processes of plant succession
- Altering ecological communities and changing soil structure and nutrient cycling, leading to significant erosion.

Relevant management strategies relevant to Austral toadflax include population control. Following the plan, control efforts should be:

- Targeted to protect sites where rabbits pose the greatest threat to biodiversity
- Undertaken in a strategic manner to take advantage of the environmental conditions and other complementary activities
- Monitored to ensure that objectives are met and allow management options to be adapted to changing circumstances.

1.2.7 References

Atlas of Living Australia (2018). *Thesium australe*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2898274#tab_recordsView [Accessed 30 August 2018].

Cohn, J.S. (2004). Effects of slashing and burning on *Thesium australe* R. Brown (Santalaceae) in coastal grasslands of NSW. *Proc. Linn. Soc. NSW*. 125:57-65. Linnean Society of NSW, Kingsford, NSW

Hunter J. (2018). *Thesium australe* (Image) [Online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2891975#gallery [Accessed 30 August 2018].

Hunter, J.T., Kingston J. and Croft P. (1999). Vegetation and floristics of Kwiambal National Park and surrounds, Ashford, New South Wales. *Cunninghamia*. 6(2):351-78.

Leigh, J., Boden R. and Briggs J. (1984). *Extinct and Endangered Plants of Australia*. Melbourne, Victoria: Macmillan.

Office of Environment and Heritage, NSW (2018). Austral toadflax. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10802 [Accessed 30 August 2018].

Scarlett, N.H., Branwell M. and Earl G. (2003). *Flora and Fauna Guarantee Action Statement 56-Austral Toad Flax* Thesium australe. [Online]. Victorian Department of Sustainability and Environment (Vic. DSE). Available from: http://www.depi.vic.gov.au/environment-and-wildlife/threatened-species-and-communities/flora-and-fauna-guarantee-act-1988/action-statements.

1.3 Blotched sarochilus (*Sarcochilus weinthalii*)

1.3.1 Status

EPBC Act – Vulnerable

1.3.2 Biology and ecology

1.3.2.1 Characteristic

Blotched sarcochilus (*Sarcochilus weinthalii*) is an epiphyte orchid that grows on rainforest trees, either projecting or hanging from the trunk, or grows on rock surfaces. It has fleshy aerial roots and a short stem with several leathery leaves. The hanging flowering stems are up to 7 cm long with up to 12 flowers on each (refer Photograph 1.3). Each flower is 15 mm across and is cream to greenish with purple to reddish blotches (DEE 2018; DECCW 2010; OEH 2018).



Photograph 1.3 Blotched sarcochilus (*Sarcochilus weinthalii*)

Source: OEH (2015)

1.3.2.2 Known distribution

Blotched sarcochilus has been recorded in northern NSW and southeast Queensland (refer Figure 1.5). The species occurs north of the Richmond River to the Bunya Mountains and the Gallangowan area. There are no available data on area of occupancy, extent of occurrence or population numbers. Illegal collection has occurred in accessible areas (DotEE 2018; OEH 2018; Quinn et al. 1995).

This species occurs within the Brigalow Belt South and southeastern Queensland IBRA bioregions and the Condamine, Northern Rivers and southeast Queensland Natural Resource Management regions (DotEE 2018).



Figure 1.5 **Distribution range of Blotched sarcochilus**

Source: ALA (2018)

1.3.2.3 Distribution in relation to the project

Sarcochilus weinthalii species was not identified during any Project-associated field surveys or for the nearby TSRC Project. Database records (AoLA) for the species have been generalised to protect the location of the species, likely from specialist collectors. As such, database records may not reflect the actual location of the record. There are two very old records (1882 and 1957) located 2 km north of the Project footprint. There are eight records to the east of Toowoomba located 8.5 km south of the Project, the most recent of which is from 2015. To the south-east of Toowoomba are three very old records (103 to 1909) located 11 km south. The only other record within 50 km of the Project is located 32 km north-east near Esk National Park and is dated 1986 (refer Figure 1.6).

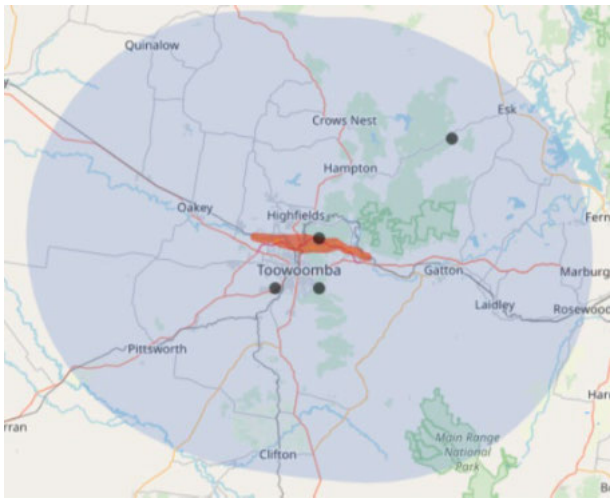


Figure 1.6 **Distribution range of the Blotched sarcochilus in relation to the Project**

Source: ALA (2020)

1.3.2.4 Biology and reproduction

Blotched sarcochilus flowers from June to October and fruits persist for 6 to 8 months after fertilisation. When ripe, the fruits release numerous light brown seeds (ALA 2015; BDEE 2018).

1.3.3 Habitat

Blotched sarcochilus grows on trees in rainforest, dry rainforest and drier scrub of sub-coastal ranges and associated foothills inland from the coast at altitudes of 400 to 700 m above sea level. In southeast Queensland, the Blotched sarcochilus has been recorded growing in a number of microphyll and notophyll rainforest types and also occurs in patches of isolated scrub. The species is known in the Bunya Mountain area (DotEE 2018; Queensland CRA/RFA Steering Committee 1998).

1.3.4 Threatening processes

The following have been identified as potentially threatening processes to the Blotched sarcochilus:

- Habitat loss through land clearing and forestry operations
- Inappropriate fire regimes
- Illegal collection
- Localised extinction as a result of small population sizes (DotEE 2018; OEH 2013).

1.3.5 Threat abatement/recovery plans

The following Threat Abatement/Recovery plans have been identified as being relevant for this species:

- Department of Environment, Climate Change and Water NSW (2010). Borders Range Rainforest Biodiversity Management Plan. Available from: https://www.environment.gov.au/system/files/resources/4249147f-26eb-416b-ae78-e982a7099e4f/files/brrb-management-plan.pdf
- Office of Environment and Heritage (n.d.), Saving our Species Programme. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1192&ReportProfileID=10221. In effect under the BC Act 2016.

1.3.6 Summary of threat abatement/recovery plan

The *Borders Range Biodiversity Plan* the Australian Government's Border Ranges North and South (Queensland and New South Wales) Biodiversity Hotspot, listing *S. weinthali* as a priority flora species.

Priority areas outlined in this biodiversity plan identify the following locations for priority action:

- Big Scrub remnants
- Slots Island Nature Reserve
- Tumbunan fauna refugia
- Gondwana Rainforests of Australia.

Key threatening processes identified in this plan that are relevant to *S. weinthali* include:

- Anthropogenic climate change
- Habitat loss or change (clearing, eucalypt dieback, high frequency fire)
- Weeds (invasion and establishment of exotic species such as Bitou Bush and Bonesee, exotic perennial grasses and Lantana)
- Pests (Grazing by feral European Rabbit, feral Goats, feral Deer, feral Pig, Red Imported Fire Ants and Yellow Crazy Ant)
- Infection of native plants by *Phytophthora cinnamomi.*

Key management outcomes that have been identified in this biodiversity plan include:

- Reduce organisational-related constraints to the conservation of biodiversity
- Minimise the impact of climate change on biodiversity
- Protect rainforest, related vegetation and species from land clearing, fragmentation, modification, degradation and from weed incursion
- Protect rainforest from fire and promote the implementation of appropriate fire regimes in related vegetation
- Protect the rainforest and related vegetation from the impact of pest animals
- Minimise the impacts associated with Bell minor associated dieback on rainforest and associated wet sclerophyll forest
- Engage landholders and community members in the conservation of biodiversity for this forest community
- Establish effective monitoring of biodiversity-related projects.

The *Save our Species* conservation strategy identifies this species as being data-deficient. As such, the objective of the strategy is to fill knowledge gaps in order to develop a targeted management strategy. The priority action is to define distribution through surveys targeting fallen branches of host plant during flowering season (September to October).

1.3.7 References

Atlas of Living Australia (2013). Atlas of Living Australia. Available on the Internet at: http://www.ala.org.au/

Atlas of Living Australia (2018), *Sarcochilus weinthalii,* accessed 23 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890229#.

Department of Environment, Climate Change and Water (2010), Border Ranges Rainforest Biodiversity Management Plan - NSW and Queensland. Sydney South, New South Wales: DECCW.

Department of the Environment (2014). Approved Conservation Advice for *Sarcochilus weinthalii* (blotched sarcochilus). Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/12673-conservation-advice.pdf. In effect under the EPBC Act from 11 April 2014.

Department of the Environment (2018). *Sarcochilus weinthalii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 Aug

Office of Environment and Heritage (2018). *Blotched sarcochilus* – profile. Sydney, New South Wales: OEH. Available on the Internet at: http://www.environment.nsw.gov.au/threatenedspecies/

Office of the Environment and Heritage, (2015), Threatened Species Website, image of: *Blotched sarcochilus*, accessed 23 August 2018, available https://images.ala.org.au/image/viewer?imageId=99342440-770e-459d-b00c-186de661ccdd.

Queensland CRA/RFA Steering Committee (1998), Survey of Threatened Plant Species in South East Queensland Biogeographical Region.

Quinn F, Williams JB, Gross CL and Bruhl J (1995), Report on rare and threatened plants of northeastern New South Wales. Armidale: University of New England

1.4 Bluegrass (*Dichanthium setosum*)

1.4.1 Status

EPBC Act – Vulnerable

1.4.2 Biology and ecology

1.4.2.1 Characteristic

Bluegrass (*Dichanthium setosum*) is an upright perennial grass less than 1 m tall. It has mostly hairless leaves about 2 to 3 mm wide. The flowers are densely hairy and clustered together along a stalk in a cylinder shape (refer Photograph 1.4) and appear mostly during summer. The species can form pure swards or occur as scattered clumps (Ayers et al. 1996; DEC 2005 as in DEWHA 2008; Harden 1993).



Photograph 1.4 **Bluegrass (*Dichanthium setosum*)**

Source: Rose (2013)

1.4.2.2 Known distribution

Bluegrass occurs on the northern tablelands in the Saumarez area, west of Armidale, and 18 to 30 km east of Guyra. It has been found sparsely on the northwestern slopes, central western slopes and northwestern plains of NSW, extending west to Narrabri. In Queensland, it has been documented to occur from the Leichhardt, Morton, North Kennedy and Port Curtis regions (refer Figure 1.7). This species occurs in the Mistake Range, in Main Range National Park, and possibly in Glen Rock Regional Park, adjacent to the Main Range National Park (Ayers et al. 199; Henderson 1997).



Figure 1.7 **Distribution range of bluegrass**

Source: ALA (2018)

1.4.2.3 Distribution in relation to the project

Bluegrass was not identified during any Project-associated field surveys or for the nearby TSRC Project. Database records (AoLA) from 1996 occur within 5 km to the north of the alignment (west of Murphy's Creek). Records from 2009 occur a similar distance to the south of the disturbance footprint to the east of Toowoomba. Scattered records for this species occur throughout the Toowoomba Range from Crows Nest in the north to Hodgson Vale in the south (refer Figure 1.8).

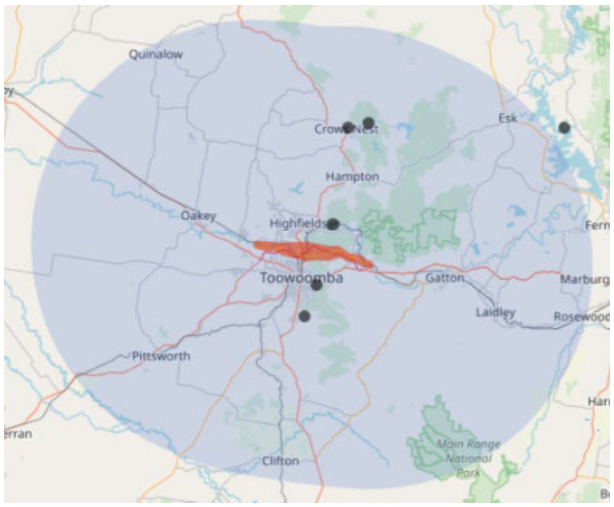


Figure 1.8 **Distribution range of the bluegrass in relation to the Project**

Source: ALA (2020)

1.4.2.4 Biology and reproduction

Bluegrass is a warm season perennial grass, that commences growing in springs, flowers in summer and becomes dormant in late autumn. A fire frequency of greater than five years has been recommended for the species (NSW OEH 2013; Yu et al. 2000).

1.4.3 Habitat

Bluegrass is associated with heavy basaltic black soils and stony red-brown hardsetting loam with clay subsoil and is found in moderately disturbed areas such as cleared woodland, grassy roadside remnants, grazed land and highly disturbed pasture. The extent to which this species tolerates disturbance is unknown. The species occurs within the Border Rivers−Gwydir, Central West, Namoi, Northern Rivers (NSW), South East and Fitzroy (Queensland) Natural Resources Management regions (Ayers et al. 1996; DEC 2005).

1.4.4 Threatening processes

The following have been identified as potentially threatening processes to Bluegrass:

- Heavy grazing by agricultural animals
- Clearing of habitat for pasture and cropping
- Frequent irregular fires for agricultural purposes
- Road widening
- Invasion by introduced grasses (NSW OEH 2013).

1.4.5 Threat abatement/recovery plans

The following threat abatement plan and recovery plan have been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1192&ReportProfileID=10221. In effect under the BC Act 2016.
- Department of Environment, Climate Change and Water NSW (2010). *National Recovery Plan for White Box - Yellow* Box - *Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Department of Environment, Climate Change and Water NSW, Sydney. Available from: . http://www.environment.gov.au/biodiversity/threatened/recovery-plans/white-box-yellow-box-blakelys-red-gum-grassy-woodland-and-derived-native-grassland-national. In effect under the EPBC Act from 22-Mar-2013.

The following threat abatement plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2016). *Threat abatement plan for competition and land* degradation *by rabbits*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.

1.4.6 Summary of threat abatement/recovery plan

The *Saving our Species* conservation strategy for *Dichanthium setosum* identifies five priority management sites in NSW:

- East of Guyra in Armidale Regional LGA
- Apex Lookout in Armidale Regional LGA
- Armidale Arboretum in Armidale Regional LGA
- Saumarez North TSR in Armidale Regional, Uralla LGA
- Wallabadah Cemetery in Liverpool Plains LGA.

Threats identified at the management sites include:

- Heavy grazing by domestic stock
- Invasion by introduced grasses such as Coolatai, African Lovegrass, Phalaris and ox-eye dasiy.
- Inappropriate slashing regimes
- Distribution and recruitment/germination issues due to low species numbers.

Management activities to protect *Dichanthium setosum* at the *Saving our Species* sites are:

- Appropriate grazing management, including excluding stock from the sites September-December or following rainfall events and fencing off areas of high density plants from stock
- Targeted, physical removal of invasive grasses
- Track species abundance/condition over time, including assessment of reproduction/seed set, weed encroachment and grazing/mowing or slashing impacts.
- Liaise with local government to ensure awareness of the species' locations and importance
- Collect and sow seeds during the species' flowering/seeding period to enhance recruitment and population density.

Threats identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Land use and management change
- Agricultural and horticultural development

- Public Infrastructure upgrades in travelling stock routes (TSRs)
- Firewood collection and ‘tidying up’
- Changed fire regimes
- Increase in soil nutrients and use of chemicals
- Mowing and slashing regimes
- Revegetation management
- Weed invasion
- Climate change
- Salinity
- Acid soils
- Declining tree health and regeneration
- Increased grazing pressure from invasive herbivores
- Disease – *Phytophthora cinnamomi*
- Collection and removal of native flora.

Recovery actions identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Collect baseline data on the locations, quality and management regimes of remnant sites
- Extent and condition mapping
- Component species surveys
- Protection of existing habitat in priority areas including on private land
- Engagement with the community, particularly where remnants occur on private land to provide information on appropriate management and with Aboriginal communities.

Summary of baseline information actions undertaken to date:

- The establishment of databases comprising of information on CMN members (land managers with Box-Gum Grassy Woodland remnants), remnant locations, composition of flora and fauna species and remnant condition from surveys of CMN members’ sites and other sites
- Minimum condition criteria and assessment method developed to assist land managers in identification of listed ecological communities
- Development of regional models using remote sensing
- Mapping of Box-Gum Grassy Woodland extent
- Surveys conducted during research programs through various organisations.

Threats identified in the threat abatement plan for competition and land degradation by rabbit relevant to *Dichanthium setosum* include:

- Preventing plant regeneration
- Overgrazing and general damage to plant species
- Reversing the normal processes of plant succession
- Altering ecological communities and changing soil structure and nutrient cycling, leading to significant erosion.

Management strategies relevant to *Dichanthium setosum* in the threat abatement plan for rabbits include population control. Following the plan, control efforts should be:

- Targeted to protect sites where rabbits pose the greatest threat to biodiversity

- Undertaken in a strategic manner to take advantage of the environmental conditions and other complementary activities
- Monitored to ensure that objectives are met and allow management options to be adapted to changing circumstances.

1.4.7 References

Atlas of Living Australia (2018). Distribution of *Dichanthium setosum,* viewed 24 August 2018, available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2905357.

AusGrass2 (2018). *Dichanthium setosum,* viewed 24 August 2018, available: http://ausgrass2.myspecies.info/content/dichanthium-setosum.

Ayers, D, Nash, S, and Baggett, K (Eds) (1996), Threatened Species of Western New South Wales, New South Wales National Parks and Wildlife Service, Hurstville.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Dichanthium setosum*. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/14159-conservation-advice.pdf. In effect under the EPBC Act from 26 March 2008.

Department of Environment and Conservation New South Wales (2005), *Dichanthium setosum* – Profile, viewed 11 December 2007, http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10221.

Harden, GJ (Ed) 1993, Flora of New South Wales, Volume Four, University of New South Wales Press,

Kensington. Henderson, RJF (1997), Queensland Plants Names and Distribution, Queensland Herbarium: Indooroopilly.

NSW Office of Environment and Heritage (2013). Bluegrass - profile. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10221.

Rose, H. (2013). *Dichanthium setosum*. [image] [online] Available at: https://www.flickr.com/photos/73840284@N04/8675273472. [13 September 2019].

Yu, P., N. Prakash and R.D.B. Whalley (2000). Comparative reproductive biology of the vulnerable and common grasses in Bothriochloa and Dicanthium. In: Jacobs, S.W.L. and J. Everett, eds. Grasses: systematics and evolution. CSIRO Publishing, Collingwood.

1.5 Brush sophora (*Sophora fraseri*)

1.5.1 Status

EPBC Act – Vulnerable

1.5.2 Biology and ecology

1.5.2.1 Characteristic

Sophora fraseri (Brush sophora), is a softly pubescent, sparsely branched leguminous shrub that grows to 1 to 2 m high. Leaves are pinnate and are 6 to 15 cm long with a 10 to 20 mm stalk. Leaves have 21 to 35 oblong to ovate leaflets 5 to 25 mm long, 3 to 10 mm wide, with smooth margins and stalks 1 to 2 mm long. Flowers occur in racemes about 10 cm long during spring (refer Photograph 1.5). Petals are pale yellow, about 10 mm long, and the sepals are about 5 mm long. The fruit, 3 to 10 cm long and up to 8 mm in diameter, is irregularly restricted between the seeds and does not open at maturity. There are 2 to 7 seeds, about 6 mm long (WetlandInfo 2018; Harden 2002; Stanley and Ross 1983).



Photograph 1.5 **Brush sophora *(Sophora fraseri)***

Source: Scott (2016)

1.5.2.2 Known distribution

Brush sophora is found north of Casino in northern NSW, where it is very rare, and into southeast Queensland (refer Figure 1.9), where it is widespread but not common. Brush sophora is conserved in Lamington National Park and Mount Mistake National Park (Briggs and Leigh 1995).



Figure 1.9 **Distribution range of the Brush sophora**

Source: ALA (2018)

1.5.2.3 Distribution in relation to the project

Sophora fraseri was recorded within the Project footprint during Project surveys near the eastern entrance of the proposed tunnel in the Toowoomba Range. Two individuals were located within eucalypt open forest adjacent to a vine forest community. There is a recent database record (AoLA) from 2018 within the Project footprint east of Mount Kynoch in the same area as the Project survey records. There are 1997 and 2011 records from the Kingsthorpe area 2 km west of the Project footprint. There is also a very old record (1930) located 5 km south of the eastern extent of the Project. There are scattered records in the wider area to the north-west and south-east (refer Figure 1.10). There is a concentration of records further to the north-east in the D'Aguilar Range. The species distribution extends from Casino in northern NSW north to the Sunshine Coast hinterland. The Project may be on the western edge of the species range.

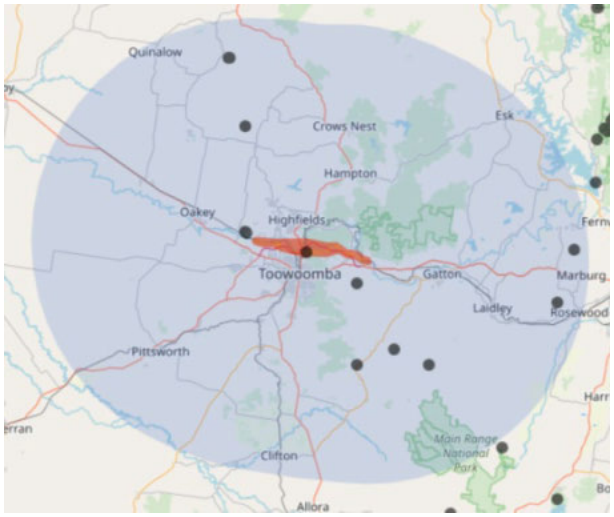


Figure 1.10 **Distribution range of the Brush sophora in relation to the Project**

Source: ALA (2020)

1.5.2.4 Biology and reproduction

Flowering of Brush sophora has been recorded in April and from late August to mid November. Fruiting has been recorded in January, April, July, August and November (Barker and Borsboom 1997; WetlandInfo 2018).

1.5.3 Habitat

Brush sophora normally grows in wet sclerophyll forest and a range of rainforest types. It has been reported growing in hilly terrain on hillslopes at altitudes at altitudes from 60 to 660m, in mostly shallow stony to shaly soils, of loam to clay texture derived from sandstone or basalt rocks. The shrub appears to prefer growing along rainforest margins, in eucalypt forests in the vicinity of rainforests or in large canopy gaps in closed forest communities (Barker and Borsboom 1997; WetlandInfo 2018).

1.5.4 Threatening processes

The following have been identified as potentially threatening processes to the Brush sophora:

- Loss of habitat through clearing for agriculture and development
- Timber harvesting
- Weed infestation
- Inappropriate fire regimes
- Loss of individuals from road/track works or maintenance
- Grazing by domestic stock
- Risk of local extinction because populations are small (OEH 2018).

1.5.5 Threat abatement/recovery plans

The following recovery plan s have been identified as being relevant for this species:

- Department of Environment and Energy (2010). National recovery plan for the Semi-evergreen vine thickets of the Bigalow Belt (North and South) and Nadewar Bioregions ecological community. Canberra, ACT: Australian Government. Available from: http://www.environment.gov.au/resource/national-recovery-plan-semi-evergreen-vine-thickets-brigalow-belt-north-and-south-and.

- Office of Environment and Heritage (2016), *Saving our Species Program.* Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10764. In effect under the BC Act 2016.

1.5.6 Summary of threat abatement/recovery plan

The threats outlined in the National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community include:

- Broad-scale land clearing of remnant vegetation
- Fire where SEVT is not protected by topography or substrate and where fuel characteristics have been altered by the introduction of introduced pasture grasses
- Incursion by exotic flora including Buffel grass *Pennisetum ciliare*, Green panic *Megathyrsus maximus var. pubiglumis*, Parthenium weed *Parthenium hysterophorus*, Velvet tree pear *Opuntia tomentosa*, Lantana *Lantana camara*, Rubber vine *Cryptostegia grandiflora* and Brazilian nightshade *Solanum seaforthianum*. Of these *L. camara* and *C. grandiflora* pose the most serious threat to this TEC.
- Trampling from cattle grazing opening up the understorey of SEVT habitat facilitating the incursion of invasive flora
- Invertebrate pest species including feral pigs, foxes, rabbits and cane toads impacting the vegetation structure and associated native fauna
- Coastal development where remnant vine thicket occurs on coastal beach ridges.

Threat abatement actions outlined in the National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community include:

- Identify and evaluate the extent, biodiversity value and condition of remnant and regrowth areas of this TEC in the Brigalow Belt (North and South) and Nandewar Bioregions
- Complete mapping of this TEC in New South Wales and refine mapping of remnants in Queensland
- Establish a condition assessment methodology establishing benchmark sites for each component regional ecosystem
- Determine the extent and condition of SEVT areas that have been impacted by invasive flora, particularly weeds of national significance
- Survey data deficient species within SEVT communities
- Identify key ecosystem components and processes determining their response to management actions
- Monitor selected populations of EPBC-Act listed species that occur within SEVT communities including *Cadellia pentastylis, Cossinia australiana, Denhamia parvifolia, Macropus dorsalis, Paradelma orientalis, Turnix melanogaster* and *Zieria verrucose*
- Establish a comprehensive, adequate and representative system of SEVT ecological community across the Brigalow Belt (North and South) and Nandewar Bioregions, protected by either reservations or conservation agreements (including MOU's)
- Ensure best practice management to sites containing SEVT
- Involve landholders and community members in the conservation and management of SEVT ecological communities
- Enhance the ability of government and non-government organisations at the national, regional and local level (including consent authorities) to recognise and incorporate SEVT ecological community conservation issues into all planning processes.

The *Saving our Species* conservation strategy for *Sophora fraseri* identifies five priority management sites:

- Cougal in Kyogle LGA
- Toonumbar in Kyogle LGA

- Ettrick in Kyogle LGA
- Bungabee in Lismore LGA
- Richmond Range in Kyogle LGA.

Threats identified at the management sites include:

- Loss of habitat through clearing or agriculture
- Weed infestation, especially by Lantana
- Inappropriate fire regimes
- Loss of individuals from road/track works or maintenance.

Management activities to protect *Sophora fraseri* at the *Saving our Species* sites are:

- Encourage landholders to enter into voluntary management agreement to maintain or enhance the species and its habitat
- Physical and chemical control of weeds, including splatter gun and foliar spray to control Lantana
- Track species abundance/condition over time by counting individuals and juveniles, monitoring weed densities and other potential threats (species surveys to be conducted when flowering in Spring/Summer)
- Liaise with relevant agency to incorporate species requirements into the Flora Fire Response Database and Reserve Fire Management Strategy
- Monitor species recruitment and adult condition post fire event
- Install green posts to indicate locations of sensitive threatened species to reduce impacts of slashing and track maintenance and monitor for evidence of disturbance.

1.5.7 References

Atlas of Living Australia (2018). *Sophora fraseri.* Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2909150#overview [Accessed 30 August 2018].

Barker, M. and Borsboom, A. (1997). *Sophora fraseri* Species Management Profile. Department of Environment and Resource Management.

Briggs, JD and Leigh, JH (1995), Rare or Threatened Australian Plants 1995 rev. edn, Collingwood, CSIRO Publishing.

Harden, G.J. (2002). '*Sophora*', **In:** Harden GJ (Ed.) *Flora of New South Wales*, vol. 2, University of New South Wales Press, Sydney.

Office of Environment and Heritage, NSW (2018). Brush sophora. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10764 [Accessed 21 August 2018].

Scott E. (2016). *Sophora fraseri* (Image) [Online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2909150# [Accessed 30 August 2018].

Stanley, T.D. and Ross, E.M. (1983). *Flora of southeastern Queensland*, vol. 1, Queensland Department of Primary Industries, Brisbane.

WetlandInfo, Department of Environment and Science, Queensland (2018). *Sophora fraseri.* [Online] Available from: https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/species/?sophora-fraseri [Accessed 30 August 2018].

1.6 Bunya Mountains bluegrass (*Bothriochloa bunyensis*)

1.6.1 Status

EPBC Act – Vulnerable

1.6.2 Biology and ecology

1.6.2.1 Characteristic

Bunya Mountains bluegrass (*Bothriochloa bunyensis*) is an erect or geniculately (bent abruptly), ascending perennial to 60 cm tall without lateral branches. Leaf-blades are 6 to 12 cm long with scaberulous margins and acuminate apex (refer Figure 1.11). The inflorescence consists of 2 to 4 digitate racemes. The spikelets are in pairs with the fertile spikelet sessile. Bunya Mountains bluegrass has the largest spikelets (8 to 9 mm long) and companion spikelets (12 to 13 mm long) of the genus (Sharp and Simon 2002).



Figure 1.11 **Bunya Mountains bluegrass (Bothriochloa bunyensis)**

Source: Simon (1982), drawn by Margaret Saul cited in Ausgrass (2015)

1.6.2.2 Known distribution

Bunya Mountains bluegrass is endemic to southeast Queensland where populations occur on Bunya Mountains north of Dalby, near Toowoomba, Crows Nest and the Main Range (Mt Mistake Plateau) (refer Figure 1.12).



Figure 1.12 **Distribution range of Bunya Mountains bluegrass**

Source: ALA (2018)

1.6.2.3 Distribution in relation to the project

This species was not identified during any Project-associated field surveys or for the nearby TSRC Project. Database records (i.e. AoLA & WildNet) indicate this species occurs within the MNES study area at Blue Mountain Heights dated 2004 (2.2 km from aboveground disturbance associated with the Project). The next closest record occurs 5 km to the south in Toowoomba dated 2005. Other records from within a 50 km buffer of the Project footprint occur in the Lockyer Forest Reserves (1985) to the north (10km north of the Project) and at Main Range National Park over 35 km to the south-east (refer Figure 1.13). Other records outside of a 50 km buffer of the disturbance footprint occur at Bunya Mountains National Park.

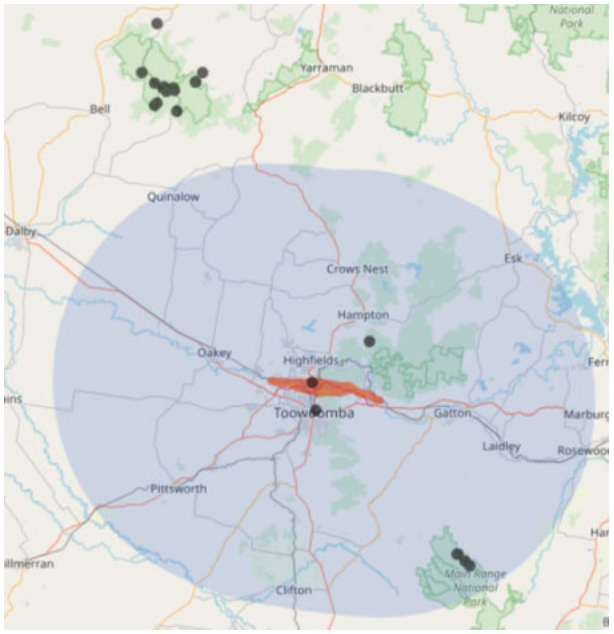


Figure 1.13 **Distribution range of the Bunya Mountains bluegrass in relation to the Project**

Source: ALA (2020)

1.6.2.4 Biology and reproduction

Leaf-blades are 6 to 12 cm long with scaberulous margins and acuminate apex. The inflorescence consists of 2 to 4 digitate racemes. The spikelets are in pairs with the fertile spikelet sessile (Sharp and Simon, 2002). *Bothriochloa bunyensis* has the largest spikelets (8 to 9 mm long) and companion spikelets (12 to 13 mm long) of the genus (Sharp and Simon 2002).

1.6.3 Habitat

This species is endemic to southeast Queensland, associated with fertile soils in grassland or woodland with grassy understorey. The species is endemic to southeast Queensland where populations occur on the Bunya Mountains. Bunya Mountains bluegrass occurs on relatively fertile krasnozem (dark brown) soils derived from basalt on upper slopes and hill crests at altitudes of 600 to 1,100 m, in grassland or woodland with a grassy understorey (DotEE 2018; Halford 1998).

The majority of populations are located in protected estate within the Main Range and Bunya Mountains National Parks. Bunya Mountains bluegrass occurs within the Burnett, Mary, Condamine and southeast Queensland Natural Resource Management Regions (Environmental Protection Agency 2007; Fensham and Fairfax 1996; Halford 1998).

1.6.4 Threatening processes

The following have been identified as potentially threatening processes to the Bunya Mountains bluegrass:

- Encroachment of woody open forest and rainforest species, possibly caused by changes in fire regime since European settlement
- Invasion of exotic weeds (Fensham and Fairfax 1996).

1.6.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species.

1.6.6 References

Atlas of Living Australia (2018), Distribution of *Bothriochloa bunyensis* – Bunya Mountains Bluegrass, viewed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2900237.

Ausgrass (2018), *Bothriochloa bunyensis -Austrobaileya,* viewed 24 August 2018, available http://ausgrass2.myspecies.info/content/bothriochloa-bunyensis.

Department of the Environment and Energy (2018). Bothriochloa bunyensis in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2008). Approved Conservation Advice for Bothriochloa bunyensis (Satin-top Grass). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/15961-conservation-advice.pdf. In effect under the EPBC Act from 03 July 2008

Fensham, RJ and Fairfax, RJ (1996), 'The grassy balds on the Bunya Mountains, southeastern Queensland: Floristics and conservation issues', Cunninghamia, vol. 4, no. 3, pp. 511–523.

Halford, DA (1998), Survey of Threatened Plant Species in south east Queensland Biogeographical Region, Queensland CRA/RFA Steering Committee.

Sharp, D and Simon, BK (2002), AusGrass: Grasses of Australia, CSIRO Publishing, Melbourne.

1.7 Four-tailed grevillea (*Grevillea quadricauda*)

1.7.1 Status

EPBC Act – Vulnerable

1.7.2 Biology and ecology

1.7.2.1 Characteristic

Grevillea quadricauda (Four-tailed grevillea) is a dense shrub growing up to 2 m high. The leaves are elliptical to oblong. There is a fine covering of hairs on both sides of the leaves, and on the stems and flowers (refer Photograph 1.6).



Photograph 1.6 Four-tailed grevillea (*Grevillea quadricauda*)

Source: Bennett (2017)

1.7.2.2 Known distribution

Grevillea quadricauda occurs in northeast NSW and near Toowoomba, in southeast Queensland. In Queensland, the species has been recorded from Helidon Hills, in the Murphy's Creek area, near Toowoomba. The species occurs in the Northern Rivers (NSW) and Condamine (Queensland) Natural Resource Management regions (refer Figure 1.14).

The distribution of this species overlaps with the following EPBC Act-listed White Box-Yellow Box Blakely's Red Gum Grassy Woodland and Derived Native Grassland threatened ecological community (ALA 2018).



Figure 1.14 Distribution range of the Four-tailed grevilia

Source: ALA (2018)

1.7.2.3 Distribution in relation to the project

This species was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs or for the nearby TSRC Project. Database records indicate this species has been detected / recorded within approximately 2 km to the north of the eastern section of the disturbance footprint to the south of the Lockyer Forest Reserves area dated 2017. There are a number of records further north and east of this record within the Lockyer Forest Reserves area. Several records occur to the east of the disturbance footprint at Helidon approximately 3 km from the alignment. A cluster of records occur to the east of Toowoomba approximately 10 km south of the disturbance footprint (refer Figure 1.15).

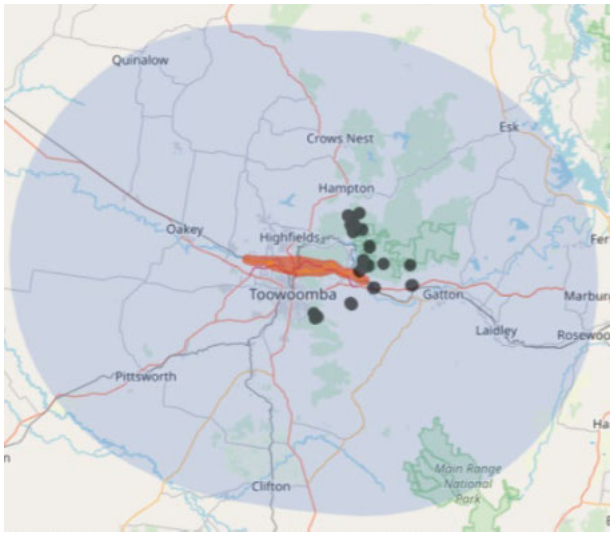


Figure 1.15 **Distribution range of Four-tailed grevilia in relation to the Project**

Source: ALA (2020)

1.7.2.4 Biology and reproduction

Flowering in this species occurs between August to September, appearing as groups of two to four pink or red flowers with green bases. New growth often appears pink or purple, especially on the tips of the leaves (DECC 2005; Makinson 2000).

1.7.3 Habitat

The species occurs on gravelly loam soils or in sandy soils. It inhabits the understorey of dry Sclerophyll forest or Eucalypt woodland, usually along creeks or drainage lines. Associated plant communities include creek line forest dominated by Turpentine (*Syncarpia glommulifera*) and Brush-box (*Lophostemon confertus*) (Makinso 2000; NSW NPWS 2005; Olde and Marriott 1995).

1.7.4 Threatening processes

The following have been identified as potentially threatening processes to the Four-tailed grevilia:

- Timber harvesting activities
- Frequent fires
- Road widening and maintenance activities
- Clearing for development and agriculture
- Invasive weeds (DECC 2005).

1.7.5 Threat abatement/recovery plan

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10375. In effect under the BC Act 2016.

No threat abatement plan has been identified as being relevant for this species.

1.7.6 Summary of threat abatement/recovery plan

The *Saving our Species* conservation strategy for *Grevillea quadricauda* identifies two priority management sites:

- Mount Belmore State Forest in Clarence Valley, Richmond Valley LGA
- Mount Neville Nature Reserve in Richmond Valley LGA
- The conservation strategy identifies too-frequent fire as the key threat to this species.

Management activities to protect this species at the sites are:

- Maintain appropriate fire regime for the species/community by liaising with neighbouring landholders to ensure planned fires are not too frequent and burning occurs under appropriate conditions
- Monitor species recruitment and adult condition post fire events
- Track species abundance and condition over time through plant counts.

1.7.7 References

Atlas of Living Australia, (2018), *Grevillea quadricauda* (Four-tailed Grevillea), accessed 24 August 2018, available: <https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2913939>.

Bennett, R. (2017). *Grevillea quadricauda*. [image] [online] Available from: https://images.ala.org.au/image/details?imageId=dd0c21bd-d124-4575-ab82-891e02b6e1e4. [13 September 2019].

Department of Environment and Climate Change (2005), Threatened species profile database, Fourtailed Grevillea – profile, viewed 11 March 2015.

Department of the Environment and Energy (2018). *Grevillea quadricauda* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts, (2008). Approved Conservation Advice for *Grevillea quadricauda* (Four-tailed Grevillea). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64651-conservation-advice.pdf. In effect under the EPBC Act from 26 March 2008.

Keith, DA (2004), Ocean shores to desert dunes, the native vegetation of New South Wales and the ACT, Department of Environment and Conservation, Hurstville.

Makinson, RO (2000), '*Proteaceae* 2 – Grevillea', Flora of Australia, vol. 17A, pp. 1-524, ABRS/CSIRO, Melbourne.

New South Wales National Parks and Wildlife Service (2005), Southern Richmond Range draft plan of management, viewed 7 December 2015.

Olde, PM and Marriott, NR (1995), The Grevillea Book, Volume 2, Kenthurst, NSW, Kangaroo Press.

Queensland Land and Resources Tribunal (2005), Hearing of applications and objections, file number AML95/03 ENO96/03, viewed 11 March 2015.

1.8 Hairy-joint grass (*Arthraxon hispidus*)

1.8.1 Status

EPBC Act – Vulnerable

1.8.2 Biology and ecology

1.8.2.1 Characteristic

Hairy-joint grass (*Arthraxon hispidus*) is a slender tufted creeping grass that roots at the nodes, with erect to semi-erect stems. The leaves are reddish to purplish, with long white hairs around the edge, broad at the base and tapering abruptly to a sharp point (refer Photograph 1.7). Flowers appear in March to July and summer to autumn. The fruit is a caryopsis (simple, dry single seeded fruit, with seed fused to the wall of the fruit and remaining closed at maturity). The seed-heads are held above the plant on a long fine stalk. Once thought to be an annual species, more recent information suggests it is a perennial that tends to die down in winter (Harden 1993; Jacobs and Wall 2007; Leigh et al. 1984; DECC NSW 2005; Queensland CRA/RFA Steering Committee 1998).



Photograph 1.7 Hairy-joint grass (*Arthraxon hispidus*)

Source: Dalgial (2015)

1.8.2.2 Known distribution

Hairy-joint grass has been recorded from scattered locations throughout Queensland and on the northern tablelands and north coast of NSW. In Queensland, the species occurs north to Port Douglas, and west to disjunct occurrences around mound springs in Carnavon National Park. However, the most common occurrences are from Noosa southwards. This species has been recorded within the Border River–Gwydir, Northern Rivers (NSW), Fitzroy, Border Rivers–Maranoa Balonne, Condamine, South East, Burnett Mary and Wet Tropics (Queensland) Natural Resource Management regions (refer Figure 1.16). It is also known to be reserved in Carnarvon Cooloola NP, Noosa NP, Carnarvon NP, and Daintree NP (Queensland CRA/RFA Steering Committee 1997; NSW Government 2005; Bostock and Holland 2007; Queensland Herbarium 2008).



Figure 1.16 **Distribution range of Hairy-joint grass**

Source: ALA (2018)

1.8.2.3 Distribution in relation to the project

This species was not identified during any Project-associated field surveys or for the nearby TSRC Project. The nearest cluster of database records (ALA 2020) are located approximately 4 km south of the disturbance footprint (refer Figure 1.17). All of these records are located within Toowoomba city. Recent records are associated with parkland areas. There are no other records within 50 km of the Project.



Figure 1.17 **Distribution range of Hairy-joint grass in relation to the Project**

Source: ALA (2020)

1.8.2.4 Biology and reproduction

Fertile material of Hairy-joint grass has been collected from March to May, and July. The species has been reported as flowering during summer-autumn. Hairy-joint grass was once considered an annual, but is now thought to be a perennial that tends to die down in winter (DECC NSW 2005; Harden 1993; Queensland CRA/RFA Steering Committee 1998; Queensland Herbarium 2011).

1.8.3 Habitat

Hairy-joint grass is found in or on the edges of rainforest and in wet Eucalypt forest, often near creeks or swamps, as well as woodland. The species has been recorded growing around freshwater springs on coastal foreshore dunes, in shaded small gullies, on creek banks, and on sandy alluvium in creek beds in open forests. It has also been recorded with bog mosses in mound springs (Queensland CRA/RFA Steering Committee 1997; 1998; Queensland Herbarium 2008; DECC NSW 2005).

1.8.4 Threatening processes

The following have been identified as potentially threatening processes to the Hairy-joint grass:

- Trampling and over grazing by stock (Queensland Herbarium 2008)
- Clearing for agriculture and development (Leigh et al. 1984)
- Inappropriate fire regimes
- Competition from introduced grasses (DECC NSW 2005; DEE 2018).

1.8.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10066. In effect under the BC Act 2016.

No threat abatement plan has been identified as being relevant for this species.

1.8.6 Summary of threat abatement/recovery plan

Arthraxon hispidus is assigned as a keep-watch species under the NSW *Saving our Species Program* as it is widespread with many small populations across NSW. State wide conservation actions identified for this species include:

- Educate the public on *Arthraxon hispidus*, particularly landowners adjacent to areas of known occurrence
- Reserve Fire Management Strategy to include operational guidelines to protect this species from fire
- Develop and implement site management plans for some of the known populations
- Establish monitoring sites to determine trends in habitat condition and population size
- Maintain populations ex situ at suitable botanic gardens, regional gardens or nurseries
- Map extent of known populations and survey areas of potential habitat near known occurrences for additional populations
- Assess weed threats to populations, manage as necessary. Implement Bitou bush control as described in the approved TAP
- Control feral animals in known habitat for this species.

1.8.7 References

Atlas of Living Australia, (2018), Distribution of Hairy-joint grass, accessed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2902385.

Batianoff, GN and Franks, AJ (1998), 'Environmental weed invasions on the southeast Queensland Foredunes

Bostock, PD and Holland, AE (2007), Census of the Queensland Flora, Queensland Herbarium, Brisbane.

Briggs, JD and Leigh, JH (1996), Rare or Threatened Australian Plants, 1995 revised edition, CSIRO Publishing, Collingwood.

Dalgial. (2015). Hairy-joint grass (*Arthraxon hispidus*). [image] [online] Available from: https://biocache.ala.org.au/occurrences/43d70452-9eee-4b0e-9310-c434a5179f85. [16 September 2019].

Department of Environment and Climate Change NSW (2005), Hairy Jointgrass profile, viewed 24 August 2018, available <http://threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10066>

Harden, GJ (Ed) (1993), Flora of New South Wales, Volume Four, University of NSW Press, Kensington.

Jacobs, SWL and Wall, CA (2007), Arthraxon hispidus (Thunb.) Makino, In: PlantNET - The Plant Information Network System of Botanic Gardens Trust, Sydney, Australia (1999-2007), viewed 23 December 2015, http://plantnet.rbgsyd.nsw.gov.au

Leigh, J, Boden, R and Briggs, J (1984), Extinct and Endangered Plants of Australia, Macmillan, Melbourne.

NSW Government (2005), BioNet, viewed 23 December 2015, <www.bionet.nsw.gov.au>.

Office of the Environment and Heritage, (2015a), Threatened Species Website, image of: *Arthraxon hispidus* - Hairy-joint grass, accessed 23 August 2018, available https://images.ala.org.au/image/viewer?imageId=3c1642c2-522e-495d-95cc-f8f60a4f2f9a.

Office of the Environment and Heritage, (2015b), Threatened Species Website, image of: *Arthraxon hispidus* - Hairy-joint grass, accessed 23 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2902385#gallery.

Queensland CRA/RFA Steering Committee (1997), Forest taxa at risk, threats, conservation needs and recovery planning in southeast Queensland, Queensland Government and Commonwealth of Australia.

Queensland CRA/RFA Steering Committee (1998), Survey of Threatened Plant Species in South East Queensland Biogeographical Region, Queensland Government and Commonwealth of Australia.

Queensland Herbarium (2008), HERBRECS, Queensland Herbarium, Brisbane.

1.9 Hawkweed (*Picris evae*)

1.9.1 Status

EPBC Act – Vulnerable

1.9.2 Biology and ecology

1.9.2.1 Characteristic

Hawkweed (*Picris evae*) is a soft-stemmed annual plant, up to 130 cm tall with most of the leaves growing around the base of the plant. The leaves are sometimes toothed, have a pointed tip, and are sparsely hairy with split-end hairs (the hairs divided into two for half their length). Leaves are 2.5 to 15 cm long and 4 to 30 mm wide. The small, yellow flowers grow in dense heads 8 to 10 mm wide at the ends of the stems (OEH 2018) (refer Photograph 1.8).



Photograph 1.8 Hawkweed (*Picris evae*)

Source: Bennett (2019)

1.9.2.2 Known distribution

Hawkweed is known to occur in the areas of northern NSW (e.g. Inverell, Elsmore, Tamworth) and the Darling Downs and Moreton pastoral districts in southeast Queensland (Bostock and Holland 2007) (refer Figure 1.18).



Figure 1.18 Distribution range of the Hawkweed

Source: ALA (2018)

1.9.2.3 Distribution in relation to the project

Picris evae was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs, but has been recorded in the area for surveys carried out for the nearby TSRC Project. The location of these records cannot be ascertained at this time due to probity issues associated with the project. This species has been recorded between 2008 to 2019 within the MNES study area to the north and south of the disturbance footprint near Cranley to the north of Toowoomba. The nearest record is recent from 2019 and is located 550 m to the north of the disturbance footprint east of the Wetalla Water Reclamation Facility. The record occurs between Gowrie Creek and Goombungee Road. Another record is from 2010 and occurs 800 m east of the disturbance footprint at Goombungee Road. Several records occur nearby and are all within 1 km of the Project disturbance footprint and are all recent. A record from 2015 occurs near Gowrie Mountain approximately 3 km south-west of the western section of the alignment. The nearest record outside of the MNES study area occurs at Toowoomba approximately 7.5 km south of the Project and is dated from 2001. Other records within a 50 km radius of the Project are scattered occurring to the north-west near to New Acland Coal Mine through to the south of Toowoomba with only one record to the north-east at Mount Hallen (refer Figure 1.19).

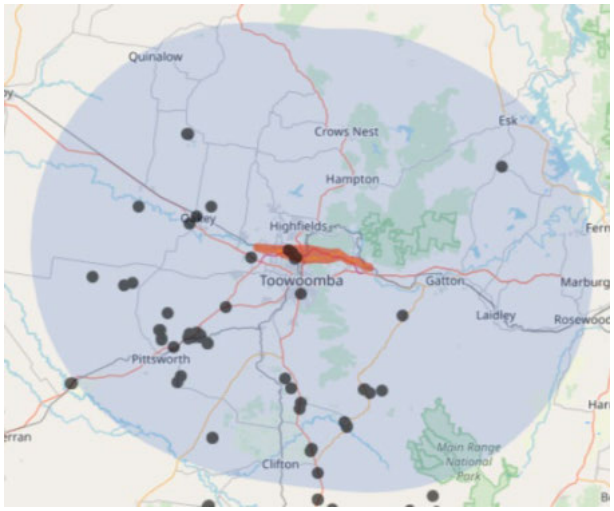


Figure 1.19 **Distribution range of Hawkweed in relation to the Project**

Source: ALA (2020)

1.9.2.4 Biology and reproduction

The flowering and fruiting period occurs during October to January and sometimes until May (OEH 2017).

1.9.3 Habitat

Hawkweed typically occurs in Eucalypt open woodlands, with grassy understories characteristically represented by *Dichanthium* spp. Upper stratum species include *Eucalyptus melliodora*, *E. crebra*, *E. populnea*, *E. albens*, *Angophora subvelutina*, *Allocasuarina torulosa*, and *Casuarina cunninghamiana*. This species has been collected along roadsides, and in cultivated areas (i.e. paddocks), on black, dark grey or red-brown soils, reddish clay-loam or medium clay soils (Holzapfel 1994; TSSC 2008).

1.9.4 Threatening processes

The following have been identified as potentially threatening processes to Hawkweed:

- Weed invasion
- Inappropriate fire regimes
- Habitat fragmentation
- Clearing of vegetation for cropping and grazing (DECC 2005).

1.9.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), Saving our Species Programme. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10627. In effect under the BC Act 2016.
- Department of Environment, Climate Change and Water NSW (2010). *National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Department of Environment, Climate Change and Water NSW, Sydney. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/white-box-yellow-box-blakelys-red-gum-grassy-woodland-and-derived-native-grassland-national In effect under the EPBC Act from 22-Mar-2013.

No threat abatement plan has been identified as being relevant for this species.

1.9.6 Summary of threat abatement/recovery plan

The *Save our Species* conservation strategy for *Picris evae* identifies two priority management sites:

- Myall Creek in Inverell LGA
- Barayamal in Inverell LGA.

Threats identified at the management sites include:

- Clearing of habitat for cropping and grazing
- Accidentally and illegally lit fires
- Accidental damage during road maintenance activities
- Invasion of habitat by introduced weeds.

Management activities to protect this species at the *Save our Species* sites include:

- Minimise impacts and incidences of clearing by providing advice to local council in order to inform planning decisions and environmental assessment
- Reduce the risk of adverse fire at the site by liasing with private landholders and local Bushfire Committee to educate on appropriate time to burn and encourage the building of fire breaks and slashing on road-edge to reduce likelihood of accidental igition of the site
- Reduce and maintain weed densities at low levels by slashing and poisoning, spot spraying.

Threats identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Land use and management change
- Agricultural and horticultural development
- Public Infrastructure upgrades in travelling stock routes (TSRs)
- Firewood collection and ‘tidying up’
- Changed fire regimes
- Increase in soil nutrients and use of chemicals
- Mowing and slashing regimes
- Revegetation management
- Weed invasion
- Climate change
- Salinity

- Acid soils
- Declining tree health and regeneration
- Increased grazing pressure from invasive herbivores
- Disease – *Phytophthora cinnamomi*
- Collection and removal of native flora.

Recovery actions identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Collect baseline data on the locations, quality and management regimes of remnant sites
- Extent and condition mapping
- Component species surveys
- Protection of existing habitat in priority areas including on private land
- Engagement with the community, particularly where remnants occur on private land to provide information on appropriate management and with Aboriginal communities.

Summary of baseline information actions undertaken to date:

- The establishment of databases comprising of information on CMN members (land managers with Box-Gum Grassy Woodland remnants), remnant locations, composition of flora and fauna species and remnant condition from surveys of CMN members' sites and other sites
- Minimum condition criteria and assessment method developed to assist land managers in identification of listed ecological communities
- Development of regional models using remote sensing
- Mapping of Box-Gum Grassy Woodland extent
- Surveys conducted during research programs through various organisations.

1.9.7 References

Atlas of Living Australia (2018). *Picris evae*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2887141 [Accessed 27 August 2018].

Bennet, M. (2019). Hawkweed (Picris evae). [Image] [Online] Available from: https://images.ala.org.au/image/details?imageId=cb7b2387-d111-4637-92da-edb043bb98e8. [19 September 2019].

Bostock, PD and Holland, AE (2007). *Census of Queensland flora*, CD-ROM, Queensland Herbarium, Brisbane.

Department of Environment and Climate Change NSW (2005). *Hawkweed – Profile*. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10627 [Accessed 27 August 2018].

Holzapfel, S (1994). A revision of the genus *Picris* (Asteraceae, Lactuceae) s.l. in *Australia, Willdenowia*, vol. 24, pp. 97-218.

Office of Environment and Heritage (2018). Hawkweed. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10627 [Accessed 27 August 2018].

Sharp, D. (nd). Queensland Herbarium, Department of Science, Information Technology and Innovation (DSITI), Queensland Government.

Threatened Species Scientific Committee (2008). *Approved Conservation Advice for Picris evae (Hawkweed)* Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10839-conservation-advice.pdf [Accessed 27 August 2018].

1.10 King blue-grass (*Dichanthium queenslandicum*)

1.10.1 Status

EPBC Act – Endangered

1.10.2 Biology and ecology

1.10.2.1 Characteristic

King blue-grass (*Dichanthium queenslandicum*) is a perennial grass growing to 80 cm tall. Its culms are solitary or rarely branched, erect, glabrous, smooth with a single groove, 4 to 5-noded with nodes prominently hairy (no image available). Leaf sheaths are hirsute with the hairs arising from wart-like projections. Inflorescences are single racemes of paired spikelets to 10 cm long. Sessile spikelets are bisexual, dorsally compressed, and straw-coloured to pale mauve. Pedicelled spikelets are male and straw-coloured to pale mauve (DotEE 2018; Sharp and Simon 2002).

1.10.2.2 Known distribution

King blue-grass is endemic to central and southern Queensland where it occurs in three disjunct populations; Hughenden district; Nebo to Monto and west to Clermont and Rolleston; and Dalby district, Darling Downs. The extent of the species occurrence is thought to be reduced from 1,100 km^2 to 245 km^2 (Accad et al. 2008; DotEE 2018).

King blue-grass occurs within the southeast Queensland, Brigalow Belt South, Brigalow Belt North, Central Mackay Coast, Desert Uplands, Mitchell Grass Downs and Einasleigh Uplands Bioregions; and the southeast Queensland, Condamine, Border Rivers Maranoa Balonne, Burnett Mary, Fitzroy, Burdekin, Mackay Whitsunday, Southern Gulf and Desert Channels Natural Resource Management regions (DotEE 2018) (refer Figure 1.20).



Figure 1.20 **Distribution range of King blue-grass**

Source: ALA (2018)

1.10.2.3 Distribution in relation to the project

King blue-grass was not identified during any Project-associated field surveys or for the nearby TSRC Project. There are no database records (AoLA) within or near the MNES study area. The nearest records from within a 50 km buffer of the alignment occur to the south-west at Pittsworth (30 km from the Project) and to the north-west between Oakey and Dalby (35 km from the Project) (refer Figure 1.21).

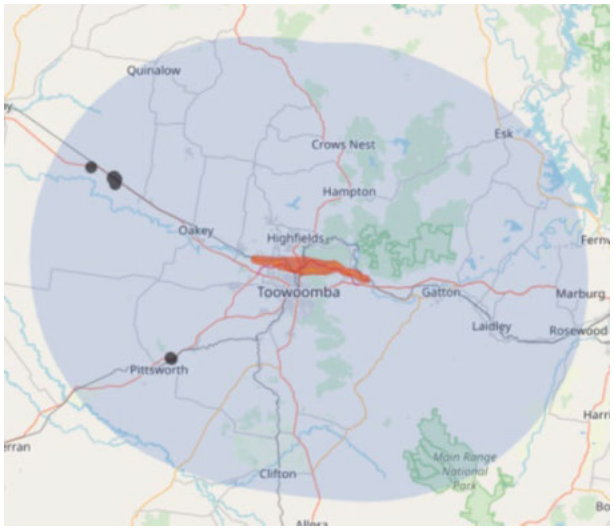


Figure 1.21 **Distribution range of King blue-grass in relation to the Project**

Source: ALA (2020)

1.10.2.4 Biology and reproduction

The species has been recorded with flowers throughout the year, however are more prevalent from March. Sessille spikelet is bisexual, dorsally compressed and straw-coloured to pale mauve. Pedicelled spikelets are male, straw-coloured to pale mauve (DEE 2018; Sharp and Simon 2002; Queensland Herbarium 2012).

1.10.3 Habitat

King blue-grass is endemic to central and southern Queensland. This species occurs on black cracking clay in tussock grasslands mainly in association with other species of Blue grasses (*Dichanthium* spp. and *Bothriochloa* spp.*)* but also with other grasses restricted to this soil type. It is mostly confined to natural bluegrass grasslands of central and southern Queensland, including the endangered EPBC ecological communities: Natural Grasslands of the Queensland Central Highlands and the northern Fitzroy Basin, and Natural Grasslands on Basalt and Fine-textured Alluvial Plains of northern NSW and southern Queensland. This habitat has been destroyed and greatly fragmented by cultivation (DotEE 2018; Fletcher 2001; Simon 1982).

1.10.4 Threatening processes

The following have been identified as potentially threatening processes to the King blue-grass:

- Loss of habit through agricultural and mining activities, road construction and other infrastructure developments
- Pastoral land and association activities
- Invasion from weeds (Butler 2007; Fensham 1999).

1.10.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species (DoEE 2018).

The following threat abatement plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2016). *Threat abatement plan for competition and land degradation by rabbits*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.

1.10.6 Summary of threat abatement/Recovery plans

Threats identified in the threat abatement plan for competition and land degradation by rabbits includes:

- Competition with native wildlife for food and shelter
- Prevention of plant regeneration
- Increased grazing pressure and damage to native vegetation
- Altering the regular process of plant succession
- Altering ecological communities and impacting soil structure and nutrient cycling contributing to serious erosion
- Increasing predation and reducing reproduction for native arboreal mammals and birds through the removal of critical habitat.

Threat abatement actions for rabbits include:

- Supress rabbit populations at the landscape scale below thresholds in identified priority areas
- Gain a better understanding of the impacts rabbits have and their interactions with other species and ecological processes
- Increase the effectiveness of rabbit control programs
- Increase engagement within the local community to provide awareness of the environmental impact of rabbits and the need for integrated control.

1.10.7 References

Accad A, Neldner VJ, Wilson B and Niehus RE (2008), Remnant vegetation in Queensland: analysis of remnant vegetation 1997–1999–2000–2001–2003–2005, including regional ecosystem information. Queensland Herbarium, Environmental Protection Agency, Brisbane.

Atlas of Living Australia (2018), *Dichanthium queenslandicum*. Australia's species Database. Viewed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2901362.

Ausgrass2, (2018), *Dichanthium queenslandicum*, viewed 24 August 2018, available: http://ausgrass2.myspecies.info/content/dichanthium-queenslandicum.

Butler DW (2007), Draft recovery plan for the 'Bluegrass (*Dichanthium* spp.) dominant grassland of the Brigalow Belt Bioregions (north and south)' endangered ecological community, 2007–2011. Report to Department of the Environment and Heritage, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Department of the Environment and Energy (2018). *Dichanthium queenslandicum* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of Sustainability, Environment, Water, Population and Communities (2013). Approved Conservation Advice for *Dichanthium queenslandicum* (king blue-grass). Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/5481-conservation-advice.pdf. In effect under the EPBC Act from 26 February 2013

Fensham RJ (1999), Native grasslands of the Central Highlands, Queensland, Australia. Floristics, regional context and conservation. Rangeland Journal 21: 82–103.

Fletcher M (2001), Rare and threatened plants of the Central Highlands. Queensland Parks and Wildlife Service, Emerald.

Sharp D and Simon BK (2002), AusGrass: Grasses of Australia. CD-ROM, Version 1.0 (Australian Biological Resources Study, Canberra, and Environmental Protection Agency, Queensland)

Simon BK (1982), New species of Gramineae from southeastern Queensland. Austrobaileya 1: 455–467.

1.11 Leionema (*Leionema obtusifolium*)

1.11.1 Status

EPBC Act – Vulnerable

1.11.2 Biology and ecology

1.11.2.1 Characteristic

Leionema (*Leionema obtusifolium*) is a shrub growing to approximately 1 m high. The species branchlets are hairless, glossy, minutely glandular-warty and often reddish, with prominent acute angles. Leaves are without stalks, papery, narrowly oval-shaped to spoon-shaped, 25 to 55 mm long, 3 to 6 mm wide, smooth, glossy, and hairless. The apex is obtuse to rounded, the base narrow wedge-shaped, the margin slightly curved downwards, the midrib impressed above and prominent below. Flowers are in flat-topped inflorescences of 10 to 20 flowers at the ends of branches (refer Photograph 1.9). The calyx is hemispherical, glossy and hairless, with broadly triangular lobes 0.25 mm long. The petals are about 4 mm long, gland-dotted, yellowish-white (Wilson 1970).



Photograph 1.9 Leionema (*Leionema obtusifolium*)

Source: Bennett (2016)

1.11.2.2 Known distribution

Leionema is known to occur in a small area of southeast Queensland, in the Helidon and Ravensbourne areas (Stanley and Ross, 1983) (refer Figure 1.22). Collections have been made at sites near Crows Nest in the upper reaches of Alice Creek, Helidon Hills, in the 17 Mile Road area, and White Mountain State Forest, northeast of Murphys Creek. The species is reserved in Crows Nest National Park and White Mountain State Forest under forest reserve tenure (BRI collection records n.d.; QLD EPA 2007 as in DEWHA 20018).

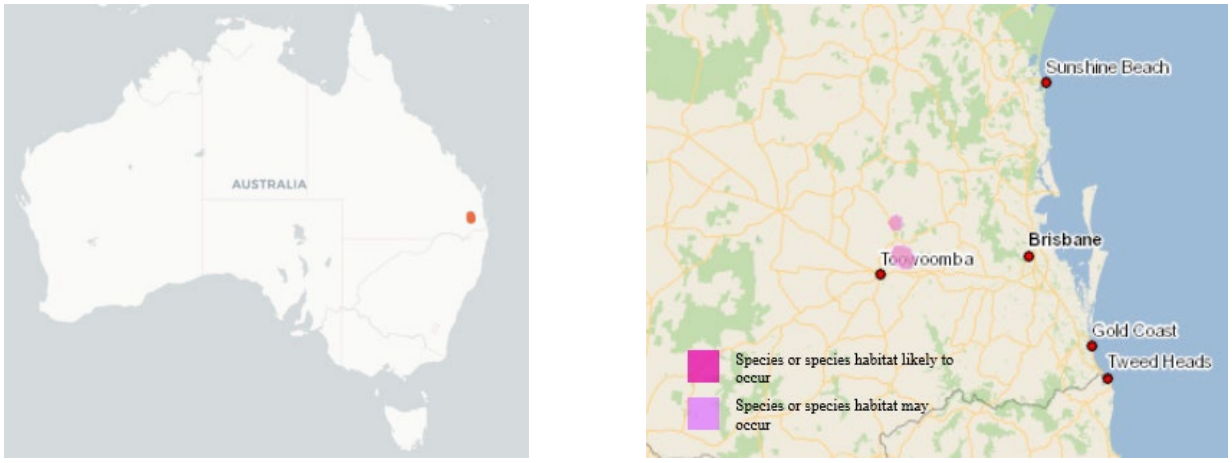


Figure 1.22 **Distribution range of Leionema**

Source: ALA (2018); DOTEE (2018)

1.11.2.3 Distribution in relation to the project

Leionema obtusifolium was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs or for the nearby TSRC Project. Database records (AoLA) describe two older records located approximately 2.7 km south-east of the eastern section of the MNES study area dated 1964 and 1978 in what is now cleared habitat. The majority of records for this species occur within the Lockyer Resource Reserve to the north and north-east of the eastern section of the Project (between 6 km and 12 km from the Project disturbance footprint) including old and recent records dated 1970 to 2016. The nearest recent record (2016) is located 6.5 km north-east of the Project. The closest record is from 1989 and located 6.1 km from the Project. A single record from 1963 is located 5.5 km south of the eastern extent of the alignment, although this record has a high degree of spatial uncertainty. Another group of records exist at Crows Nest located approximately 30 km north of the Project (refer Figure 1.23).

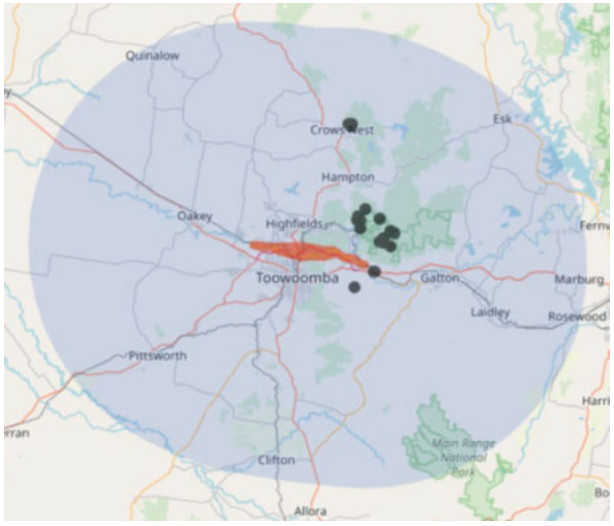


Figure 1.23 **Distribution range of Leionema in relation to the Project**

1.11.2.4 Biology and reproduction

Little is known about the biology and reproduction of Leionema, apart from the species is known to flower in spring (Stanley and Ross 1983).

1.11.3 Habitat

Leionema is known to inhabit eucalypt forest, often with White mahogany (*Eucalyptus acmenoides*) and Brown bloodwood (*Corymbia trachyphloia*), on sandstone substrates in the Helidon Hills and White Mountain State Forest areas, and on granite at Crows Nest National Park (BRI collection records n.d.).

1.11.4 Threatening processes

The following have been identified as potentially threatening processes to the Leionema:

- Habitat loss due to fragmentation, clearing and forest operations
- Inappropriate fire regimes
- Grazing pressures (Boyes 2004).

1.11.5 Threat abatement/recovery plan

No threat abatement/recovery plan has been identified as being relevant for this species.

1.11.6 References

Atlas of Living Australia (2018), *Leionema obtusifolium* - A Leionema, accessed 25 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2900053.

Bennett, M. (2016), *Leionema obtusifolium* - A Leionema, [image] [online] Available from: https://images.ala.org.au/image/viewer?imageId=cb89f0b3-9f9e-4dca-bbed-655b912fec51. [18 September 2019]

Boyes, B. (2004), Descriptions, Habitat and Threats for the Significant Species and Ecological Communities of Gatton and Laidley Shires, Southeast Queensland, Appendix B to the Biodiversity Recovery Plan for Gatton and Laidley Shires, Southeast Queensland 2003-2008, Version 2, 5 March 2004, Lockyer Catchment Association (LCA) Inc., Forest Hill.

BRI Collection Records (n.d.), Queensland Herbarium specimens.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for Leionema obtusifolium. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/64925-conservation-advice.pdf. In effect under the EPBC Act from 16 December 2008.

Department of the Environment and Energy (2018). *Leionema obtusifolium* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Sat, 25 August 2018

Halford, D (1996), Conservation Statement and Draft Recovery Plan for *Phebalium obtusifolium* Paul G.Wilson – Rutaceae, Queensland Herbarium, Brisbane.

Stanley, TD and Ross, EM (1983), Flora of Southeastern Queensland, vol. 1, Queensland Department of Primary Industries, Brisbane.

Queensland Environmental Protection Agency (2007), Future Tenures for SEQFA reserves, viewed 30 June 2008, http://www.epa.qld.gov.au/parks_and_forests/managing_parks_and_forests/forest_transfer_processes_in_queensland/south_east_queensland_forests_agreement_seqfa/future_tenures_for_s eqfa_reserves/.

Wilson, PG (1998), 'New species and nomenclatural changes in *Phebalium* and related genera (*Rutaceae*)', Nuytsia, vol. 12, no. 2, pp. 267-288.

1.12 Queensland nut tree (*Macadamia integrifolia*)

1.12.1 Status

EPBC Act – Vulnerable

1.12.2 Biology and ecology

1.12.2.1 Characteristic

Queensland nut tree (*Macadamia integrifolia*) is a medium sized tree that grows to 20 m in height with a 20 m wide crown. This species produces cream or creamy-white flowers that have been recorded in January, March and June to November. Flowers occur on the end of 30 cm long racemes (refer Photograph 1.15). Fruit is a hard brown spherical nut encased in a green leathery outer shell with a diameter of 2 to 3 cm (DotEE 2018).



Photograph 1.10 Queensland nut tree (*Macadamia integrifolia*)

Source: McMaster (2019)

1.12.2.2 Known distribution

Queensland nut tree occurs from Mt Bauple, near Gympie, to Currumbin Valley in the Gold Coast hinterland, southeast Queensland (refer Figure 1.36). The species occurs as a scattered rare to occasional tree, and population sizes have been noted as difficult to estimate (Barry and Thomas 1994).

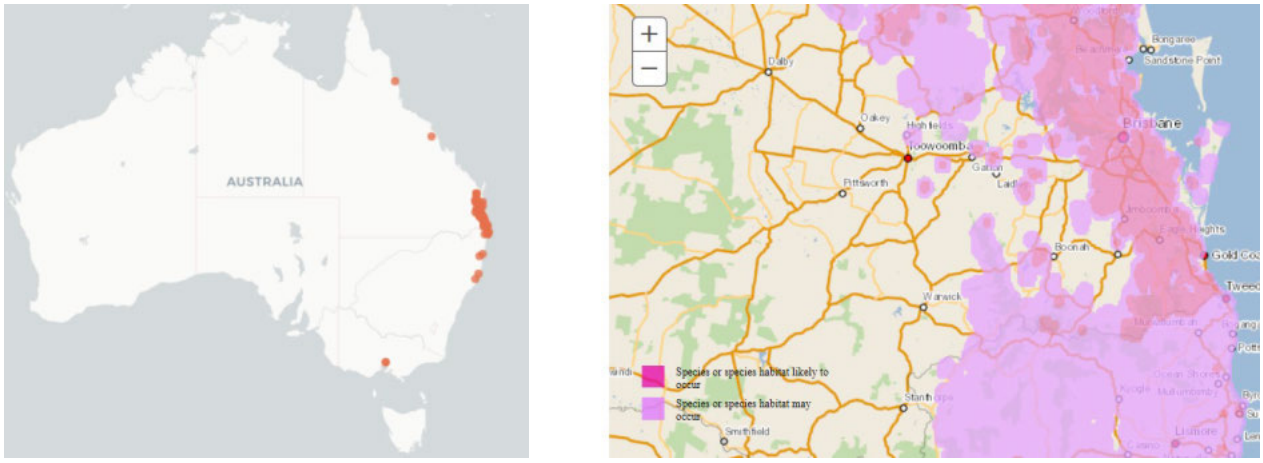


Figure 1.24 **Distribution range of Queensland nut tree**

Source: ALA (2018), DotEE (2018)

1.12.2.3 Distribution in relation to the project

Macadamia integrifolia has been predicted to occur within the ecology study area. Database records (i.e. AoLA & WildNet) indicate no records from within the disturbance footprint or the ecology study area. One record exists within a 50 km buffer of the disturbance footprint to the north-east near Eskvale from 2019. No other occurrence records exist in relation to the Project (refer **Figure 1.25**).

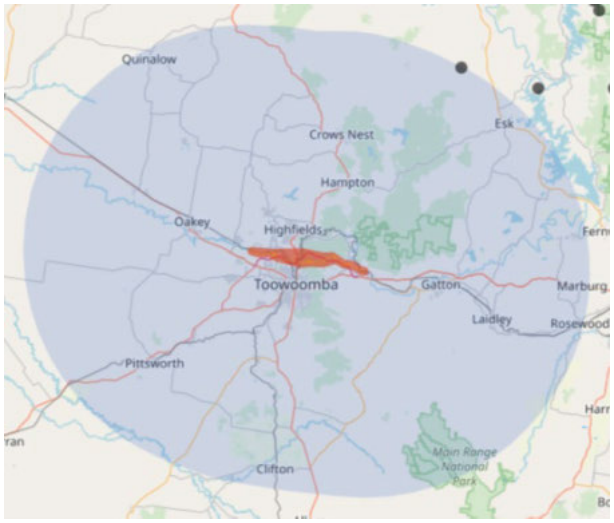


Figure 1.25 **Distribution range of Queensland nut tree in relation to the Project**

1.12.2.4 Biology and reproduction

Queensland nut tree flowers in January, March and June to November. Fruits have been recorded from November to January and March to April. Macadamia nuts begin to produce viable nut loads at around 10 years of age. Reproduction is by seed, with a seed viability of 3 to 6 months. The species has a juvenile period of over six years. The seeds are eaten by mammals and are dispersed by stream. The plant re-sprouts when damaged (DotEE 2018, DEWHA 2008).

1.12.3 Habitat

Queensland nut tree grows in remnant rainforest, including complex mixed notophyll forest, and prefers partially open areas such as rainforest edges (DEWHA 2008). This species occurs within the Northern Rivers (NSW) and southeast Queensland Natural Resource Management regions.

Queensland nut tree is known to prefer to grow in mild frost-free areas with a reasonably high rainfall. There have been records of planted specimens bearing fruit as far south as Sydney (DotEE 2018).

Vegetation communities in which the Queensland nut tree is found range from complex notophyll mixed forest, extremely tall closed forest, simple notophyll mixed very tall closed forest to simple microphyll-notophyll mixed mid-high closed forest with *Araucaria* and *Argyrodendron* emergents (DotEE 2018).

1.12.4 Threatening processes

The following have been identified as potentially threatening processes to the Queensland nut tree:

- Land clearing for urban and agricultural development (DotEE 2018).
- Inappropriate fire regimes (DotEE 2018)
- Land clearing making them more susceptible to wind damage, as well as reducing the availability of natural pollinators (DotEE 2018)
- Invasive weed species
- Compaction of the soil layer (DotEE 2018).

1.12.5 Threat abatement/recovery plans

No threat abatement plan has been identified as being relevant for this species. The following recovery plan is relevant to this species:

- Costello, G., M. Gregory & P. Donatiu (2009). Southern Macadamia Species Recovery Plan. Report to Department of the Environment, Water, Heritage and the Arts, Canberra by Horticulture Australia Limited, Sydney. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/southern-macadamia-species-recovery-plan. In effect under the EPBC Act from 13-Nov-2009 as *Macadamia integrifolia*.

1.12.6 Summary of threat abatement/recovery plans

The threats outlined in the Southern Macadamia Species Recovery Plan include:

- Land clearing, fragmentation and loss of connectivity
- Inappropriate fire regimes
- Habitat modification by weeds
- Lack of appropriate gazing regimes
- Reduce gene flow
- Climate change.

Current recovery actions include:

- Restoration of rainforest habitat for private landholders under SEQ Rainforest Recovery Project
- Designation of ecologically appropriate fire regimes under the Hotspots Fire Project
- Rebates for fencing under Australian Government funding programs to assist in managing grazing
- Studies on the genetic characterisation of macadamia species and impacts of habitat fragmentation.

Future actions proposed by the Southern Macadamia Species Recovery Plan include:

- Assist landholders in accessing resources to protect macadamia habitat on their property through grazing control, weed management and rehabilitation strategies
- Provide fire and biodiversity workshops to land managers
- Continue research on population genetics
- Model the projected impact of climate change on the ecology, distribution and habitat of southern macadamia species.

1.12.7 References

Atlas of Living Australia (2018), *Macadamia integrifolia,* accessed 24 August 2018, available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890419.

Department of the Environment and Energy (2018). *Macadamia integrifolia* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Macadamia integrifolia* (Macadamia Nut). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/7326-conservation-advice.pdf. In effect under the EPBC Act from 16 December 2008.

McMaster, I. (2019). Macadamia integrifolia. [image] [online] Available from: https://biocache.ala.org.au/occurrences/88cb72d2-8082-49f5-aeb1-1eea15566a39. [16 September 2019].

Queensland CRA/RFA Steering Committee (1997). Forest taxa at risk, threats, conservation needs and recovery planning in southeast Queensland. Queensland Government and Commonwealth of Australia.

1.13 Miniature moss-orchid (*Bulbophyllum globuliforme*)

1.13.1 Status

EPBC Act – Vulnerable

1.13.2 Biology and ecology

1.13.2.1 Characteristic

Miniature moss-orchid or Hoop pine orchid (*Bulbophyllum globuliforme*) is a tiny rhizomatous orchid that grows only on the bark of Hoop pine trees, (*Araucaria cunninghamii*), forming a dense mat. It produces green, globular, bulb-like stems 1 to 2 mm in diameter. Leaves are narrow-triangular, 1 to 2 mm long, 0.2 to 0.3 mm wide, papery and concave. The inflorescence is 1 to 1.5 cm long, bearing one flower (refer Photograph 1.11). The sepals and petals are white to pale yellow. Miniature moss-orchid flowers from September to November (Weston and Hill 1993).



Photograph 1.11 Miniature moss-orchid (*Bulbophyllujm globuliforme*)

Source: ALA (2018)

1.13.2.2 Known distribution

Endemic to eastern Australia, the species is recorded from near Paluma, northeast Queensland, south to the McPherson Range on the Queensland/NSW border (refer Figure 1.26). This species is known to occur in four locations including Puzzle Creek near Paluma (northeast Queensland), Kroombit Tops near Calliope (central Queensland), Cainbable Creek in Lamington National Park (southeast Queensland) and Levers Plateau (northeast NSW) (DotEE 2018; Jones and Clements 2001; Weston and Hill 1993).



Figure 1.26 Occurrence record of Miniature moss-orchid

Source: ALA (2018)

1.13.2.3 Distribution in relation to the project

This species was not identified during any Project-associated field surveys or for the nearby TSRC Project. There are no records close to the MNES study area (refer Figure 1.27). The nearest database records are located approximately 120 km from the Project in Lamington and Border Ranges National Parks to the south-east.

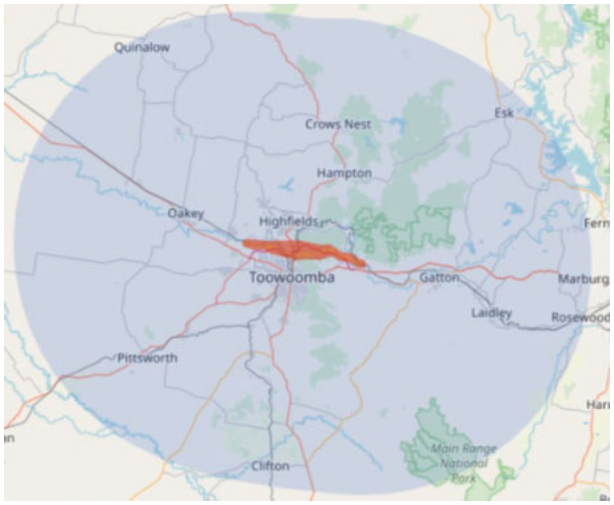


Figure 1.27 Distribution range of Miniature moss-orchid in relation to the Project

1.13.2.4 Biology and reproduction

Miniature moss-orchid flowers in May to November. The growth form of this species is unusual, as it forms mats of tiny bulbs (leaves) on the wrinkled bark of hoop pine, making it very difficult to identify in the field. Generation length is unknown however, as the plant forms colonies by rhizome growth, each clump may be very long-lived (Nicholls 1969; Weston and Hill 1993).

1.13.3 Habitat

This species has been previously recorded in the Bunya Mountains. The species grows only on Hoop pines, colonising the upper branches of mature trees in upland rainforest. Miniature moss-orchid are conserved in Noosa National Park, Lamington National Park and Bunya Mountains National Park, Queensland, and the Border Ranges National Park, NSW (Briggs and Leigh 1996; DotEE 2018; Harrison 2002).

1.13.4 Threatening processes

The following have been identified as potentially threatening processes to the Miniature moss-orchid:

- Destruction of habitat by clearing of Hoop pine host-trees
- Disturbance of habitat by timber harvesting and road works
- Inappropriate fire regimes
- Disturbance of habitat by weeds
- Damage and collection by orchid enthusiasts (Barker 1999).

1.13.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10105. In effect under the BC Act 2016.

1.13.6 Summary of threat abatement/recovery plan

Bulbophyllum globuliforme is assigned as a keep-watch species under the NSW *Saving our Species Program* as relatively large populations are known to occur within reserves where current management is sufficient to ensure their long-term security. State wide conservation actions identified for this species include:

- Assess all known sites for population condition, habitat quality and threats
- Ensure that managers are aware of populations, habitat and threats and that fire plans, pest management plans take account of requirements for the recovery of the orchid
- Ensure confidentiality is applied to information about locations of the orchid to protect against illegal collection
- Avoid damage to and lopping of Hoop Pines within the habitat and range of the orchid
- Investigate and apply appropriate method for estimating populations.

1.13.7 References

Atlas of Living Australia (2018), *Bulbophyllum globuliforme*, accessed 23 August 2018, available https://images.ala.org.au/image/viewer?imageId=050ae1de-9eb1-4f7d-926f-073d9e7ab02c.

Barker, M. (1999). *Bulbophyllum globuliforme*. Species Management Profile, Species Management Manual. Queensland Department of Natural Resources, Brisbane

Briggs, J.D. and J.H. Leigh (1996). Rare or Threatened Australian Plants - Revised Edition. Collingwood: CSIRO Publishing.

Department of the Environment and Energy (2018). *Bulbophyllum globuliforme* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Thu, 23 August 2018

Harrison, M (2002), 'Bulbophyllum species of Australia', Australian Orchid Review Dec 2001/Jan 2002, pp. 4–19.

Jones, D.L. and Clements, M.A. (2001), *Oncophyllum*, a new genus of Orchidaceae from Australia. The Orchadian. 13 (9):421-424.

Jones DL (2006), Native Orchids of Australia, including the island territories. Reed New Holland. Sydney

Nicholls WH (1969), Orchids of Australia. Nelson. Melbourne.

Stanley, T. D. and E. M. Ross (1989). Flora of southeastern Queensland. Volume Three. Brisbane: Qld Department of Primary Industries

Weston, P. H. and K. D. Hill (1993), *Bulbophyllum.* In: Harden, G.J., ed. Flora of New South Wales, Volume Four. 4. Kensington, New South Wales: University of NSW Press.

1.14 Mt. Berryman phebalium (*Phebalium distans*)

1.14.1 Status

EPBC Act – Critically Endangered

1.14.2 Biology and ecology

1.14.2.1 Characteristic

The Mt. Berryman phebalium (*Phebalium distans*) is a small tree growing to 8 m and up to 15 cm in diameter. The bark is grey mottled and distinctly rough and flaky with a strong aromatic scent (DotEE 2018). The flowers of the species are cream, and the leaves are 1.5 to 5 cm long, 2 to 10 mm wide, and more or less smooth on the upper surface (refer Photograph 1.12). The leaves have a variable shape and are usually linear to oblong or lance-shaped but may also be elliptic to broad-elliptic or egg-shaped (DotEE 2018; Forster 2003).



Photograph 1.12 Mt. Berryman phebalium (*Phebalium distans*)

Source: Simmonds (2003)

1.14.2.2 Known distribution

Mt. Berryman phebalium is endemic to southeastern Queensland, where it is currently known from ten populations at three locations. Five of the known populations are in close proximity at Mt. Berryman (Lockyer Valley Regional Council), four are near Kingaroy (South Burnett Regional Council) and the tenth at Mt Walla, near Coalstoun Lakes (North Burnett Regional Council) (DotEE 2018) (refer Figure 1.28).



Figure 1.28 **Distribution range of Mt. Berryman phebalium**

Source: ALA (2018)

1.14.2.3 Distribution in relation to the project

Phebalium distans has been predicted to occur within the ecology study area. Database records (i.e. AoLA & WildNet) indicate no records from within the disturbance footprint or the ecology study area. The nearest records occur to the south-east of the disturbance footprint near Berlin Scrub Nature Reserve with records occurring as recent as 2016. Records outside of a 50 km buffer of the disturbance footprint occur to the north at Kingaroy more than 100 km from the alignment (refer Figure 1.29).

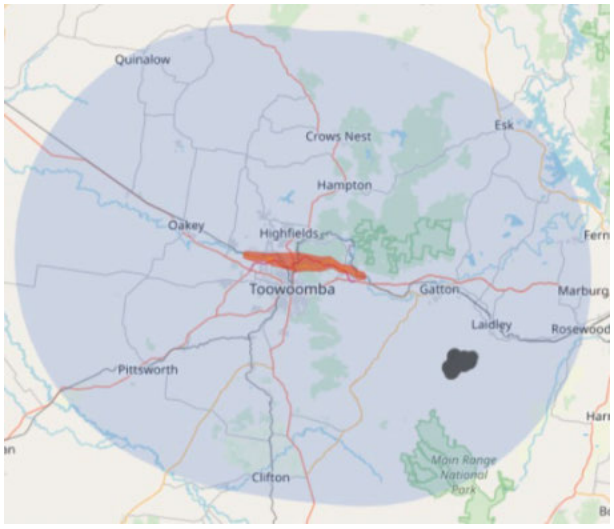


Figure 1.29 **Distribution range of Mt. Berryman phebalium in relation to the Project**

1.14.2.4 Biology and reproduction

Mt. Berryman phebalium generally flowers during spring, however, opportunistic flowering can occur at other times after moderate falls of rain. Fruiting generally occurs during late summer and early autumn. The capsular fruit produce small seeds that have a limited dispersal ability. Plants become sexually mature after they reach 1 to 2 m in height. The plant has not been recorded as reproducing vegetatively, and monitoring indicates that this species does not readily reproduce under disturbance regimes (DEWHA 2008).

1.14.3 Habitat

Mt. Berryman phebalium is found in semi-evergreen vine thicket on red volcanic soils, or in communities adjacent to this vegetation type in small groups or as solitary specimens. Soils were the species occurs range from red-brown earths to brown clays (derived from siltstone and mudstones), and lithosols to shallow, gravelly krasnozems (very dark brown loam), derived from the Main Range Volcanics of the Tertiary period (DotEE 2018; DEWHA 2008; EPA 2006; Forster 2003).

1.14.4 Threatening processes

The following have been identified as potentially threatening processes to the Mt. Berryman phebalium:

- Habitat fragmentation and clearing
- Road works and roadside maintenance
- Irregular fire events
- Weed invasion
- Drift of agricultural chemicals
- Erosion and soil compaction due to human traffic
- Dumping of rubbish (DotEE 2018).

1.14.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species (DoEE 2018).

1.14.6 References

Atlas of Living Australia (2018), *Phebalium distans.* Australia's species Database, accessed 26 August 2018, available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2908293.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Phebalium distans* (Mt. Berryman Phebalium). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/81869-conservation-advice.pdf. In effect under the EPBC Act from 24 December 2008.

Department of the Environment and Energy (2018). *Phebalium distans* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Sun, 26 August 2018

Environmental Protection Agency (2006), Regional Ecosystem Description Database (REDD Version 5.0). Brisbane: Queensland Herbarium.

Forster, P. I. (2003), '*Phebalium distans* P. I. Forst. (Rutaceae), a new and endangered species from southeastern Queensland, and reinstatement of P. longifolium S. T. Blake, Austrobaileya, vol. 6, no. 3, pp 437-444.

Simmonds, J.H. (2003). Mt. Berryman phebalium (Phebalium distans). [image] [online] Available from: https://biocache.ala.org.au/occurrences/4ab51c21-6c5a-4fe4-98b1-f56fe9301877. [16 September 2019]

1.15 Ooline (*Cadellia pentastylis*)

1.15.1 Status

EPBC Act – Vulnerable

1.15.2 Biology and ecology

1.15.2.1 Characteristic

Ooline (*Cadellia pentastylis*) is a very slow growing medium-sized tree that generally grows to 10 m high, but occasionally reaching 25 m. The species has glossy leaves with prominent venation that grow to 2 to 4 cm long, 1.5 to 2 cm wide and with broadly rounded tips (refer Photograph 1.13). The upper sides of the leaves are darker and glossier than the undersides. The white flowers are small and usually single. Each flower produces a cluster of up to five rounded, brown berries, 3 to 5 mm wide (OEH 2017).



Photograph 1.13 Ooline (*Cadellia pentastylis*)

Source: McMaster (2008)

1.15.2.2 Known distribution

Ooline occurs on the northwest slopes of NSW and in central and southern Queensland (refer Figure 1.30). The species occurs between 23° S to 30° S within the 500 mm and 750 mm rainfall isohyets. In Queensland, Ooline occurs from Balcomba (west of Rockhampton) south to the NSW border and west to near Blackall. In NSW, Ooline occurs in an area bounded by Gunnedah, Tenterfield and the Queensland border (ALA 2018; Leigh and Briggs 1992).

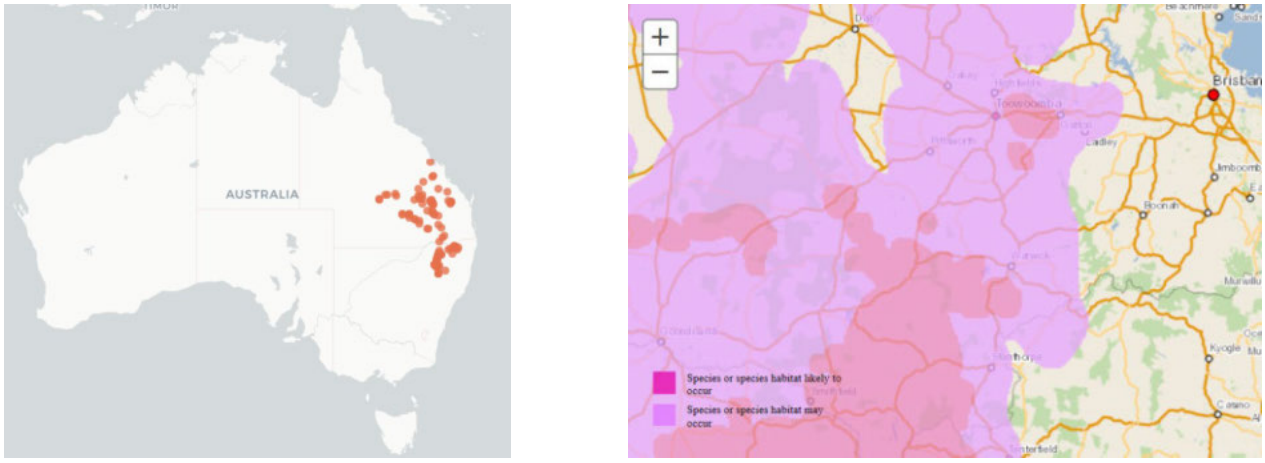


Figure 1.30 Distribution range of Ooline

Source: ALA (2018), DotEE (2018)

1.15.2.3 Distribution in relation to the project

Cadellia pentastylis has been predicted to occur within the ecology study area. Database records (i.e. AoLA & WildNet) indicate no records from within the disturbance footprint, the ecology study area or from with a 50 km buffer of the disturbance footprint. The nearest records occur to the south, south-west and west of the Project from Tenterfield to Miles however all of these records are more than 100 km from the disturbance footprint (refer Figure 1.31).



Figure 1.31 **Distribution range of Ooline in relation to the Project**

1.15.2.4 Biology and reproduction

Ooline flowers sporadically. In NSW, flowering events occur in spring and summer and, in Queensland, flowering events occur in spring through to autumn. Fruits are borne in November to December and seed dispersal is probably via passive fall or birds. Seeds have shown a high rate of infertility at all sites. Fire germination is known to occur and vegetative growth has been noted as being very common. Ooline also has the capacity to re-sprout from rootstock and coppice vigorously from stumps. (Benson 1993; Harden 1991; QDNR 2000).

1.15.3 Habitat

Ooline grows in semi-evergreen vine thickets and sclerophyll vegetation on undulating terrain of various geology, including sandstone, conglomerate and claystone (Harden 1991). Soils generally have low to medium nutrient content and are normally associated with upper and mid-slopes in the landscape. The altitude is generally 300 to 460 m above sea level, with some stands known to occur at 600 m above sea level. Ooline has also been found in semi-evergreen vine thickets, pure stands and Brigalow-Belah communities (Benson 1993; Harden 1991).

1.15.4 Threatening processes

The following have been identified as potentially threatening processes to Ooline:

- Fragmentation and vegetation clearing
- Logging of tree species, such as Callitris, within habitat may have affected the microclimate in the understorey of the forest
- Inbreeding depression
- Inappropriate fire regimes
- Intensive grazing (i.e. where stocking is high, seedling recruitment is likely to be hampered due to grazing and soil compaction)
- Risk of local extinction due to small, scattered populations
- Tunnel and sheet erosion
- Low seed viability
- Damage to roadside populations during roadworks (OEH 2017).

1.15.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10118. In effect under the BC Act 2016.

The following threat abatement plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2017). *Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs* (Sus scrofa) (2017). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017. In effect under the EPBC Act from 18-Mar-2017.

1.15.6 Summary of threat abatement/recovery plan

Cadellia pentastylis is assigned as a keep-watch species under the NSW *Saving our Species Program* as relatively large populations are known to occur within reserves (Kaputar National Park and Gamillaroi Nature Reserve) where current management is sufficient to ensure their long-term security. State wide conservation actions identified for this species include:

- Identify a minimum of 3 sites for implementation of recovery actions and monitoring. The Tenterfield Creek population is of particular interest for investigated
- Establish a comprehensive monitoring program to determine the effectiveness of recovery actions
- Control feral goats in areas of known and potential habitat
- Erect signage and fence off roadside remnants to protect from damage and disturbance from road works and traffic
- Liaise with landholders where the species occurs on private property to discuss issues, management actions and fencing
- Restrict areas of habitat with fencing to protect from stock and feral animal grazing
- Improve knowledge and understanding of the species' ecology by conducting research into population dynamics, genetic variation and establishment & recruitment of new individuals
- Ensure the Threatened Species Hazard Reduction List is updated with the requirements of this species and that personnel undertaking burns are educated on its presence and fire sensitivity
- Provide advice and assistance for the removal of weed species within Ooline habitat such as Tiger Pear
- Review / include operational guidelines for Mt Kaputar NP and Gamilaroi NR Reserve Fire Management Strategies to protect this species from fire.

The threats outlined in the threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) include:

- Impacts on plant species composition and succession
- Alterations to nutrient, water cycling and water quality
- Predation of native fauna and flora including small mammals, birds, reptiles, frogs, crayfish, eggs, invertebrates, fungi and all part of plants including fruit, seeds, roots, tubers, bulbs and foliage
- Digging and disturbance to substrate resulting in the destruction of plants threatening their survival and recruitment of new plants altering the floral composition and soil structure
- Disturbance caused by pigs can increase the incursion and recruitment of weeds and provide reservoirs for endemic animal diseases.

Threat abatement actions for feral pics (*Sus scrofa*) include:

- Implementation of control measures including trapping, aerial and ground shooting, poisoning and fencing

- Using tracking dogs to detect and flush out feral pigs by commercial harvesters
- Manipulating habitat by reducing watering points and crop waste
- Manage feral pigs within a policy, legislative and planning framework.

1.15.7 References

Atlas of Living Australia (2018). *Cadellia pentastylis*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2912802# [Accessed 28 August 2018].

Benson, J.S. (1993). The biology and management of Ooline (*Cadelia pentastylis*) in NSW. *Species Management Report No. 2*. Hurstville: NSW NPWS.

Harden, G.J. (ed.) (1991*). Flora of New South Wales, Volume Two*. Kensington, NSW: University of NSW Press.

McMaster, I. (2008). *Cadellia pentastylis*. [image] [online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2912802# [28 August 2018].

Office of Environment and Heritage (2018). *Ooline - Profile*. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10118 [Accessed 28 August 2018].

Queensland Department of Natural Resources (2000). *Species Management Manual*. Forest and Fauna Conservation and Ecology Section, Queensland Department of Natural Resources.

1.16 *Paspalidium grandispiculatum*

1.16.1 Status

EPBC Act – Vulnerable

1.16.2 Biology and ecology

1.16.2.1 Characteristic

Paspalidium grandispiculatum is a perennial, tufted grass growing to 1.5 m tall. This species can be distinguished from other Australian *Paspalidium* by its large spikelets, 3.5 to 4.8 mm long and characteristic woody culms arising from robust woody rhizomes (no image available). Most other species of *Paspalidium* possess contracted rootstocks and sometimes contracted rhizomes but not the elongated rhizomes of *P. grandispiculatum* (Sharp and Symon 2002; Simon 1982; DEWHA 2008).

Leaf sheaths are glabrous, ligules ciliate, about 1 mm long. Leaf blades are linear, flat or incurved, to 10 cm long and 4 mm wide, glabrous or minutely scabrous (Simon 1982; Sharp and Simon 2002; Jacobs 2004).

1.16.2.2 Known distribution

Paspalidium grandispiculatum occurs in southeast Queensland in a band from Canungra to Kingaroy, over a range of approximately 100 km (refer Figure 1.32). It occurs in mixed Eucalypt forest, mixed open forest, and native pasture occurring as a result of land clearing for agriculture. One population has been recorded in the Crows Nest Falls National Park, the remaining known populations occur in either state forest or on private land (Boyes 2001; DotEE 2018; Halford 1998; Queensland Herbarium 2008).



Figure 1.32 **Distribution range of *P. grandispiculatum***

Source: ALA (2018)

1.16.2.3 Distribution in relation to the project

Paspalidium grandispiculatum was not identified within any Project-associated field surveys including protected plant surveys within the alignment where this species occurs or for the nearby TSRC Project. Database records (i.e. AoLA) indicate this species occurs to the north-east of the eastern end of the Project disturbance footprint in the Lockyer Forest Reserves area. The nearest records dated 1997 and 1999 are located 2.25 km north and 3.9 km north-east (respectively) from the Project disturbance footprint. A 2016 record is located 4.4 km north-east of the Project. All other records (from 1980 to 2013) in the vicinity of the Project occur further north throughout the Lockyer Forest Reserves and Crows Nest area (refer Figure 1.33). Other records within a 50 km buffer of the disturbance footprint occur to the north with scattered records as far away as Kingaroy.

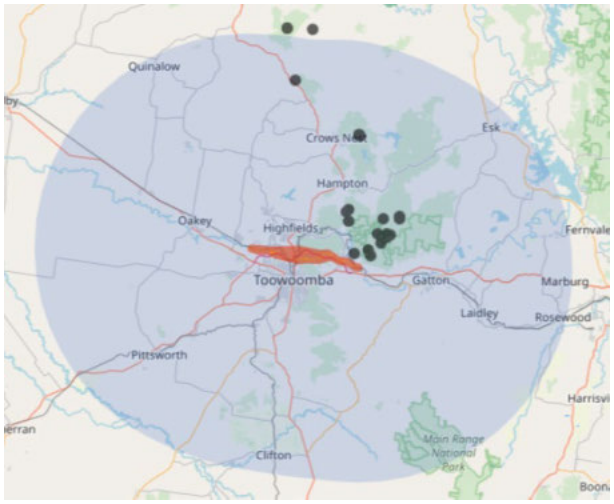


Figure 1.33 **Distribution range of P. grandispiculatum in relation to the Project**

1.16.2.4 Biology and reproduction

Paspalidium grandispiculatum is a perennial grass which is assumed to be wind-pollinated. The flowering and fruiting period of *P. grandispiculatum* flowering and fruiting period is from January to May for Queensland populations. The above ground parts of the grass are killed by fire, but it is capable of regenerating from the rhizome. No information is available on seed viability or longevity (DotEE 2018; Halford 1998; NSW OEH 2013; Queensland CRA/RFA Steering Committee 1998).

1.16.3 Habitat

In Queensland, *P. grandispiculatum* occurs in mixed forest with *Corymbia citriodora*, on sub-coastal, old loamy and sandy plains (RE 12.5.1) and mixed open forest often with *Corymbia trachyphloia*, *Corymbia citriodora, Eucalyptus crebra*, and *Eucalyptus fibrosa* (RE 12.9-10.5). Records also exist from native pastures and open-forest communities. The soil type where *P. grandispiculatum* is generally found are shallow with a sandy texture, dark in colour, well drained and derived from sandstone rocks (DotEE 2018; DEWHA 2008; Halford 1998).

1.16.4 Threatening processes

The following have been identified as potentially threatening processes to *P. grandispiculatum*:

- Destruction and fragmentation of habitat by clearing
- Habitat disturbance by timber harvesting
- Inappropriate grazing regimes
- Inappropriate fire regimes
- Grazing by stock
- Competition from introduced groundcover species (NSW OEH 2013).

1.16.5 Threat abatement/recovery plan

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=20151. In effect under the BC Act 2016.

No threat abatement plan has been identified as being relevant for this species.

1.16.6 Summary of threat abatement/recovery plan

Paspalidium grandispiculatum is assigned as a keep-watch species under the NSW *Saving our Species Program* as relatively large populations are known to occur within reserves (for example 1000's of individuals are estimated in Bundjalung State Conservation Area) where current management is sufficient to ensure their long-term security.

1.16.7 References

Atlas of Living Australia (2018), *Paspalidium grandispiculatum*. Australia's species Database. Accessed 24 August 2018, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2905357.

AusGrass2 (2018), image of *Paspalidium grandispiculatum* – a grass, accessed 24 August 2018, available http://ausgrass2.myspecies.info/content/paspalidium-grandispiculatum.

Boyes, B. (2001), Recovery Plan for the Threatened Species and Ecological Communities of Gatton and Laidley Shires Southeast Queensland 2001- 2005. Lockyer Landcare Group

Department of the Environment and Energy (2018). *Paspalidium grandispiculatum* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Paspalidium grandispiculatum*. Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10838-conservation-advice.pdf. In effect under the EPBC Act from 01 October 2008.

Environmental Protection Agency (2008), Copy of the certified regional ecosystem map for the purpose of the Vegetation Management Act 1999, online RE Maps, Environmental Protection Agency, Brisbane, viewed 8 December 2015

Halford, D. (1998), Survey of Threatened Plant Species in Southeast Queensland Biographical Region. [Online]. Brisbane: Queensland CRA/RFA Steering Committee. Available from: http://www.daff.gov.au/rfa/regions/qld/environment/threatened-plant.

Jacobs, S.W.L. (2004), Paspalidium grandispiculatum. PlantNET - The Plant Information Network System of Botanic Gardens Trust. [Online]. Sydney, Australia. Available from: http://plantnet.rbgsyd.nsw.gov.au. Simon, BK 1982, 'New Species of Gramineae from southeastern Queensland', Austrobaileya, vol. 1, no. 5, pp. 455–467.

NSW Office of Environment and Heritage (2013). Paspalidium grandispiculatum - profile. Available from: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20151.

Sharp, D and Simon, BK (2002), AusGrass: Grasses of Australia, ABRS Identification Series, interactive CD ROM, ABRS, CSIRO Publishing, Melbourne.

Simon, B.K. (1982), New Species of Gramineae from southeastern Queensland. Austrobaileya. 1(5):455-467.

Queensland CRA/RFA Steering Committee (1998). Survey of Threatened Plant Species in South East Queensland Biogeographical Region. Available from: http://www.daff.gov.au/rfa/regions/qld/environment/threatened-plant.

1.17 Quassia (*Samadera bidwillii*)

1.17.1 Status

EPBC Act – Vulnerable

1.17.2 Biology and ecology

1.17.2.1 Characteristic

Quassia (*Samadera bidwillii*) is a small shrub or tree that grows to about 6 m in height, with red flowers and red fruit. Branchlets are ribbed, with fine, pale-brown hairs. The leaves are 4.5 to 9 cm long, 6 to 12 mm wide, glossy and hairless above, silky to pubescent on the lower surface and have secondary veins that are numerous and regularly arranged. The leaves are also stiff and leathery, narrow-elliptic or lanceolate, blunt or bluntly pointed with the margins bent under. Quassia flowers occur in clusters of 1 to 4, and each flower has 8 to 10 stamens, with filaments densely villous on the outer surface (refer Photograph 1.14). The sepals are 0.75 to 1 mm long and the red petals are approximately 2.5 mm in length. The fruit are ovid-ellipsoid, 1 cm long, hairy and sometimes appear winged (George 1985; Harden 2000; Williams et al. 1984).



Photograph 1.14 Quassia (*Samadera bidwillii*)

Source: Gavin (2019)

1.17.2.2 Known distribution

Quassia is currently known to occur in coastal localities between Scawfell Island, near Mackay, and Goomboorian, north of Gympie. Quassia is also likely to be found further south around Brisbane and Jimboomba (QDNR 2001) (refer Figure 1.34).



Figure 1.34 Distribution range of the Quassia

Source: DotEE (2018)

1.17.2.3 Distribution in relation to the project

Samadera bidwillii has been predicted to occur within the ecology study area. Database records (i.e. AoLA & WildNet) indicate no record of this species within the disturbance footprint, ecology study area or within a 50 km buffer of the disturbance footprint. The nearest records occur to the north between Gympie and Hervey Bay approximately 200 km from the Project (refer Figure 1.35).

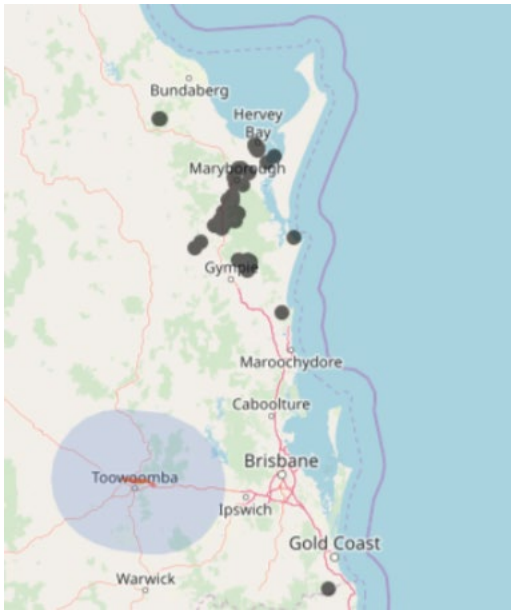


Figure 1.35 **Distribution range of Quassia in relation to the Project**

1.17.2.4 Biology and reproduction

Quassia flowers have been recorded in November, December, January and March. Fruit has been recorded from February to April (QDNR 2000).

1.17.3 Habitat

Quassia commonly occurs in lowland rainforest or on rainforest margins, but it can also be found in other forest types, such as open forest and woodland. Quassia is commonly found in areas adjacent to both temporary and permanent watercourses in locations up to 510 m altitude. The species occurs on lithosols, skeletal soils, loam soils, sands, silts and sands with clay subsoils (Belleng Pty Ltd 2004; Hewson 1985; QDNR 2001; Stanley and Ross 1983).

1.17.4 Threatening processes

The following have been identified as potentially threatening processes to the Quassia:

- Soil erosion and habitat clearing (e.g. agriculture, forestry, urban development and recreational activities)
- Inappropriate fire regimes and weed encroachment (QDNR 2001; TSSC 2008).

1.17.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species.

1.17.6 References

Belleng Pty Ltd (2004). *Proposed Residential Development Lot 3 RP35335 Doolong Road South, Hervey Bay, Preliminary Information (Part 1) for Environmental Assessment and Approval under Chapter 4 of the Environment Protection and Biodiversity Conservation Act 1999.*

Department of the Environment and Energy (2018). *Samadera Bidwillii* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=29708 [Accessed 31 August 2018].

George, A., ed. (1985). Melianthaceae to Simaroubaceae. **In:** *Flora of Australia*. 25. Canberra, ACT: Australian Government Publishing Services.

Harden, G.J., ed. (2000). *Flora of New South Wales*. Sydney, NSW: University of New South Wales Press.

Hewson, H.J. (1985). Simaroubaceae. In: *Flora of Australia*. 25:188-196. Canberra, ACT: AGPS.

Queensland Department of Natural Resources (2001). Species management profiles for plants. *Species Management Manual.* 3.

Queensland Department of Natural Resources (2000). *Updated map prepared from information supplied by the Queensland Herbarium*. Brisbane, Queensland: Environmental Protection Agency.

Reef Catchments (2018). *Samadera Bidwillii* (Image) [Online] Available from: http://reefcatchments.com.au/species_ecosystems/samadera-bidwillii/ [Accessed 31 August 2018].

Stanley, T.D. and Ross E.M. (1983). *Flora of southeastern Queensland*. Volume One. Brisbane, Queensland: Department of Primary Industries.

Threatened Species Scientific Committee (2008). Approved Conservation Advice for *Quassia bidwillii* (Quassia). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/10094-conservation-advice.pdf. In effect under the EPBC Act from 03 July 2008.

Williams, J.B., Harden G.J. and McDonald W.J.F. (1984). *Trees and shrubs in rainforests of New South Wales and southern Queensland*. Armidale, NSW: Botany Department, University of New England.

1.18 Queensland nut tree (*Macadamia integrifolia*)

1.18.1 Status

EPBC Act – Vulnerable

1.18.2 Biology and ecology

1.18.2.1 Characteristic

Queensland nut tree (*Macadamia integrifolia*) is a medium sized tree that grows to 20 m in height with a 20 m wide crown. This species produces cream or creamy-white flowers that have been recorded in January, March and June to November. Flowers occur on the end of 30 cm long racemes (refer Photograph 1.15). Fruit is a hard brown spherical nut encased in a green leathery outer shell with a diameter of 2 to 3 cm (Barry and Thomas 1994; Forster et al. 1991; Gross 1995; Stanley and Ross 1986).



Photograph 1.15 Queensland nut tree (Macadamia integrifolia)

Source: McMaster (2019)

1.18.2.2 Known distribution

Queensland nut tree occurs from Mt Bauple, near Gympie, to Currumbin Valley in the Gold Coast hinterland, southeast Queensland (refer Figure 1.36). The species occurs as a scattered rare to occasional tree, and population sizes have been noted as difficult to estimate (Barry and Thomas 1994).



Figure 1.36 Distribution range of Queensland nut tree

Source: ALA (2018)

1.18.2.3 Distribution in relation to the project

Database records (i.e. ALA) indicate that no records of *Macadamia integrifolia* exist within the ecology study area. The closest record is located just within a 50 km buffer of the disturbance footprint approximately 50 km to the northeast and is dated 2019. The next closest record is located approximately 58 km from the alignment near Lake Wivenhoe and is dated 1954. A number of other records of this species exist beyond 50 km of the disturbance footprint to the east and northeast in the surrounds of Brisbane and in D'Aguilar National Park (refer Figure 1.37).

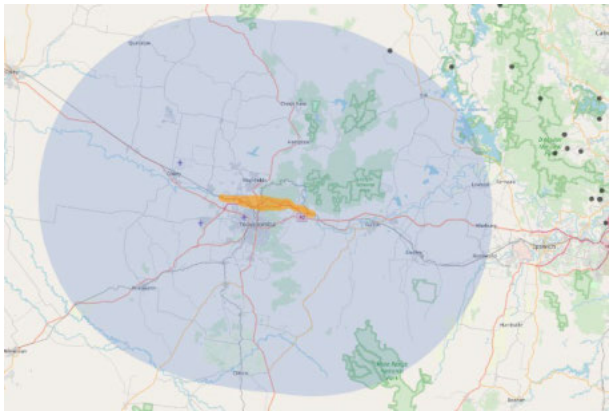


Figure 1.37 Distribution range of Queensland nut tree in relation to the Project

Source: ALA (2020)

1.18.2.4 Biology and reproduction

Queensland nut tree flowers in January, March and June to November. Fruits have been recorded from November to January and March to April. Macadamia nuts begin to produce viable nut loads at around 10 years of age. Reproduction is by seed, with a seed viability of 3 to 6 months. The species has a juvenile period of over six years. The seeds are eaten by mammals and are dispersed by stream. The plant re-sprouts when damaged (Barry and Thomas 1994; Forster et al. 1991; Gross 1995; Stanley and Ross 1986; Queensland CRA/RFA Steering Committee 1997).

1.18.3 Habitat

Queensland nut tree grows in remnant rainforest, including complex mixed notophyll forest, and prefers partially open areas such as rainforest edges (Ryan 2006 as in DEWHA 2008). This species occurs within the Northern Rivers (NSW) and southeast Queensland Natural Resource Management regions.

Queensland nut tree is known to prefer to grow in mild frost-free areas with a reasonably high rainfall. There have been records of planted specimens bearing fruit as far south as Sydney (DotEE 2018; Ryan 2006).

Vegetation communities in which the Queensland nut tree is found range from complex notophyll mixed forest, extremely tall closed forest, simple notophyll mixed very tall closed forest to simple microphyll-notophyll mixed mid-high closed forest with *Araucaria* and *Argyrodendron* emergents (Barry and Thomas 1994; Queensland CRA/RFA Steering Committee 1997; Ryan 2006).

1.18.4 Threatening processes

The following have been identified as potentially threatening processes to the Queensland nut tree:

- Land clearing for urban and agricultural development (Queensland CRA/RFA Steering Committee 1997; Ryan 2006).
- Inappropriate fire regimes (Queensland CRA/RFA Steering Committee 1997; Ryan 2006)
- Land clearing making them more susceptible to wind damage, as well as reducing the availability of natural pollinators (Ryan 2006)
- Invasive weed species
- Compaction of the soil layer (Ryan 2006).

1.18.5 Threat abatement/recovery plans

No threat abatement plan has been identified as being relevant for this species. The following recovery plan is relevant to this species:

- Costello, G., M. Gregory & P. Donatiu (2009). Southern Macadamia Species Recovery Plan. Report to Department of the Environment, Water, Heritage and the Arts, Canberra by Horticulture Australia Limited, Sydney. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/southern-macadamia-species-recovery-plan. In effect under the EPBC Act from 13-Nov-2009 as *Macadamia integrifolia*.

1.18.6 Summary of threat abatement/recovery plans

The threats outlined in the Southern Macadamia Species Recovery Plan include:

- Land clearing, fragmentation and loss of connectivity
- Inappropriate fire regimes
- Habitat modification by weeds
- Lack of appropriate gazing regimes
- Reduce gene flow
- Climate change.

Current recovery actions include:

- Restoration of rainforest habitat for private landholders under SEQ Rainforest Recovery Project
- Designation of ecologically appropriate fire regimes under the Hotspots Fire Project
- Rebates for fencing under Australian Government funding programs to assist in managing grazing
- Studies on the genetic characterisation of macadamia species and impacts of habitat fragmentation.

Future actions proposed by the Southern Macadamia Species Recovery Plan include:

- Assist landholders in accessing resources to protect macadamia habitat on their property through grazing control, weed management and rehabilitation strategies
- Provide fire and biodiversity workshops to land managers
- Continue research on population genetics
- Model the projected impact of climate change on the ecology, distribution and habitat of southern macadamia species.

1.18.7 References

Atlas of Living Australia (2018), *Macadamia integrifolia,* accessed 24 August 2018, available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890419.

Barry SJ and Thomas GT (1994), Threatened Vascular Rainforest Plants of Southeast Queensland: A Conservation Review, Queensland Department of Environment and Heritage.

Department of the Environment and Energy (2018). *Macadamia integrifolia* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for *Macadamia integrifolia* (Macadamia Nut). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/7326-conservation-advice.pdf. In effect under the EPBC Act from 16 December 2008.

Forster, PI, Bostock, PD, Bird, LH and Bean, AR (1991), Vineforest Plant Atlas for Southeast Queensland with Assessment of Conservation Status, Queensland Herbarium, Brisbane.

Gross, CL (1995), 'Macadamia' In: Orchard, AE and McCarthy PM (Eds) Flora of Australia, vol. 16, pp. 419-425, ABRS, Canberra/CSIRO, Melbourne.

McMaster, I. (2019). Macadamia integrifolia. [image] [online] Available from: https://biocache.ala.org.au/occurrences/88cb72d2-8082-49f5-aeb1-1eea15566a39. [16 September 2019].

Stanley, TD and Ross, EM (1986), Flora of southeastern Queensland, Volume Two, Brisbane, Queensland Dept of Primary Industries

Queensland CRA/RFA Steering Committee (1997). Forest taxa at risk, threats, conservation needs and recovery planning in southeast Queensland. Queensland Government and Commonwealth of Australia.

Ryan, S (2006), Conservation Management Profile: Queensland nut tree Macadamia integrifolia, Queensland: Environmental Protection Agency, Ecosystem Conservation Branch, viewed 20 October 2008, http://www.epa.qld.gov.au/publications/p02096aa.pdf/Queensland_nut_tree_emMacadamia_integrifolia/em.pdf.

1.19 Stream clematis (*Clematis fawcettii*)

1.19.1 Status

EPBC Act – Vulnerable

1.19.2 Biology and ecology

1.19.2.1 Characteristic

Stream clematis (*Clematis fawcettii*) is a weak climber with stems 1 to 2 m long. The paired leaves are divided once (biternate) or twice (triternate) into three toothed leaflets. Leaflets are 0.6 to 4 cm long and 0.5 to 3 cm wide (refer Figure 1.38). Flowers are white to pink-purple. Fruit form achenes, 4 mm long and less than 1 mm wide that are three-ridged and have a feathery tail (awn) 2 to 2.5 cm long that assists with wind dispersal of seeds (DECC 2005; Harden 1990; Stanley and Ross 1983).



Figure 1.38 **Stream clematis (*Clematis fawcettii*)**

Source: QLD Herb (2018)

1.19.2.2 Known distribution

Stream clematis occurs from the Richmond River in northeast NSW to the Bunya Mountains in southeast Queensland. This species is conserved within the Richmond Range National Park, Toonumbar National Park, Lamington National Park, Main Range National Park and Mt Barney National Park. This species occurs over a range of 65,000 km^2 and herbaria collections have been made from about 35 locations (refer Figure 1.39). This species occurs within the Northern Rivers (NSW), Condamine (Queensland) and southeast Queensland Natural Resource Management regions (Briggs and Leigh 1996; NSW NPWS 2005; QLD CRA/RFA Steering Committee 1998).



Figure 1.39 **Distribution range of Stream clematis**

Source: ALA (2018)

1.19.2.3 Distribution in relation to the project

This species was not identified during any Project-associated field surveys or for the nearby TSRC Project. The nearest database records are located approximately 9 km south of the disturbance footprint to the east of Toowoomba at Mount Davidson with two records from 1990 (ALA 2020). Two records exist approximately 25 km north-west of the disturbance footprint at Gumbungee dated 1987. Two more recent records (2011) occur at Irongate Conservation Park approximately 45 km south-west of the disturbance footprint (refer Figure 1.40).

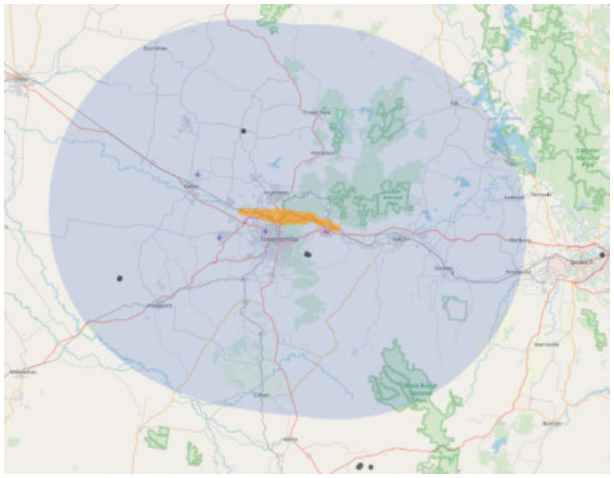


Figure 1.40 **Distribution range of Stream clematis in relation to the Project**

Source: ALA (2020)

1.19.2.4 Biology and reproduction

Flowering in this species is known to occur from October through to December and fruits have been recorded in January, June and December. The pollination mechanism is unknown. It is not known whether the species is capable of vegetative reproduction. Vines generally only flower and fruit in high light conditions, and therefore the species favours disturbance that would open up the tree canopy (Bean pers. comm. 2009).

1.19.3 Habitat

The Stream clematis is a perennial climbing vine found in drier rainforests near streams. The species is mostly found in semi-evergreen vine thicket, *Araucarian microphyll* vine forest or in complex notophyll vine forest, but occasionally in Eucalypt woodland communities that are close to vine thicket or rainforest. Soil types very, though mainly fertile clays have been recorded from specific location where the species has been observed (DotEE 2018).

1.19.4 Threatening processes

The following have been identified as potentially threatening processes to the Stream clematis:

- Invasion by introduced weeds (DotEE 2018)
- Habitat loss from land clearing, grazing by domestic stock
- Frequent fire events
- Forest eucalypt dieback associated with over-abundant Bell Miners (*Manorina melanophrys*) and psyllid insects (*Glycaspis* spp.*)* (NSW DECC 2007).

1.19.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Department of Environment and Energy (2010). National recovery plan for the Semi-evergreen vine thickets of the Bigalow Belt (North and South) and Nadewat Bioregions ecological community. Canberra, ACT: Australian Government. Available from: http://www.environment.gov.au/resource/national-recovery-plan-semi-evergreen-vine-thickets-brigalow-belt-north-and-south-and. In effect under the EPBC Act from 12-Mar-2010.
- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10169. In effect under the BC Act 2016.

No threat abatement plan has been identified as being relevant for this species.

1.19.6 Summary of threat abatement/recovery plan

The threats outlined in the National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community include:

- Broad-scale land clearing of remnant vegetation
- Fire where SEVT is not protected by topography or substrate and where fuel characteristics have been altered by the introduction of introduced pasture grasses
- Incursion by exotic flora including Buffel grass *Pennisetum ciliare*, Green panic *Megathyrsus maximus var. pubiglumis*, Parthenium weed *Parthenium hysterophorus*, Velvet tree pear *Opuntia tomentosa*, Lantana *Lantana camara*, Rubber vine *Cryptostegia grandiflora* and Brazilian nightshade *Solanum seaforthianum*. Of these *L. camara* and *C. grandiflora* pose the most serious threat to this TEC.
- Trampling from cattle grazing opening up the understorey of SEVT habitat facilitating the incursion of invasive flora

- Invertebrate pest species including feral pigs, foxes, rabbits and cane toads impacting the vegetation structure and associated native fauna
- Coastal development where remnant vine thicket occurs on coastal beach ridges.

Threat abatement actions outlined in the National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community include:

- Identify and evaluate the extent, biodiversity value and condition of remnant and regrowth areas of this TEC in the Brigalow Belt (North and South) and Nandewar Bioregions
- Complete mapping of this TEC in New South Wales and refine mapping of remnants in Queensland
- Establish a condition assessment methodology establishing benchmark sites for each component regional ecosystem
- Determine the extent and condition of SEVT areas that have been impacted by invasive flora, particularly weeds of national significance
- Survey data deficient species within SEVT communities
- Identify key ecosystem components and processes determining their response to management actions
- Monitor selected populations of EPBC-Act listed species that occur within SEVT communities including *Cadellia pentastylis, Cossinia australiana, Denhamia parvifolia, Macropus dorsalis, Paradelma orientalis, Turnix melanogaster* and *Zieria verrucose*
- Establish a comprehensive, adequate and representative system of SEVT ecological community across the Brigalow Belt (North and South) and Nandewar Bioregions, protected by either reservations or conservation agreements (including MOU's)
- Ensure best practice management to sites containing SEVT
- Involve landholders and community members in the conservation and management of SEVT ecological communities
- Enhance the ability of government and non-government organisations at the national, regional and local level (including consent authorities) to recognise and incorporate SEVT ecological community conservation issues into all planning processes.

Clematis fawcettii is assigned as a keep-watch species under the NSW *Saving our Species Program* as large populations (e.g. over 500 individuals) are known to occur within reserves where current management is sufficient to ensure their long-term security. State wide conservation actions identified for this species include:

- Assess weed threats to populations, manage as necessary, take precautions against accidental damage to threatened vines during weed management
- Collect baseline population data, using detailed census methods at priority sites and rapid assessment techniques at others
- Increase community awareness to assist in detecting new locations, and with habitat rehabilitation projects
- Confirm existing records, estimate abundance and extent of populations
- Identify information and resource needs required to ensure land managers and other stakeholders are aware of populations and habitat.
- Ensure that PoMs, fire plans, pest management plans take account of requirements for the recovery of *Clematis fawcettii*
- Ensure the species is considered in statutory plans for LGA's relevant to its distribution
- Establish a data recording system for the species
- Model habitat to identify sites for further survey
- Protect areas of known habitat from timber harvesting and other land clearing.

- Regional fire plans, protected area Fire Plans and hazard reduction burn guidelines to include protection for the species and its habitat
- Survey before road and track maintenance in the habitat of the species, assess need to protect trackside plants
- Use molecular techniques to investigate genetic variation within and between populations
- Identify critical factors limiting the recovery of the species.
- Research fire response
- Map populations and habitats.

1.19.7 References

Atlas of Living Australia (2018), Clematis fawcettii - Stream clematis, viewed 24 August 2018, available: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2889478#gallery.

Bean AR (2009), Personal communication provided on Species Information Sheet, 19 April 2010. Queensland Herbarium, Department of Environment and Resource Management.

Briggs, JD and Leigh JH (1996), Rare or Threatened Australian plants, Centre for Plant Biodiversity Research, CSIRO Division of Plant Industry, Canberra, ACT.

Department of the Environment, Water, Heritage and the Arts (2008). Approved Conservation Advice for Clematis fawcettii (Stream Clematis). Canberra: Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/4311-conservation-advice.pdf. In effect under the EPBC Act from 01 October 2008.

Department of the Environment and Energy (2018). Clematis fawcettii in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Fri, 24 August 2018

Department of Environment and Climate Change NSW (2005), Northern Clematis – Profile, viewed 24 August 2018.

Department of Environment and Climate Change NSW (2007), Forest eucalypt dieback associated with over-abundant Bell Miners and psyllids – preliminary determination, viewed 24 August 2018.

Eichler HJ and Jeanes JA (2007), Clematis. In: 'Flora of Australia, vol. 2' (ed. AJG Wilson). Australian Biological Resources Study. Canberra.

Harden, G.J. (ed) (1990), Flora of New South Wales. Volume One. Kensington, NSW: University of NSW Press.

NSW National Parks and Wildlife Service (2005), The parks and reserves of the Northern Richmond Range – Plan of Management, Department of Environment and Climate Change, viewed 24 August 2018.

Queensland CRA/RFA Steering Committee (1998), Survey of Threatened Plant Species of South East Queensland Biological Region, Department of Environment.

Queensland Herbarium. (2018). Stream clematis (Clematis fawcettii). [Image] [Online] Available from https://images.ala.org.au/image/details?imageId=e8911df9-98c1-42b3-b349-1ddbe1365fed. [19 September 2019].

Stanley, TD and Ross, EM (1983), 'Clematis' in Flora of southeastern Queensland, vol. 1, Brisbane, Queensland Dept. of Primary Industry, pp. 169–170.

1.20 Tall velvet sea-berry (*Haloragis exalata* subsp. *velutina*)

1.20.1 Status

EPBC Act – Vulnerable

NC Act – Vulnerable

1.20.2 Biology and ecology

1.20.2.1 Characteristic

Tall velvet sea-berry (*Haloragis exalata* subsp. *velutina*) is a shrub growing to 1.5 m, with a red, square-shaped stem that is covered with fine velvety hairs. It has narrow, opposite leaves which are 50 to 60 mm long, 6 to 8 mm wide, finely toothed and red to yellowish green. The flowers are small and are usually in clusters of three to seven towards the end of the branchlets. Individual flowers are stalked and have four sepals and four petals. The sepals are approximately 0.6 mm long, reddish in colour and are persistent on the fruit. The petals are also reddish, hooded and about 2.5 to 3.5 mm long (refer Photograph 1.16). Each flower has eight stamens, with the anthers 1.5 to 2 mm long. The fruit are small and pear-shaped, they are slightly wrinkled. Each fruit is approximately 2 mm long (DECC NSW 2005; Harden 2002; ALA 2018).



Photograph 1.16 Tall velvet sea-berry (*Haloragis exalata* subsp. *velutina*)

Source: Ruming (n.d.)

1.20.2.2 Known distribution

Tall velvet sea-berry occurs on the north coast of NSW and in southeast Queensland. It occurs from near Kempsey, north to Carnarvon National Park inland of Bundaberg (refer Figure 1.41). This species is locally common in some areas such as Bunya Mountains NP but is often recorded in low numbers (NSW DECC 2005; Queensland Herbarium 2008).



Figure 1.41 **Distribution range of the Tall velvet sea-berry**

Source: ALA (2018)

1.20.2.3 Distribution in relation to the project

Haloragis exalata subsp. *velutina* has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that no records of *Haloragis exalata* subsp. *velutina* exist within the ecology study area or within a 50 km buffer of the disturbance footprint. The closest record is located approximately 64 km northeast of the alignment in D'Aguilar National Park and is dated 2007. The next closest record is located approximately 65 km northeast of the disturbance footprint in Deer Reserve National Park and is dated 1994 (refer Figure 1.42).

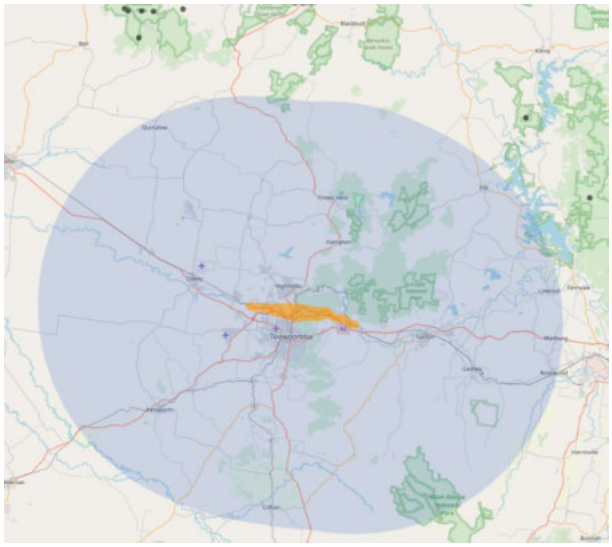


Figure 1.42 **Distribution range of the Tall velvet sea-berry in relation to the Project**

Source: ALA (2020)

1.20.2.4 Biology and reproduction

The Tall velvet sea-berry flowers from January to April and fruits in April (OEH 2018).

1.20.3 Habitat

In Queensland, Tall velvet sea-berry occurs in rainforest and rainforest margins and adjacent grassland and open grassy woodland above 500 m altitude. Species it is often found in association with include Broad-leaved apple (*Angophora subvelutina*), Forest redgum (*Eucalyptus tereticornis*), Green wattle (*Acacia irrorata*), and *Scutellaria humilis* (Queensland CRA/RFA Steering Committee 1998; Queensland Herbarium 2008).

1.20.4 Threatening processes

The following have been identified as potentially threatening processes to the Tall velvet sea-berry:

- Weed invasion of streamside areas
- Road work
- Erosion
- Inappropriate/ frequent fire regimes
- Degradation of habitat by feral pigs (OEH 2018).

1.20.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10393. In effect under the BC Act 2016.

No threat abatement plan has been identified as being relevant for this species.

1.20.6 Summary of threat abatement/recovery plans

Haloragis exalata subsp. *velutina* is assigned as a keep-watch species under the NSW Saving our Species Program. State wide conservation actions identified for this species include:

- Validate old database records and amend those that are spatially incorrect
- Map extent of known populations.
- Survey areas of potential habitat in nearby areas for further populations
- Determine and monitor current population size and demography and monitor, habitat condition and threats at known sites.
- Conduct research to determine ecological requirements, including fire ecology, and undertake field studies to monitor seedling establishment and survivorship. May involve autecological study or literature search for information on similar species.
- Control weeds (esp. blackberry) in known habitat of species.

1.20.7 References

Atlas of Living Australia (2018). *Haloragis exalata* subsp. *velutina*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2903322#overview [Accessed 30 August 2018].

Department of Environment and Climate Change NSW (2005). *Haloragis exalata subsp velutina* – profile [Accessed 30 August 2018].

Office of Environment and Heritage, NSW (2018). Tall velvet sea-berry. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10393 [Accessed 21 August 2018].

Queensland CRA/RFA Steering Committee. (1998). Survey of Threatened Plant Species in South East Queensland Biogeographical Region [Accessed 30 August 2018].

Queensland Herbarium. (2008). HERBRECS, Queensland Herbarium, Brisbane.

Ruming S. (n.d.). *Haloragis exalata* subsp. *velutina* (Image) [Online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2903322#gallery [Accessed 30 August 2018].

1.21 Wandering pepper-cress (*Lepidium peregrinum*)

1.21.1 Status

EPBC Act – Endangered

1.21.2 Biology and ecology

1.21.2.1 Characteristic

Wandering pepper-cress (*Lepidium peregrinum*) is a perennial plant that grows to 10 to 80 cm tall, sometimes ascending to 2 m in surrounding vegetation. The lower cauline leaves are deeply divided with a large broad-lanceolate terminal lobe and measure 6 to 10 cm long by 15 to 25 mm wide (refer Figure 1.43). Leaf edges are fringed with eyelash-like hairs. The mid-cauline leaves are lanceolate in outline with serrate to serrulate margins and measure 4 to 9 cm long by 4 to 9 mm wide. The small flowers are less than 1 mm long and arranged in hairy, terminal racemes (ALA 2018; Hewson 1982; OEH 2018; Scarlett 1999).

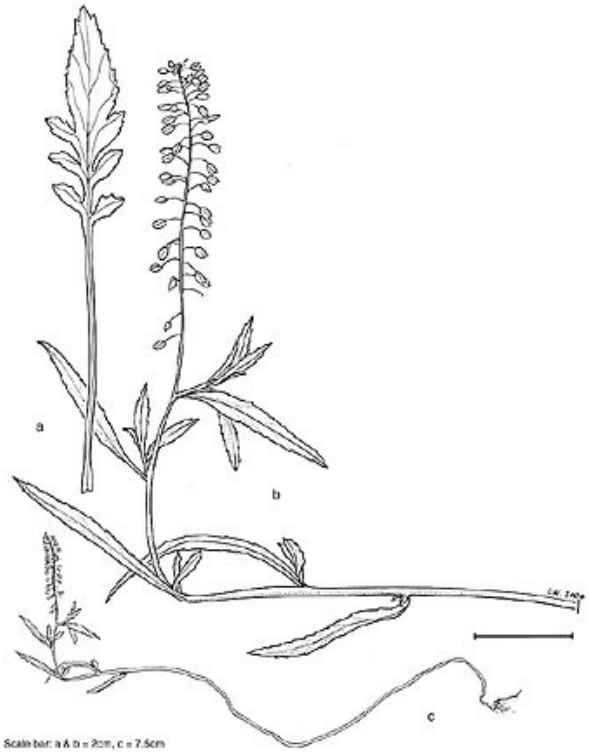


Figure 1.43 **Wandering pepper-cress (*Lepidium peregrinum*)**

Source: OEH (n.d.)

1.21.2.2 Known distribution

Wandering pepper-cress occurs from the Bunya Mountains, southeast Queensland, to near Tenterfield, in northern NSW. This species occurs within the New England Tableland and southeast Queensland Bioregions and the southeast Queensland, Condamine and Border-Rivers Maranoa-Balonne Natural Resource Management regions (OEH 2018; Queensland Herbarium 2007; Queensland Herbarium 2009) (refer Figure 1.44).



Figure 1.44 **Distribution range of the Wandering pepper-cress**

Source: ALA (2018)

1.21.2.3 Distribution in relation to the project

Wandering pepper-cress was not identified during any Project-associated field surveys or for the nearby TSRC Project. Database records (AoLA) indicate that there are no records of this species within the MNES study area. The closest records are located approximately 6 km north of the disturbance footprint at Highfields Falls Bushland Reserve and are dated 2007. The next closest records are located approximately 8 km south of the alignment immediately east of Toowoomba and are dated 2007. A number of other records are located within a 50 km buffer of the disturbance footprint. These are concentrated near Ravensbourne National Park (19 km north-east of the Project) (refer Figure 1.45).

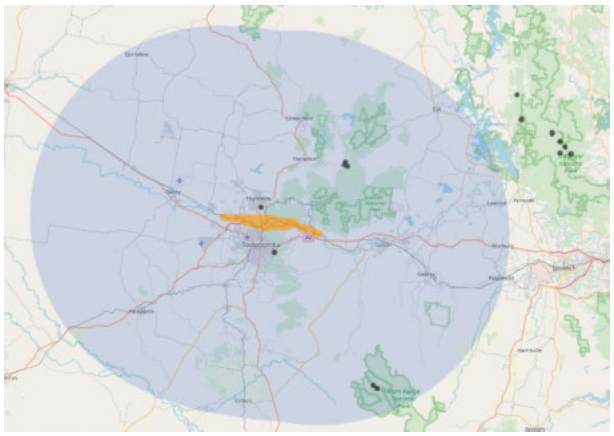


Figure 1.45 **Distribution range of the Wandering pepper-cress in relation to the Project**

Source: ALA (2020)

1.21.2.4 Biology and reproduction

Wandering pepper-cress flowers from January to April. Initial studies of Wandering pepper-cress subpopulations found some have little or no recruitment, while others have juvenile plants in the absence of mature plants. This could be indicative that the species requires specific triggers to break seed dormancy, and naturally experiences 'boom and bust' cycles in the number of mature plants. It is possible the species persists in some locations as dormant seed with no vegetative specimens being evident (OEH 2018).

1.21.3 Habitat

The species has been recorded growing in riparian open forest dominated by *Eucalyptus camaldulensis* and *Casuarina cunninghamiana* with variably dense shrubby understorey. The species was most abundant in the tussock grassland fridge of the riparian open forest, with some plants reaching a height of 2 m in thickets of *Hymenanthera*. It has also been recorded in shade under shrubs close to the creek bank, in which cases most plants have been small, approximately 30 cm in height. Herbarium records and observations in the wild suggest this species responds to disturbance events, due to observations along walking tracks, native pine plantations and car parks, and therefore population densities may fluctuate as a response to such events (Scarlett 1999; OEH 2018; Queensland Herbarium 2009).

1.21.4 Threatening processes

The following have been identified as potentially threatening processes to the Wandering pepper-cress:

- Populations are fragmented and generally very small, with recruitment spasmodic or limited
- Clearing of habitat for agriculture and grazing
- Grazing
- Introduced weeds
- Destruction of plants following misidentification
- Extended drought periods and other forms of land degradation (OEH 2018).

1.21.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2016). Threat abatement plan for competition and land degradation by rabbits. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.

1.21.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for competition and land degradation by rabbits includes:

- Competition with native wildlife for food and shelter
- Prevention of plant regeneration
- Increased grazing pressure and damage to native vegetation
- Altering the regular process of plant succession
- Altering ecological communities and impacting soil structure and nutrient cycling contributing to serious erosion
- Increasing predation and reducing reproduction for native arboreal mammals and birds through the removal of critical habitat.

Threat abatement actions for rabbits include:

- Supress rabbit populations at the landscape scale below thresholds in identified priority areas
- Gain a better understanding of the impacts rabbits have and their interactions with other species and ecological processes
- Increase the effectiveness of rabbit control programs
- Increase engagement within the local community to provide awareness of the environmental impact of rabbits and the need for integrated control.

1.21.7 References

Atlas of Living Australia (2018). Wandering pepper-cress. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2896651# [Accessed 30 August 2018].

Hewson H.J. (1982). The genus *Lepidium* L. (Brassicaceae) in Australia. *Brunonia* 4: 217-308.

Office of Environment and Heritage, NSW (2018). Wandering pepper-cress. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10464 [Accessed 30 August 2018].

Queensland Herbarium (2007). *Lepidium peregrinum*, nomination for re-classifying rare wildlife under the Nature Conservation Act 1992. Queensland Government, Environmental Protection Agency, Queensland National Parks and Wildlife Service. (unpublished)

Queensland Herbarium (2009). Specimen label information. [Accessed 30 August 2018].

Scarlett N.H. (1999). The identity of *Lepidium peregrinum* (Brassicaceae), an endangered Australian plant species. *Teleopea* 8: 337-350.

1.22 Waxy sarcochilus (Sarcochilus hartmannii)

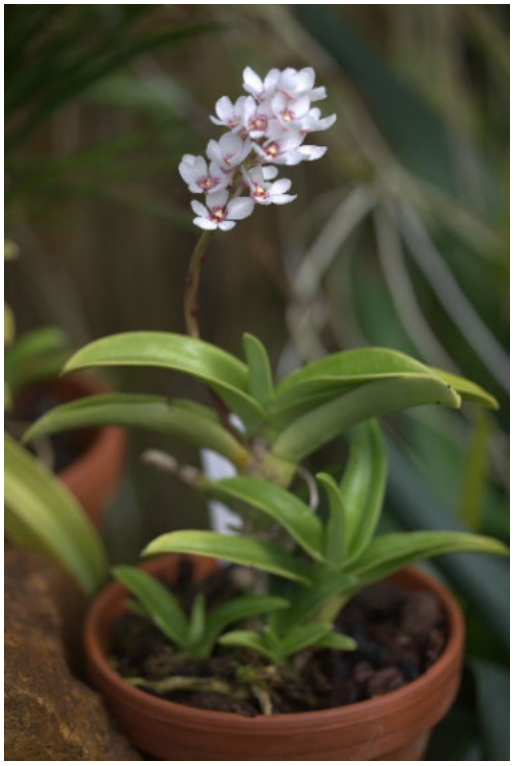
1.22.1 Status

EPBC Act – Vulnerable

1.22.2 Biology and ecology

1.22.2.1 Characteristic

Waxy sarcochilus (*Sarcochilus hartmannii*) is an epilithic, (grows on rocks) orchid. Stems are 8 to 100 cm long, sometimes found in dense groups of upright tufted shoots (DotEE 2018). The leaves are narrow oblong to triangular 5 to 20 cm long, 10 to 20 mm wide, deeply channelled, acute or obliquely emarginate, sometimes falcate (DotEE 2018). The inflorescence consists of 5 to 25 flowers, 6 to 25 cm long with the rachis much shorter than the peduncle. The elliptic to spoon-shaped white sepals and lateral petals often have red or reddish-brown spots at the base. The labellum (flower lip) is hairless, 1.5 to 3 mm long, about one fifth the length of the dorsal sepal (refer Photograph 1.17). Flowering occurs in October and November. The capsules are cylindrical, up to about 8.5 cm long (ALA 2018; DotEE 2018; Stanley and Ross 1989; Weston 1993).



Photograph 1.17 Waxy sarcochilus (*Sarcochilus hartmannii*)

Source: Averator (2015)

1.22.2.2 Known distribution

Waxy sarcochilus is known from the Richmond River in northern NSW to Main Range National Park in south-eastern Queensland (refer Figure 1.46). The species is conserved in Lamington National Park, Main Range National Park, Tambourine Mountain National Park, Mount Warning National Park, and Nightcap National Park. It is also known to occurs within the Northern Rivers (NSW) and Condamine and southeast Queensland Natural Resource Management regions (Briggs and Leigh 1995).



Figure 1.46 Distribution range of Waxy sarcochilus

Source: ALA (2018)

1.22.2.3 Distribution in relation to the project

Sarcochilus hartmannii was not identified during any Project-associated field surveys or for the nearby TSRC Project. Waxy sarcochilus is an epilithic orchid (i.e. grows on rocks and cliff faces) in sclerophyll forests, edges of rainforest and open areas from 500 m to 1,000 m altitude (DEWHA 2008). A single record exists within a 50 km buffer of the disturbance footprint located approximately 15 km south of the alignment near Barry Griffith Park (refer Figure 1.47). The collection date for this record is between 1850 to 1890 and has a high degree of spatial uncertainty possibly to protect the exact location as a major threat to this species is excessive illegal collecting. Given the date and high degree of spatial uncertainty this record is not reliable. The nearest records outside of a 50 km buffer of the disturbance footprint occur approximately 75 km south east of the alignment at Main Range National Park.

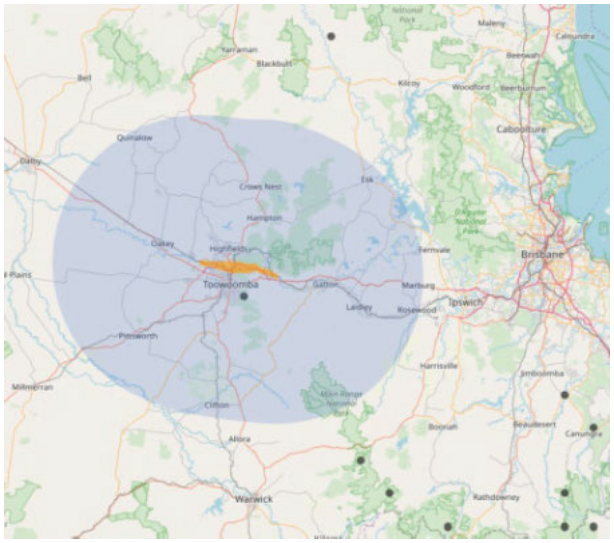


Figure 1.47 Distribution range of Waxy sarcochilus in relation to the Project

Source: ALA (2020)

1.22.2.4 Biology and reproduction

Waxy sarcochilus flowers from September to November. The petals, sepals and labellum are very broad, fairly thick-textured and widely spreading. The petals and sepals are more or less ovate with the sepals slightly broader than the petals. The labellum is projected forward, has three lobes and is very small – generally about one-fifth as long as the sepals. Seed capsules are cylindrical and reach 8.5 cm in length (ALA 2018; DotEE 2018).

1.22.3 Habitat

This species is a lithophytic orchid that favours cliff faces on steep narrow ridges supporting Eucalypt forest. It grows on volcanic rocks, in shallow soils and exposed cliffs in sclerophyll forests, rainforest margins or open areas at 500 to 1,000 m altitude. It is also found occasionally at the base of fibrous trunks of trees, including cycads and grasstrees (DotEE 2018; DECC 2005; Stanley and Ross 1989; Weston 1993).

1.22.4 Threatening processes

The following have been identified as potentially threatening processes to the Waxy sarcochilus:

- Illegal collection
- Localised extinction due to small populations
- Invasion of weeds
- Inappropriate fire regimes (DECC 2005).

1.22.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10745. In effect under the BC Act 2016.

The following threat abatement plans has been identified as being relevant for this species:

- Department of the Environment, Water, Heritage and the Arts (2008). *Threat abatement plan for competition and land degradation by unmanaged goats*. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-unmanaged-goats. In effect under the EPBC Act from 01-Oct-2008.

1.22.6 Summary of threat abatement/recovery plan

The conservation strategy for Waxy sarcochilus identifies four priority management sites in NSW:

- Toonumbar National Park in Kyogle LGA
- Blue Knob in Lismore, Tweed LGA
- Goonengerry National Park in Byron LGA
- Richmond Range National Park in Kyogle LGA.

Threats specific to the species identified in the strategy include:

- Small populations having a high risk of local extinctions
- Poor knowledge of current species distribution within its historic range.

Management strategies relevant to Waxy sarcochilus include:

- Restricting access to sites where the species is known to occur
- Collect seeds and cultivate in an ex-situ environment such as at botanical gardens and reintroduce into the wild
- Undertake targeted surveys to establish the presence of potential nearby locations where suitable habitat occurs, including along rocky ridgelines, cliffs and vine forest
- Map and document all known occurrences and estimate total population size during the flowering season (October – November)
- Conduct monitoring over a three-year period to establish the health of individual plants and any evidence of recruitment.

Threats identified in the threat abatement plan for competition and land degradation by unmanaged goats relevant this species include:

- Overgrazing by goats and resulting soil erosion
- Introduction of weeds through seeds carried in their dung.

The primary focus of the abatement plan is the control of unmanaged goat populations. The main objectives of controlling unmanaged goats are:

- Prevent unmanaged goats from occupying new areas in Australia and eradicate them from high-conservation value areas
- Promote the maintenance and recovery of native species and ecological communities that are affected by competition and land degradation by unmanaged goats
- Improve knowledge and understanding of unmanaged goat impacts and interactions with other species and other ecological processes
- Improve the effectiveness, target specificity, integration and humaneness of control options for unmanaged goats

- Increase awareness of all stakeholders of the objectives and actions of threat abatement plan, and of the need to control unmanaged goats.

1.22.7 References

Atlas of Living Australia (2018), *Sarcochilus hartmannii.* Australia's species Database. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2898379. Accessed 23 August 2018.

Avertor. (2015). Waxy sarcochilus (Sarcochilus hartmannii). (Image) [Online] Available from: https://commons.wikimedia.org/w/index.php?curid=39382770. [20 September 2019].

Clemets, M. (2015), *Sarcochilus hartmannii* - Waxy sarcochilus, accessed 23 August 2018, Available https://images.ala.org.au/image/viewer?imageId=63c04e82-389d-4d4f-9eef-c461dcf648e0.

Department of the Environment and Energy (2018). *Sarcochilus hartmannii* in Species Profile and Threats Database, Department of the Environment, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed Thu, 23 August 2018

Department of Environment and Climate Change NSW (2005), Hartman's Sarcochilus – Priority actions (New South Wales Threatened Species Priority Action Statement), viewed 23 August 2018.

Stanley, TD and Ross, EM (1989), Flora of southeastern Queensland, vol. 3, Queensland Department of Primary Industries, Brisbane.

Weston, PH (1993), '*Sarcochilus*', In: Harden, GJ Flora of New South Wales, vol. 4, University of New South Wales Press, Sydney.

2 Fauna species – Conservation significant species – Fish

2.1 Murray cod (*Maccullochella peelii*)

2.1.1 Status

EPBC Act – Vulnerable

2.1.2 Biology and ecology

2.1.2.1 Characteristics

The Murray cod (*Maccullochella peelii*) is the largest freshwater species of fish in Australia, measuring up to 1.8 m in length and weighing about 10 kg although some records indicate the species may reach over 100 kg in weight. The Murray cod has a broad head, rounded snout, equal length jaws and has a concaved facial profile. The light olive to dark green scales of the fish has mottled pattern, with a white ventral colouration. The pectoral fins of the fish are rounded and large with soft dorsal, anal and caudal fins with distinctive red or white edging (DotEE 2018) (refer Photograph 2.1).



Photograph 2.1 Murray cod (*Maccullochella peelii*)

Source: flagstaffotos (2006)

2.1.2.2 Known distribution

The Murray cod was once a widespread species and abundant in the lower and mid reaches of the Murray-Darling Basin between Queensland and South Australia (refer Figure 2.1). However, the distribution of the species has now reduced to several bioregions between Queensland and Victoria, including the Brigalow Belt South Bioregion (National Murray Cod Recovery Team 2010).



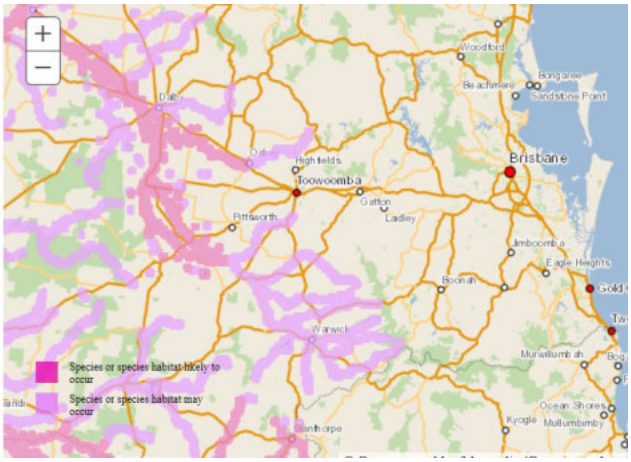


Figure 2.1 **Distribution range of Murray cod**

Source: ALA (2018), DotEE (2018)

2.1.2.3 Distribution in relation to the project

Maccullochella peelii has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that no records of *Maccullochella peelii* exist within the ecology study area. The nearest database record (AoLA) is from 2014 in a parkland area in Toowoomba (7 km south of the Project) which is very likely to be the result of artificial introduction. As such it has been disregarded. The nearest downstream record (2008) is from Oakey Creek near Jondaryan (30 km north-west of the Project). There is a 2009 record further downstream on Oakey Creek from the Bowenville area (45 km north-west) (refer Figure 2.2). There are scattered records further downstream of the the confluence of the Condamine River and Oakey Creek at Dalby and Chinchilla. It is noted DAWE habitat mapping does not indicate the species as occurring in the Toowoomba area or Gowrie Creek.

Aquatic habitat assessments within the MNES study area along three sections of Gowrie Creek were carried out during low flow conditions although flow was present. In general, the surveyed areas were dominated by shallow pools with little riparian cover and little instream woody debris present. These areas along Gowrie Creek appear to show poor habitat values for Murray cod. Nevertheless, Platypus (*Ornithorhynchus anatinus*) was observed during the survey indicating the presence of some larger pools and as such Murray cod may utilise the area, potentially during upstream migrations in flood events when water levels are higher.

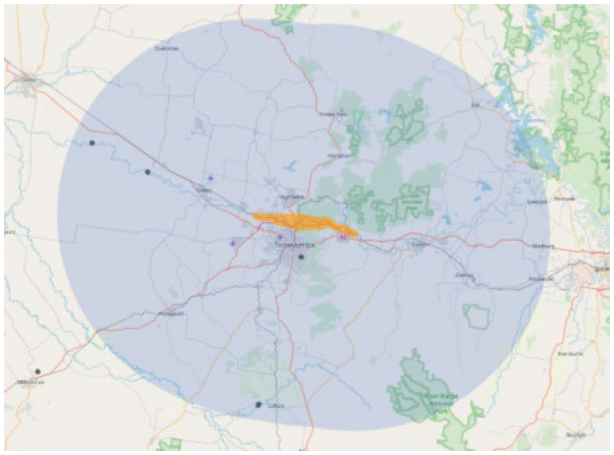


Figure 2.2 **Distribution range of Murray cod in relation to the Project**

Source: ALA (2020)

2.1.2.4 Biology and reproduction

Due to the size of the Murray cod, it is considered the apex predator of the Murray-Darling river system and known to ambush its prey. The demersal species is known to hunt from sunset to sunrise, feeding on spiny crayfish and shrimp as well as reptiles and other fish species including cod (DotEE 2018).

The Murray cod has relatively low fertility compared to many other freshwater fish with the species generally reaching sexual maturity, which is heavily dependent on size, at 5 years of age. Male Murray cod, who are known to guard and fan the eggs during incubation, mature at a larger size than females with the species breeding as a pair. A female cod weighing 3 kg can produce up to 10,000 eggs often laid in logs or snags after developing them through winter until spawning, which is triggered by an increase in temperature and day length (DotEE 2018).

Upon hatching larvae tend to remain clustered in their nest for up to 11 days with the male continually providing protection before the larvae leave the nest to drift downstream and feed on zooplankton as well as aquatic insects (DotEE 2018).

2.1.3 Habitat

The habitat of the species is diverse, ranging from clear rocky streams to slow-flowing, turbid lowland rivers or billabongs where the fish is found frequently in the main channel. Due to the species preferred breeding environment, it is often found in streams containing large rock, snags, overhanging vegetation, stumps or other woody structures (DotEE 2018).

The species is known to take long distance journeys prior to spawning travelling up to several hundred kilometres upstream despite their naturally sedentary nature (Koehn et al. 2009).

2.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Murray cod:

- Impoundment of streams and altered water flow
- Loss of riparian vegetation
- Habitat removal, modification and degradation (DotEE 2018).

2.1.5 Threat abatement/recovery plans

No threat abatement plan has been identified as being relevant for this species. The following recovery plan is applicable to this species:

- National Murray Cod Recovery Team (2010). National Recovery Plan for the Murray Cod *Maccullochella peelii peelii*. Department of Sustainability and Environment, Melbourne. Available from: http://www.environment.gov.au/resource/national-recovery-plan-murray-cod-maccullochella-peelii-peelii. In effect under the EPBC Act from 16-Dec-2010 as *Maccullochella peelii*.

2.1.6 Summary of threat abatement/recovery plans

Important populations outlined in the National Recovery Plan for the Murray Cod *Maccullochella peelii peelii* that could be relevant to the Project include:

- New South Wales: Darling River main channel and tributaries
- New South Wales: Murray River main channel and tributaries
- New South Wales: Murrumbidgee River from Wagga to Hay
- New South Wales: Edwards River and tributaries
- New South Wales: Naomi River, Peel River junction to Wee Waa
- New South Wales: Gwydir River and major tributaries from Copeton Dam to Gwydir River
- New South Wales: Birder rivers (Barwon and Macintyre) including major tributaries in NSW
- Queensland: Border Rivers
- Queensland: Condamine River

- Queensland: Warrego River between Charleville and Cunnamulla
- Queensland: McIntyre River downstream of Texas.

Threats identified in the National Recovery Plan include:

- Flow regulation
- Habitat degradation
- Lowered water quality
- Barriers
- Exotic/alien species
- Commercial fishing
- Recreational fishing
- Illegal fishing
- Stocking and translocations
- Genetic issues
- Disease
- Climate change.

Objectives outlined in the National Recovery Plan include:

- Determine the distribution, structure and population dynamics across the MDB
- Manage river flows in a way that enhances recruitment
- Risk assess the threats and evaluate benefits of recovery actions
- Determine habitat requirements for various life stages
- Manage recreational fishing in a sustainable manner taking into account the social, economic and recreational value of the fishery
- Encourage community ownership of conservation for the species
- Manage recovery plan implementation.

2.1.7 References

Atlas of Living Australia. (2018). *Maccullochella peelii*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:54e10f17-f08c-4f93-b576-681f361ffe56 [Accessed 22 August 2018].

Department of Environment and Energy. (2018). *Maccullochella peelii* (Murray Cod) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66633 [Accessed 22 August 2018].

Flagstaffotos. (2006). Maccullochella peelii - Murray Cod. [image] [online] Available from: https://commons.wikimedia.org/wiki/File:Murray_cod_melb_aquarium.jpg. [16 September 2019].

Koehn J.D., J.A. McKenzie, D.J. O'Mahony, S.J. Nicol, J.P. O'Connor and W.G. O'Connor. (2009). Movements of Murray cod (*Maccullochella peelii peelii*) in a large Australian lowland river. Ecology of Freshwater Fish. 18:594-602. John Wiley and Sons A/S.

Murray Darling Basin Authority. (2007). Native Species – Murray Cod (*Maccullochella peelii peelii*). Available from: https://www.mdba.gov.au/sites/default/files/archived/mdbc-NFS-reports/2202_factsheet_native_murray_cod.pdf [Accessed 22 August 2018].

National Murray Cod Recovery Team (2010). National Recovery Plan for the Murray Cod *Maccullochella peelii peelii*. Department of Sustainability and Environment, Melbourne. Available from: http://www.environment.gov.au/resource/national-recovery-plan-murray-cod-maccullochella-peelii-peelii [Accessed 22 August 2018].

3 Fauna species – Conservation significant species – Reptiles

3.1 Collared delma (*Delma torquata*)

3.1.1 Status

EPBC Act – Vulnerable

3.1.2 Biology and ecology

3.1.2.1 Characteristics

The Collared delma (*Delma torquata*) is a flap-footed lizard that has no forelimbs but retains vestigial hind limbs in the form of small scaly flaps. The body of the Collared delma is brown to reddish-brown in colour becoming grey to bluish-grey on the tail. It has large black bands across the head and nape interspaced by four cream-yellow stripes (refer Photograph 3.1). This species moves with a snake-like gait through the matrix but travel with a series of wriggling leaps over open ground. The Collared delma is a small cryptic species reaching a maximum size of 7 cm (snout-vent) and a maximum total length of approximately 190 mm (DotEE 2018; Santos 2012).



Photograph 3.1 Collared delma (*Delma torquata*)

Source: Aurecon (2019)

3.1.2.2 Known distribution

The Collared delma is endemic to southeast Queensland. The known distribution of the species occurs at Lockyer Forest Reserves, Western Creek near Millmerran, the Toowoomba Range eastward to Moggill on the western outskirts of Brisbane (refer Figure 3.1). The largest known occurrence of this species occurs on the Toowoomba range where large numbers of this species were subject to translocation activities associated with the Toowoomba second range crossing project (DotEE 2018; Schell and Stark pers. obs. 2017).



Figure 3.1 **Distribution range of the Collared delma**

Source: ALA (2018)

3.1.2.3 Distribution in relation to the project

Collared delma was recorded in the Toowoomba Range during Project-associated surveys. The species is also known to occur in the Toowoomba Range as derived from early surveys in 2006 (Peck and Hobson 2007) and more recent studies associated with the TSRC Project. There are 2003 database records (AoLA) located within the Project footprint. There are also two 1995 records approximately 10 km to the north-east in the Lockyer Reserves north-east of Helidon (refer Figure 3.2).

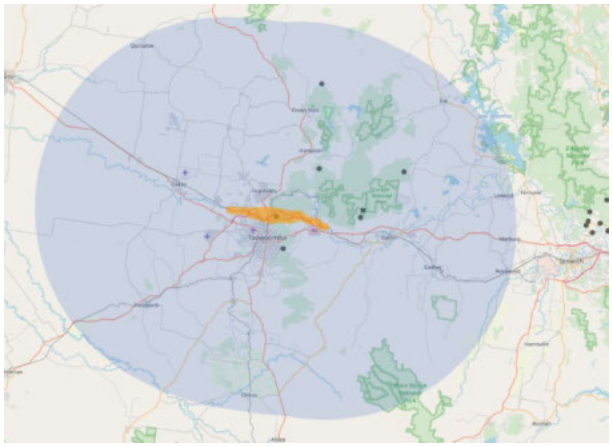


Figure 3.2 **Distribution range of the Collared delma in relation to the Project**

Source: ALA (2020)

3.1.2.4 Biology and reproduction

The Collared delma feeds on insects and spiders, with small cockroaches the most common prey item. Some individuals have been captured in subterranean termite colonies (Davidson 1993; Porter 1998; Schell and Stark pers. obs. 2017).

As with all members of the Pygopodidae family, the Collared delma produces two small white, elongated eggs in December. These hatch in February to March (Peck and Hobson 2007; Schell and Stark pers. obs. 2017).

3.1.3 Habitat

The Collared delma typically inhabits Eucalypt-dominated woodlands and open-forests in Queensland RE Land Zones 3, 9 and 10 (Brigalow Belt Reptiles Workshop 2010). However, recent studies associated with the species indicate that the species is most frequently associates with open *Eucalyptus crebra* woodland (canopy cover between 10 to 30%) located on northwest facing slopes (Schell and Stark pers. obs. 2017).

The Collared delma has been recorded from rocky areas associated with dry open forests. This species occurs in open Eucalypt and acacia woodland with an understorey of native grasses and loose rocks. The Collared delma has also been recorded from Eucalypt woodland adjacent to semi-evergreen vine thicket. This species shelters under rocks, fallen timber, leaf litter and in soil cracks (Richardson 2006).

The presence of rocks, logs, bark and other coarse woody debris, and mats of leaf litter (typically 30 to 100 mm thick) appears to be an essential characteristic of the Collared delma microhabitat and is always present where the species occurs (Brigalow Belt Reptiles Workshop 2010; Davidson 1993; Schell and Stark pers. obs. 2017).

3.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Collared delma:

- Loss and modification of habitat due to urban and agricultural development
- Landscaping activities removing surface rocks
- Invasive weed species such as Dwarf lantana (*Lantana montevidensis*) (DotEE 2018).

3.1.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species. The Priority Threat Management for Imperilled Species of the Queensland Brigalow Belt has been identified as being relevant for this species. Available from: https://publications.csiro.au/rpr/download?pid=csiro:EP154521&dsid=DS5 (Ponce Reyes, R., J. Firn, S. Nicol, I. Chadès, D.S. Stratford, T.G. Martin, S. Whitten & J. Carwardine, 2016).

3.1.6 Summary of threat abatement/recovery plans

Given the difficulty in detecting the Collared delma (*Delma torquata*) the Commonwealth environmental department considers that the presence of suitable and important habitat for this species is a surrogate for an important population of the species. Important habitat as described in the Draft referral guidelines for the nationally listed Brigalow Belt reptiles (available from: http://www.environment.gov.au/system/files/resources/570964ac-15bf-4e07-80da-848fead7b0cd/files/draft-referral-guidelines-comment-brigalow-reptiles.pdf) includes:

- Open forest eucalypt woodland dominated by ironbarks
- Woodland adjacent to exposed rocky areas
- RE Land Zones 3, 9 and 10

Threats to the Brigalow belt environmental community outlined in the Threat Management for Imperilled Species of the Queensland Brigalow Belt includes:

- Grazing
- Cultivation of arable crops
- Coal mining
- Coal Seam Gas industry development and associated infrastructure
- Changes in hydrology and pollution
- Invasive animals

- Invasive flora
- Fire
- Climate change.

Conservation management outcomes identified in the Threat Management for Imperilled Species of the Queensland Brigalow Belt document includes:

- Management of 29 national parks through the Department of National Parks, Sport and Racing
- Management of four Conservation Parks and one Resource Reserve that protects the brigalow ecosystems through the Department of Natural Resources and Mines supporting conservation and rehabilitation of the natural environment
- Encouraging sustainable agriculture to improve biodiversity and farm practices
- 'Back on Track' initiative prioritising the conservation, management and recovery of Queensland's native species
- Indigenous land management practices implemented for weed and fire management by Traditional Owners
- Biodiversity offsets through voluntary or mandatory investments in conservation management.

3.1.7 References

Atlas of Living Australia (2018). *Delma torquata Kluge*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:3796d07c-7e2c-4d8b-be2d-3846aa4c2bf1 [Accessed 2 September 2018].

Brigalow Belt Reptiles Workshop. (2010). Proceedings from the workshop for the nine listed reptiles of the Brigalow Belt bioregions. 18-19 August 2010. Brisbane: Queensland Herbarium.

Davidson, C. (1993). Recovery Plan for the Collared Legless Lizard (*Delma torquata*). Page(s) 1-10. Brisbane, Queensland: Department of Environment and Heritage.

Department of Environment and Energy (2018). *Delma torquata* (Adorned Delma/Collared Delma) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1656 [Accessed 22 August 2018].

Peck, S. and R. Hobson. (2007). Survey results and management options for the Collared delma (*Delma torquata*) along the proposed Toowoomba Bypass, Toowoomba Range, Southeast Queensland, November 2006. Queensland Parks and Wildlife Service.

Porter, R. (1998). A preliminary field investigation of the Collared delma Delma torquata (Reptilia: Pygopodidae). Queensland: Lone Pine Koala Sanctuary.

Richardson, R. (2006). Queensland Brigalow Belt Reptile Recovery Plan 2008 – 2012, Report to the Department of the Environment, Water, Heritage and the Arts, Canberra. WWF-Australia, Brisbane.

Santos. (2012). GLNG Project. Available from: https://www.santos.com/media/3820/significant-species-management-plan-smmp-part-2-p.pdf [Accessed 22 August 2018].

Schell, C and J. Stark (2017). Personal observations of *Delma torquata* associated with the implementation of the Collared Delma translocation Management Plan for the Toowoomba Second Range Crossing Project.

Steve Wilson. (2018). Arkive - Collared delma (*Delma torquata*). Available from: https://www.arkive.org/collared-delma/delma-torquata/image-G82236.html [Accessed 22 August 2018].

3.2 Condamine earless dragon (*Tympanocryptis condaminensis*)

3.2.1 Status

EPBC Act – Endangered

3.2.2 Biology and ecology

3.2.2.1 Characteristics

The Condamine earless dragon (*Tympanocryptis condaminensis*) is a small, plump, spiny earless dragon lizard that grows to an average size of 12 cm. The species colour ranges from reddish-brown to almost black with prominent pale banding of brown-black or white (no image available). The throat and chin of the Condamine earless dragon can be yellow and marbled with black. Its body colour affords the species good camouflage in their environment (DES 2017).

Currently limited information is known about the difference in gender and life stages (juveniles or adults) of Condamine earless dragon. However, studies of similar species in the Agamidae family have identified males tend to be more animated than females as well as having a set of distinct pre-anal pores between the back legs and hemi-penal bulges at the vent area (Phipps and Titmuss 2006).

3.2.2.2 Known distribution

The known distribution of the Condamine earless dragon is within the eastern Darling Downs region in southeast Queensland (refer Figure 3.3). Condamine earless dragons are often found in the Condamine River floodplains surrounded by Jimbour in the northeast, Millmerran in the southwest, Clifton in the southeast and Toowoomba in the northeast with records from Oakey, Bongeen, Bowenville, Brookstead and Mt Tyson (TSSC 2016).

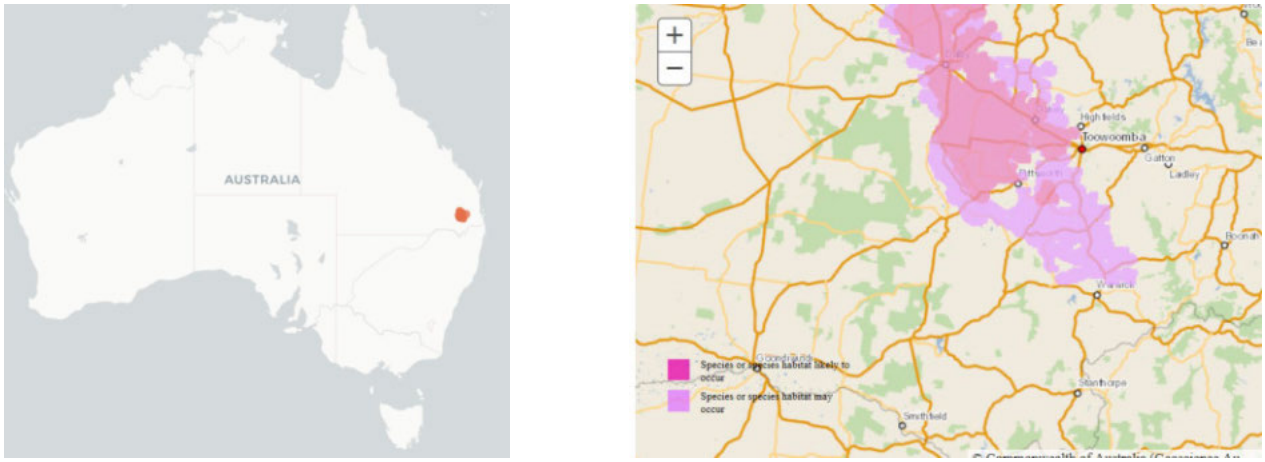


Figure 3.3 **Distribution range of the Condamine earless dragon**

Source: ALA (2018)

3.2.2.3 Distribution in relation to the project

Tympanocryptis condaminensis was not identified during any Project-associated surveys. There is a database record for Condamine earless dragon approximately 2 km south of the disturbance footprint in north Toowoomba from 2013. However, the location of this record is erroneous and it should be located in the Bongeen area (pers. comm. R. Hobson) over 35 km west of the Project. The nearest record is from 2008 and is located west of Oakey and approximately 23 km to the north-west of the Project disturbance footprint. Most records are concentrated on the Condamine River floodplain west of Toowoomba between 25 and 50 km south-west of the disturbance footprint between Jondaryan in the north and south to Pittsworth (refer Figure 3.4). The species is not confirmed to occur within the Toowoomba area.

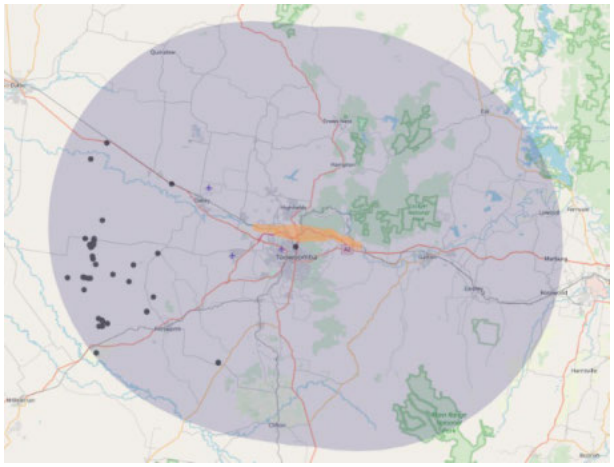


Figure 3.4 **Distribution range of the Condamine earless dragon in relation to the Project**

Source: ALA (2020)

3.2.2.4 Biology and reproduction

Knowledge of Condamine earless dragon diet is still limited, however it is thought the species feeds on small invertebrates with anecdotal evidence suggesting ants are a popular source of food (DES 2017).

Limited information is also known about the reproductive behaviour and biology of the Condamine earless dragon, but it has been observed males will take on their breeding colours, which are canary yellow at the throat and chin, during December and a gravid female was recorded in November (Melville et al. 2017).

All Agamidae species are known however to be oviparous and deposit their eggs in burrows with snout to vent length a measure of sexual maturity. Clutch size studies undertaken for the Eyrean earless dragon (*Tympanocryptis tetraporophora*), a species of the Tympanocryptis genus, was found to produce an average clutch size of 8 eggs. Body size of females was also found to be a strong determinant of clutch size (Uetz 2011).

3.2.3 Habitat

This dragon species appears to survive in areas that are intensely cropped and previously occupied as naturally treeless grassland. The dragon uses ballast, surface rocks and rocky outcrops as shelter, while cracks in the black clay of the Condamine River floodplain appear provide them with plenty of holes to seek alternate shelter when disturbed (DES 2017).

3.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Condamine earless dragon:

- Habitat loss due to development
- Soil degradation due to changed agricultural practices
- Predation by cats and foxes (Melville et al. 2017).

3.2.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Robertson, P. & M. Evans (2009). *National Recovery Plan for the Grassland Earless Dragon* Tympanocryptis pinguicolla. As varied October 2012. ACT Department of Territory and Municipal Services, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-grassland-earless-dragon-tympanocryptis-pinguicolla. In effect under the EPBC Act from 13-Aug-2010.

The following threat abatement plan is applicable to this species:

- Department of the Environment (2015). *Threat abatement plan for predation by feral cats*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

3.2.6 Summary of threat abatement/recovery plans

Important populations for the Grassland earless dragon includes:

- All extant populations
- All currently known, and subsequently discovered populations should be considered in conservation strategies for this species.

Summary of threats outlined in the National Recovery Plan for the Grassland Earless Dragon include:

- Habitat loss and fragmentation as a result of urban, industrial and agricultural development
- Degradation of existing habitat resulting from ploughing, inappropriate fire regimes, overgrazing, weed invasion, agricultural chemicals and rock removal
- Introduced animals including foxes, cats, rabbits, mouse, sheep and cows impacting the species as a result of predation or by grazing
- Threats to existing suitable habitat sites include airport modifications, railway expansion, new roads, road construction, industrial development, landfill extensions, urban or rural residential development
- Frequent fires and high intensity grazing particularly resulting in the loss of tussock grasses, which are used as shelter for the species
- Ploughing and cropping of grasslands

Summary of recovery actions outline in the National Recovery Plan for the Grassland Earless Dragon include:

- Determine the distribution and abundance of the species in order to define habitat critical to the survival of the species
- Maintain and improve the current abundance and distribution by better understanding the species through ecological research to enable effective management
- Better understand and address the threats faced by the species and their habitat so that impacts can be measured and abated
- Protect and manage suitable habitat
- Ongoing monitoring to enable adaptive management
- Salvage and translocate existing populations at sites that are not suitable for the long-term survival of the local population.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups

- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

3.3 Dunmall's snake (*Furina dunmalli*)

3.3.1 Status

EPBC Act – Vulnerable

3.3.2 Biology and ecology

3.3.2.1 Characteristics

Dunmall's snake (*Furina dunmalli*) is a small to medium-sized, venomous (family Elapidae), snake that typically grows to a length of up to 75 cm. It has a uniform dark grey-brown colour on the top of the body, which fades to white at its lower flanks and has 21 rows on the mid-section (no image available). Most of the scales near the upper lip exhibit pale blotches. The head is large and distinct from the neck (DES 2017).

3.3.2.2 Known distribution

Dunmall's snake is endemic to Australia and inhabits areas near the Queensland border within the Brigalow Belt South bioregion to the Nandewar bioregion in NSW (refer Figure 3.5). In Queensland, the snake is often found in areas 200 to 500 m above sea level with recorded sightings in Oakey and Inglewood. In NSW, the species is predominantly found in the northeast inland region (DotEE 2018).



Figure 3.5 **Distribution range of the Dunmall's snake**

Source: ALA (2018)

3.3.2.3 Distribution in relation to the project

Database records (i.e. ALA) indicate that no records of *Furina dunmalli* exist within the ecology study area. This species was not detected during Project associated field investigations. The closest record is located approximately 18 km northwest of the disturbance footprint in Oakey (not dated). No other records exist within a 50 km buffer of the alignment (refer Figure 3.6).

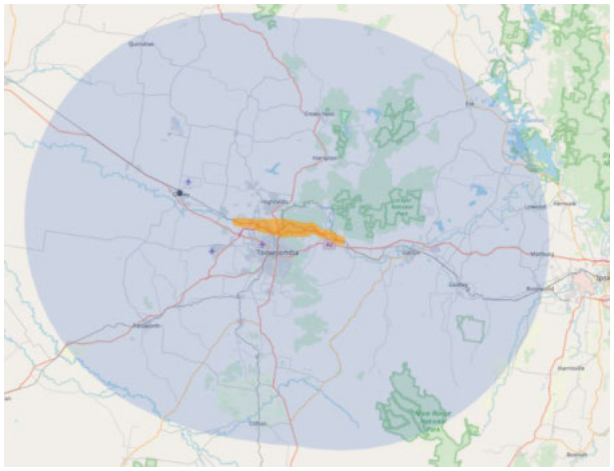


Figure 3.6 **Distribution range of the Dunmall's snake in relation to the Project**

Source: ALA (2020)

3.3.2.4 Biology and reproduction

Dunmall's snake are known to eat small lizards such as skinks and geckos. Analysis of the gut contents of this species yielded the remains of Tree skink (*Egernia striolata*). Limited knowledge is available on the snake's life cycle or reproductive behaviour, however, it is known that the species lays eggs rather than live young (DotEE 2018).

3.3.3 Habitat

Given the rarity, and difficulty of detecting Dunmall's snake, all suitable habitats (remnant or non-remnant vegetation) that are coincident with the known locations of the species are considered important habitats. Dunmall's snake has been found in a broad range of habitats, including:

- Forests and woodlands on black alluvial cracking clay and clay loams dominated by Brigalow (*Acacia harpophylla*), other Wattles (*A. burowii, A. deanii, A. leioclyx*), native Cypress (*Callitris* spp.) or Bull-oak (*Allocasuarina luehmannii*)
- Various Spotted gum (*Corymbia citriodora*), Ironbark (*Eucalyptus crebra* and *E. melanophloia*), White cypress pine (*Callitris glaucophylla*) and Bull-oak open forest and woodland associations on sandstone derived soils
- The edge of dry vine scrub near Tarong Power Station, Queensland, and hard ironstone country (Queensland RE Land Zone 7) at Lake Broadwater near Dalby, Queensland.

There is a paucity of information related to ecological requirements of this species, however it has been observed sheltering under fallen timber and ground debris, and is known to utilise cracks in alluvial clay soils (DES 2017; DotEE 2018).

3.3.4 Threatening processes

The following have been identified as potentially threatening processes to Dunmall's snake:

- Habitat loss and fragmentation due to land clearing in core areas of the Darling Downs
- Predation by feral animals such as foxes, cats and pigs
- Inappropriate road side management (DES 2017).

3.3.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species.

3.3.6 References

Atlas of Living Australia (2018). Furina dunmalli. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:9ba2edaa-574b-4c18-8503-d0b658b16cc4 [Accessed 2 September 2018].

Department of Environment and Energy (2018). Furina dunmalli (Dunmall's Snake) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59254 [Accessed 22 August 2018].

Department of Environment and Science (2017). Dunmall's snake. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/dunmalls_snake.html [Accessed 22 August 2018].

Wilson, S (n.d). Dunmall's snake. In. Shy snake is hard to spot. ABC Wide Bay Publication. Available from: http://www.abc.net.au/local/stories/2009/04/21/2548064.htm [Accessed 22 August 2018].

3.4 Long-legged worm-skink (*Anomalopus mackayi*)

3.4.1 Status

EPBC Act – Vulnerable

3.4.2 Biology and ecology

3.4.2.1 Characteristic

The Long-legged worm-skink, also called the Five-clawed worm skink (*Anomalopus mackayi*), is a burrowing skink, which is characterised by three fingers and two toes. This species typically grows to 27 cm long. It has smooth scales with an overall greyish-brown upper body, with dark spots in longitudinal rows. Its ventral surface is yellow-green with dark flecking (no image available). In the southern region of its range, this species is unpatterned, while in the north, it has longitudinal rows of dark spots on the dorsal and lateral surfaces (Cogger 2000; DotEE 2018).

3.4.2.2 Known distribution

The known distribution of the Long-legged worm-skink is patchy in north-eastern NSW and south-eastern Queensland (refer Figure 3.7). In south-eastern Queensland, the species' known distribution is on the upper Condamine River floodplain, from Warwick in the south, to the Jimbour region in the north, and bordered by the western edge of the granite belt (Brigalow Belt Reptiles Workshop 2010; DotEE 2018).



Figure 3.7 **Distribution range of the Long-legged worm-skink**

Source: ALA (2018)

3.4.2.3 Distribution in relation to the project

Anomalopus mackayi has been predicted to occur within the region and associated habitat within the Ecology study area. There is an older database record (1983) within the disturbance footprint near Gowrie Junction. The nearest records to this are at Oakey (1983) located 13.5 km west, and three records near Pittsworth (2002 and 2009) located 28 km south-west of the disturbance footprint (AoLA 2020). There are a number of records within 50 km to the west of the MNES study area on the Condamine River floodplain in the Cecil Plains area, and from Oakey to Dalby (refer Figure 3.8).

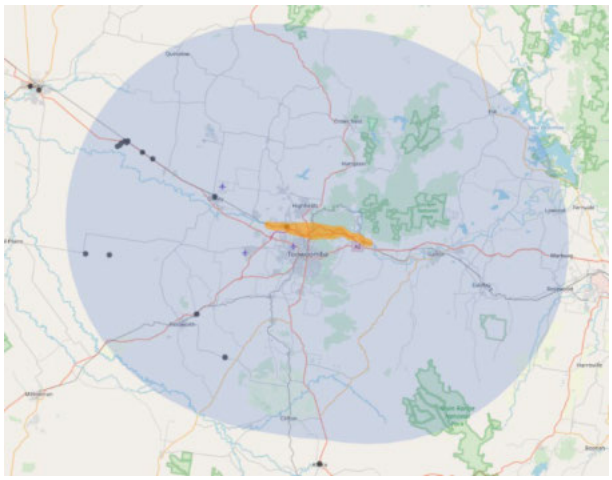


Figure 3.8 **Distribution range of the Long-legged worm-skink in relation to the Project**

Source: ALA (2020)

3.4.2.4 Biology and reproduction

Very little is known about the Long-legged worm-skink's reproduction and diet. However, it is believed to feed on arthropods, such as white ants and captive specimens have been recorded eating mealworms (Cogger et al. 1983; Shea et al. 1987).

Long-legged worm-skinks lay up to three eggs per clutch during Spring (Shea et al. 1987; Wilson and Knowles 1988; Ehmann 1992).

3.4.3 Habitat

The Long-legged worm-skink is known to occur in both remnant and non-remnant woodlands and grasslands, and in areas modified by agriculture and other human activities. It is typically found under timber, leaf litter and other debris. It is also known to inhabit rotting tree base cavities, logs and tussock bases. This species has been found sheltering under artificial materials lying flat on the ground, such as discarded railway sleepers, sheet metal and hay bales. On the Darling Downs, the species occurs in Bluegrass (*Dichanthium sericeum*) and/or Mitchell Grass (*Astrebla* spp.) dominated grasslands, or mixed grasslands dominated by other grass species (Brigalow Belt Reptiles Workshop 2010; DotEE 2018).

3.4.4 Threatening processes

The following have been identified as potentially threatening processes to the Long-legged worm-skink:

- Land clearing for agriculture has been particularly severe within the Long-legged worm-skink's range
- Overgrazing compacts soil making it difficult for the species to find suitable shelter
- Removal of logs and timber also reduces soil humidity and the amount of shelter available for the species. Agricultural chemicals may poison and pollute the soil which may adversely affect the species
- Predation by feral species, such as cats and foxes, is another threat facing much of Australia's native wildlife including the Long-legged worm-skink (Brigalow Belt Reptiles Workshop 2010; NSW NPWS 1999).

3.4.5 Threat abatement/recovery plans

No threat abatement/recovery plan exist for this species. The following recovery plan s are relevant to this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10055. In effect under the BC Act 2016.
- Department of Environment, Climate Change and Water NSW (2010). *National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Department of Environment, Climate Change and Water NSW, Sydney. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/white-box-yellow-box-blakelys-red-gum-grassy-woodland-and-derived-native-grassland-national. In effect under the EPBC Act from 22-Mar-2013.

The following threat abatement plan is relevant to this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

3.4.6 Summary of threat abatement/recovery plans

Anomalopus mackayi is assigned as a data-deficient species under the NSW *Saving our Species Program* as there is little known about the ecology and habitat requirements of this species. State wide conservation actions identified for this species include:

- Encourage community education, awareness and involvement
- Encourage landholders to enter voluntary conservation and site management agreements
- Create corridors to reduce isolation of known population sites
- Protect or fence areas to create high quality habitat that sustains a significant population or foraging area
- Develop and test artificial refuge habitat as an interim protection measure

- Monitor the species for movement patterns, habitat range, success of management actions and for new threats at the site, movement pa
- Develop a successful technique to survey
- Identify two targeted populations annually to focus recovery actions on
- Conduct fox baiting

Threats identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Land use and management change
- Agricultural and horticultural development
- Public Infrastructure upgrades in travelling stock routes (TSRs)
- Firewood collection and 'tidying up'
- Changed fire regimes
- Increase in soil nutrients and use of chemicals
- Mowing and slashing regimes
- Revegetation management
- Weed invasion
- Climate change
- Salinity
- Acid soils
- Declining tree health and regeneration
- Increased grazing pressure from invasive herbivores
- Disease – *Phytophthora cinnamomi*
- Collection and removal of native flora.

Recovery actions identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Collect baseline data on the locations, quality and management regimes of remnant sites
- Extent and condition mapping
- Component species surveys
- Protection of existing habitat in priority areas including on private land
- Engagement with the community, particularly where remnants occur on private land to provide information on appropriate management and with Aboriginal communities.

Summary of baseline information actions undertaken to date:

- The establishment of databases comprising of information on CMN members (land managers with Box-Gum Grassy Woodland remnants), remnant locations, composition of flora and fauna species and remnant condition from surveys of CMN members' sites and other sites
- Minimum condition criteria and assessment method developed to assist land managers in identification of listed ecological communities
- Development of regional models using remote sensing
- Mapping of Box-Gum Grassy Woodland extent
- Surveys conducted during research programs through various organisations.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

3.4.7 References

Atlas of Living Australia (2018). *Anomalopus mackayi*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:bcbb3f69-0f90-4b6d-a062-218439a61a51 [Accessed 23 August 2018].

Brigalow Belt Reptiles Workshop (2010). Proceedings from the workshop for the nine listed reptiles of the Brigalow Belt bioregions. 18-19 August. Brisbane: Queensland Herbarium.

Cogger H.G. (2000). *Reptiles and Amphibians of Australia*, (6th edition) Ralph Curtis Books, NSW

Department of the Environment and Energy (2018). *Anomalopus mackayi* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=25934 [Accessed 23 August 2018].

Dolley, C (n.d.). Photograph: Long-legged worm-skink, Department of National Parks, Sport and Racing, (Image) [Online] Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/longlegged_wormskink.html [Accessed 23 August 2018].

Ehmann, H. (1992). Encyclopaedia of Australian Animals: Reptiles. Angus and Robertson: Sydney

NSW National Parks and Wildlife Service (1999). *Five-clawed Worm-skink - Threatened Species Information*. Available from: http://www.environment.nsw.gov.au/resources/nature/tsprofileFiveclawedWormskink.pdf

Shea, G.M., Millgate M. and Peck S. (1987). A range extension for the rare skink *Anomalopus mackayi. Herpetofauna.* 17 (2):16-19.

Wilson, S.K. and Knowles, D.G. (1988). Australia's Reptiles A Photographic Reference to the Terrestrial Reptiles of Australia. Collins: Sydney.

3.5 Three-toed snake-tooth skink (*Coeranoscincus reticulatus*)

3.5.1 Status

EPBC Act – Vulnerable

3.5.2 Biology and ecology

3.5.2.1 Characteristic

The Three-toed snake-tooth skink (*Coeranoscincus reticulatus*) has reduced limbs, each with three digits and a total length of approximately 483 to 565 mm. Adults are usually dark around the eyes and ears with a distinct wedge-shaped, pointed pale snout. Dorsal colour in adults is generally brown to yellowish brown or grey with a dark brown collar (no image available). Individual flecked scales have dark brown streaks and there are small, dark brown scattered spots on the back and streaks on the throat. Ventral scales are normally greyish and dark-edged to form a fine reticulum-like pattern (DotEE 2018).

Juveniles are cream to brown dorsally with prominent, irregular transverse dark bands that are more conspicuous on the anterior and often absent on the posterior. In juveniles the scales on the sides of the body are dark-edged, forming irregular longitudinal streaks (DotEE 2018).

3.5.2.2 Known distribution

The Three-toed snake-tooth skink occurs from Crescent Head in northeast NSW to Fraser Island in southeast Queensland. Most records are from the Border Ranges in the vicinity of the NSW/Queensland border (refer Figure 3.9). In Queensland, the Three-toed Snake-tooth skink has a disjunct north-south distribution, with the species absent from apparently suitable habitat in the D'Aguilar Ranges, between the lowland areas of Fraser Island and Cooloola and upland records from Blackall Range and Conondale Range (DotEE 2018).

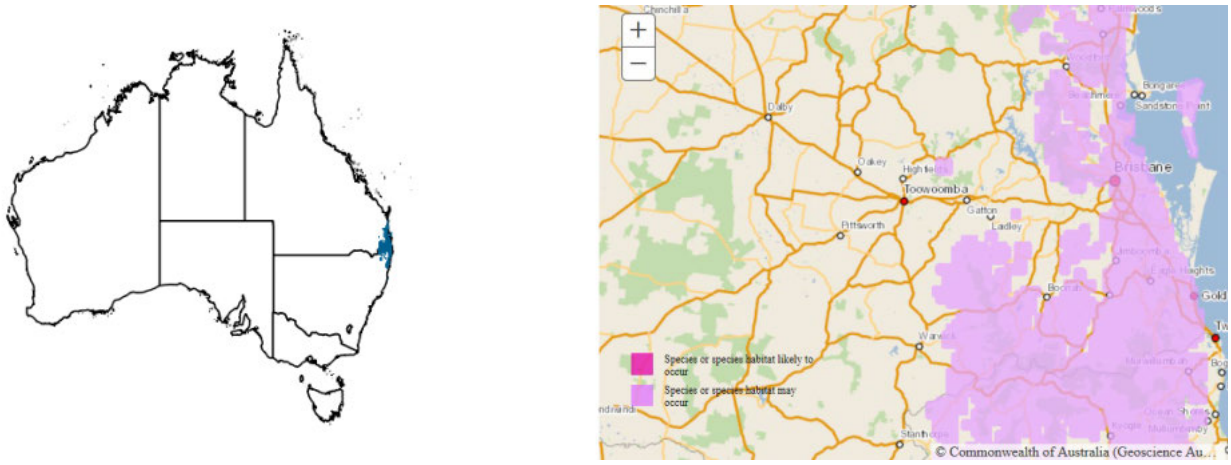


Figure 3.9 **Distribution range of the Three-toed snake-tooth skink**

Source: ALA (2018), DotEE (2018)

3.5.2.3 Distribution in relation to the project

Coeranoscincus reticulatus has been identified as potentially occurring within the ecology study area. Data records (i.e. ALA) indicate no records of *Coeranoscincus reticulatus* exist within the ecology study area. The closest records are located approximately 48 km southeast of the disturbance footprint in Glen Rock State Forest and are dated 1992. A number of records exist beyond a 50 km buffer of the disturbance footprint, approximately 55 km to the southeast of the alignment in Glen Rock State Forest (refer Figure 3.10).

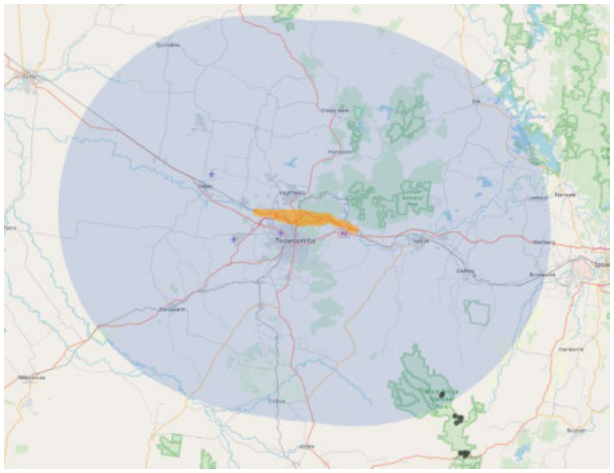


Figure 3.10 **Distribution range of the Three-toed snake-tooth skink in relation to the Project**

Source: ALA (2020)

3.5.2.4 Biology and reproduction

Examination of the Three-toed snake-tooth skink's stomach contents indicates that they eat earthworms, beetle larvae and insects. It is believed that they encounter earthworms on the forest floor at night and in the loose soil that the skink burrows (DotEE 2018).

Females of the Three-toed snake-tooth skink have been recorded with 2 to 6 oviducal eggs. Records show that eggs (23.7 to 28.9 mm) are large for a skink of this size (DotEE 2018).

3.5.3 Habitat

The Three-toed snake-tooth skink has been found in loose, well mulched friable soil, in and under rotting logs, forest litter, bark and under decomposing cane mulch. In Queensland, the Three-toed snake-tooth skink has been recorded in rainforest, closed forest, wet sclerophyll forest, tall open Blackbutt forest, tall layered open eucalypt forest and closed Brush Box forest and regrowth in heavily logged areas. In NSW, the Three-toed snake-tooth skink has been recorded in dry rainforest, northern warm temperate rainforest, subtropical rainforest, grassy wet sclerophyll forest and shrubby sclerophyll forest (DotEE 2018; OEH 2018).

3.5.4 Threatening processes

The following have been identified as potentially threatening processes to the Three-toed snake-tooth skink:

- Clearing of habitat for agriculture and grazing,
- Removal of fallen logs and leaf litter through frequent fire
- Soil compaction from livestock grazing
- The domestic cat and the red fox are also known to prey on skinks (DotEE 2018; OEH 2018).

3.5.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=316&ReportProfileID=10131. In effect under the BC Act 2016.

3.5.6 Summary of threat abatement/recovery plans

Coeranoscincus reticulatus is assigned to the landscape species management under the NSW *Saving our Species Program* as it is distributed over a large area and is subject to threatening processes that effect at the landscape scale.

Threats identified in the Saving our Species program include:

- Alterations to fire regime resulting in a loss of habitat within rainforest (considered to be an emerging threat due to climate change)
- Grazing stock causing loss of leaf litter and compaction of soil
- Firewood collection resulting in reduced habitat in fallen logs and leaf litter
- Habitat degradation, loss of shelter and forage habitat through feral pig activity

Management activities to protect this species at the sites are:

- Raise awareness with relevant landholders and reduce deliberate burning that is likely to affect this species
- Promote strategic grazing that maintains the structure and function of the ground layer
- Educate private and commercial firewood collectors on the importance of retaining woody debris in areas of known habitat
- Identify important areas of habitat within state forests so disturbance to the ground layer can be minimised
- Monitor pig activity in the species habitat and control via cage trapping and/or poison ground-baiting.

3.5.7 References

Atlas of Living Australia (2018). *Saiphos reticulatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:25b1747b-a67b-4603-9d13-e98da9a0122e#overview [Accessed 23 August 2018].

Department of the Environment and Energy (2018). *Coeranoscincus reticulatus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59628 [Accessed 23 August 2018].

Lewis Ecological (2016). *Additional Crossing of Clarence River at Grafton: Biodiversity Gap Field Survey (Stage 2) March 2016*. Available from: http://www.rms.nsw.gov.au/documents/projects/northern-nsw/grafton-clarence-river-crossing/biodiversity-gap-field-survey-2016-03.pdf [Accessed 23 August 2018].

Office of Environment and Heritage, NSW (2018). *Three-toed Snake-tooth Skink - profile*. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10172 [Accessed 23 August 2018].

3.6 Yakka skink (*Egernia rugosa*)

3.6.1 Status

EPBC Act – Vulnerable

3.6.2 Biology and ecology

3.6.2.1 Characteristic

The Yakka skink (*Egernia rugosa*) is a pale fawn reptile growing up to 40 cm long. It has a broad dark brown to black stripe from nape to tail bordered on either side by a narrow, pale fawn back/side stripe. Dark brown to pale brown to reddish-brown scales on the flanks form a faintly variegated orange-brown pattern (refer Photograph 3.2). The throat is cream-yellow in colour, with blackish flecks/spots, and the chest and abdomen are yellow-orange. Mid-body scales are in rows of 26 to 30 (DotEE 2018; DES 2017).



Photograph 3.2 **Yakka skink (*Egernia rugosa*)**

Source: Farquhar (2017)

3.6.2.2 Known distribution

The known distribution of the Yakka skink extends from the coast to the hinterland of sub-humid to semi-arid eastern Queensland. Locations range from the Queensland/NSW border to the Brigalow Belt (North and South), Mulga Lands, Einasleigh Uplands and up to Cape York Peninsula (Brigalow Belt Reptiles Workshop 2010; DotEE 2018) (refer Figure 3.11).



Figure 3.11 **Distribution range of the Yakka skink**

Source: ALA (2018), DotEE (2018)

3.6.2.3 Distribution in relation to the project

Egernia rugosa has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that no records of *Egernia rugosa* exist within the ecology study area or within a 50 km buffer of the disturbance footprint. The closest record is located approximately 70 km northwest of the disturbance footprint in Bunya Mountains National Park and is dated 1994. A number of records exist further from the alignment to the northwest in the surrounds of Chinchilla (refer Figure 3.12).

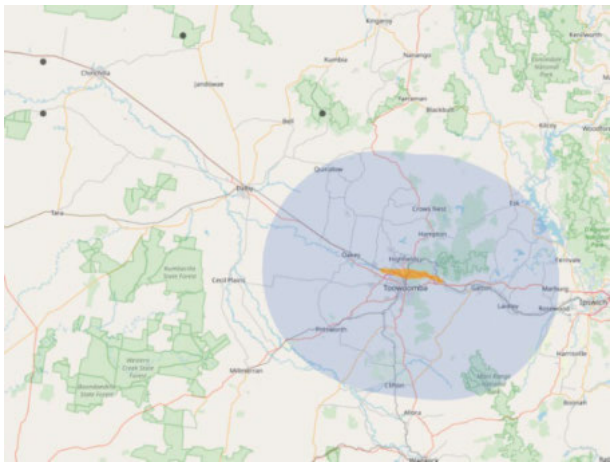


Figure 3.12 **Distribution range of the Yakka skink in relation to the Project**

Source: ALA (2020)

3.6.2.4 Biology and reproduction

The Yakka skink is omnivorous, consuming soft plant materials and fruits and a wide variety of invertebrates which they ambush from their burrows (TSN 2008).

The Yakka skink produces live young, with around six per litter. They are highly gregarious, with populations occurring primarily as colonies or aggregations. The breeding season for this species has not been recorded (QLD DERM 2010; TSN 2008).

3.6.3 Habitat

The Yakka skink is known to occur in open dry sclerophyll forest, woodland and scrub. It occurs in several different vegetation types within a wide variety of Queensland Regional Ecosystem Land Zones from alluvium (river and creek flats) to sandstone ranges (LZs 3, 4, 5, 7, 8, 9, 10). The Yakka skink is commonly found in vegetation types such as Brigalow, Mulga, Bendee, Lancewood, Belah, Poplar Box, Ironbark and White Cypress Pine (Brigalow Belt Reptiles Workshop 2010; DotEE 2018; QLD DERM 2010).

The Yakka skink is commonly found in cavities under and between partly buried rocks, hollow logs or tree stumps, root cavities and abandoned animal burrows. The species is known to excavate deep burrow systems, sometimes under dense ground vegetation (Brigalow Belt Reptiles Workshop 2010; DotEE 2018, TSN 2008).

3.6.4 Threatening processes

The following have been identified as potentially threatening processes to the Yakka skink:

- Habitat reduction and degradation due to agricultural and urban development
- Inappropriate roadside management
- Feral animal impacts include predation by Red foxes and Feral cats and the ripping of rabbit warrens (DotEE 2018; TSN 2008).

The Yakka skink exhibits high site-fidelity, low fecundity and are long-lived which makes the species susceptible to potential population crashes or local extinctions given large environmental disturbances (Brigalow Belt Reptiles Workshop 2010).

3.6.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species

3.6.6 References

Atlas of Living Australia (2018). *Egernia rugosa*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:b3a63292-e63d-480d-b2ba-6ea3d3924d74 [Accessed 23 August 2018].

Brigalow Belt Reptiles Workshop (2010). Proceedings from the workshop for the nine listed reptiles of the Brigalow Belt bioregions. 18-19 August. Brisbane: Queensland Herbarium.

Department of the Environment (2008). Yakka skin *Egernia rugosa* (Image) [Online] Available from: https://www.environment.gov.au/system/files/resources/d91e2790-b7a9-482c-a4eb-4c02a2e89920/files/tsday08-skink.pdf [Accessed 23 August 2018].

Department of the Environment and Science (2017). Yakka skink. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/yakka_skink.html. [Accessed 23 August 2018].

2019Queensland Department of Environment and Resource Management (2010). *Wildlife and Ecosystems-Yakka Skink*. Available from: http://www.derm.qld.gov.au/wildlife-ecosystems/wildlife/az_of_animals/yakka_skink.html [Accessed 23 August 2018].

Threatened Species Network (2008). *Yakka Skink;* Egernia rugosa*; National Threatened Species Day Information Sheet*. World Wildlife Foundation; Threatened Species Network; Department of the Environment, Water, Heritage and the Arts. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tsday08-skink.html [Accessed 23 August 2018].

4 Fauna species – Conservation significant species – Mammals

4.1 Brush-tailed rock-wallaby (*Petrogale penicillata*)

4.1.1 Status

NC Act – Vulnerable

4.1.2 Biology and ecology

4.1.2.1 Characteristic

The male Brush-tailed rock-wallaby (*Petrogale penicillata*) is typically larger than the female and generally weigh 5.5 to 10.9 kg with females weighing 4.9 to 8.2 kg. Males grow to 529 to 586 mm and females to 510 to 570 mm in head-body length. Individuals are brown above, tending to be rufous on the rump and grey on the shoulders. Typically, the chest and belly is paler, with some individuals possessing a white blaze on the chest. The Brush-tailed rock-wallaby has a white to buff cheek stripe and a black dorsal stripe from the forehead to the back of the head. The exterior of the ears is black, and inside the ears is buff (refer Photograph 4.1). Individuals from the north of the species range tend to be lighter and have a less prominent tail brush (DotEE 2018; Eldridge and Close 1998).



Photograph 4.1 Brush-tailed rock-wallaby

Source: Bryant (2019)

4.1.2.2 Known distribution

Populations of the Brush-tailed rock-wallaby occur throughout the Great Dividing Range from the border with NSW to Nanango, 100 km northwest of Brisbane (refer Figure 4.1). Although there are no recent surveys published from Queensland, this species is considered to be declining and vulnerable, with the population in Lamington National Park now considered to be extinct (Clancy and Close 1997; Eldridge and Close 1992; Maxwell et al. 1996).



Figure 4.1 **Distribution range of the Brush-tailed rock-wallaby**

Source: ALA (2018)

4.1.2.3 Distribution in relation to the project

Petrogale penicillata has not been recorded during Project-associated surveys or surveys for the TSRC project. Database records (ALA 2020) indicate this species has been recorded from the Toowoomba Range 2 km north of the alignment (two records from 1978). To the east of the alignment there is a record north of Helidon from 1996 (3 km east). There is a 1997 and 2004 record located in Helidon Hills to the north-east of the eastern extent of the alignment (6 km and 12 km north-east). Other database records exist to the north of the eastern end of the alignment in or near Ravensbourne National Park and Crows Nest National Park (over 14 km north of the Project). To the west there is a single 2018 record from Gowrie Mountain (2.7 km south of the western extent of the Project) although the source of this record cannot be verified. There are no records in the Toowoomba Range to the south of the Project (refer Figure 4.2).

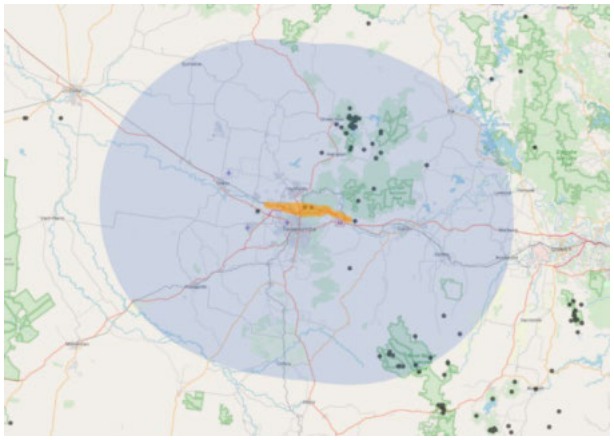


Figure 4.2 **Distribution range of the Brush-tailed rock-wallaby in relation to the Project**

Source: ALA (2020)

4.1.2.4 Biology and reproduction

The diet of the Brush-tailed rock-wallaby consists primarily of grasses (35 to 50%), forbs (25 to 40%) and "browse" (shrubs, trees and climbers) (12 to 30%) with ferns and sedges constituting a very minor component. Brush-tailed rock-wallabies typically forage at night (Jarman and Phillips 1989; NSW NPWS 2003; Short 1989).

Sexual maturation of females occurs at 18 months and males at 20 to 24 months. Brush-tailed rock-wallabies are a polygamous species and a dominant male will be found with up to four females. They appear to live in family groups of two to five adults and usually one or two juveniles and sub-adult individuals, but are also known to occur in male-female pairs (DEC 2005; DES 2018; Lee and Ward 1989; Joblin 1983; Short 1980).

Females give birth to one pouch young at a time, after a gestation period of approximately 30 days. The young remain in the pouch for six months. Weaning is believed to occur 86 days after leaving the pouch, when the joey is nine months old (Close 1993; Lee and Ward 1989).

4.1.3 Habitat

The Brush-tailed rock-wallaby prefers rocky habitats, including loose boulder-piles, rocky outcrops, steep rocky slopes, cliffs, gorges and isolated rock stacks. However, it is also known to use tree limbs (Sharman and Maynes 1983; Short 1982; Maxwell et al. 1996; Murray et al. 2008)

Rocky outcrops appear crucial to current habitat selection by rock-wallabies, however, vegetation structure and composition is also considered to be an important factor determining habitat suitability. In many parts of their range, including at the Warrumbungles, Brush-tailed rock-wallabies are closely associated with dense arboreal cover, especially fig trees. The vegetation on and below the cliff appear to be important to this species as a source of food and shelter and in some cases may provide some protection from predation. A range of vegetation types are associated with Brush-tailed rock-wallaby habitat, including dense rainforest, wet sclerophyll forest, vine thicket, dry sclerophyll forest, and open forest (NSW NPWS 2003; Murray et al. 2008; Wong 1993; 1997).

Brush-tailed rock-wallabies are known to shelter during the day in rock crevices, caves and overhangs, but have been observed to bask in exposed sunny spots. Within their home range, rock-wallabies habitually use the same refuges, sunning spots, feeding areas and pathways and these are often defended vigorously (Bayne 1994; Joblin 1983; Sharman and Maynes 1983).

Brush-tailed rock-wallabies select foraging locations that tend to be more open and with a greater abundance of short green grasses and forbs than other locations nearby. Foraging Brush-tailed rock-wallabies do not favour areas that are concealed by tussocks or near to the cliffs (Carter and Goldizen 2003).

4.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Brush-tailed rock-wallaby:

- Habitat modification continues due to rural, residential and tourist developments have led to changes in vegetation structure, extent, species assemblages and species proportions (DEC 2005)
- Other impacts also include changed fire regimes, competition from exotic herbivores, land degradation, altered nutrient status, and even altered behaviour and numbers of other native animals (DEC 2005)
- The invasion of grassy feeding areas by weed species such as Lantana is thought to reduce habitat quality for the species (Capararo and Beynon 1996; NSW NPWS 2003; Wong 1997)
- Predation from domestic cats, red foxes and wild dogs are known threats to *P. penicillata* (Capararo and Beynon 1996; NSW NPWS 2003; Wong 1997)
- Brush-tailed rock-wallabies are found in small, fragmented populations which exhibit low migration rates and are highly vulnerable to local catastrophes, predations, inbreeding and the associated loss of genetic variation (DEC 2005)
- Bioclimatic changes resulting in lower rainfall and a decline in rainforest vegetation, may have contributed to the recently contracting distribution of *P. penicillata* throughout its range (Bugg 1995; DEC 2005).

4.1.5 Threat abatement/recovery plans

The following threat abatement plans have been identified as being relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment and Energy (2016). Threat abatement plan for competition and land degradation by rabbits. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for competition and land degradation by unmanaged goats. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-unmanaged-goats. In effect under the EPBC Act from 01-Oct-2008.

The following recovery plan has been identified as being relevant to this species:

- Menkhorst, P. & E. Hynes (2010). National Recovery Plan for the Brush-tailed Rock-wallaby Petrogale penicillata. Department of Sustainability and Environment, East Melbourne. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/brush-tailed-rock-wallaby-petrogale-penicillata. In effect under the EPBC Act from 10-Feb-2012.

4.1.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

Threats identified in the threat abatement plan for competition and land degradation by rabbits includes:

- Competition with native wildlife for food and shelter
- Prevention of plant regeneration
- Increased grazing pressure and damage to native vegetation
- Altering the regular process of plant succession
- Altering ecological communities and impacting soil structure and nutrient cycling contributing to serious erosion
- Increasing predation and reducing reproduction for native arboreal mammals and birds through the removal of critical habitat.

Threat abatement actions for rabbits include:

- Supress rabbit populations at the landscape scale below thresholds in identified priority areas
- Gain a better understanding of the impacts rabbits have and their interactions with other species and ecological processes
- Increase the effectiveness of rabbit control programs
- Increase engagement within the local community to provide awareness of the environmental impact of rabbits and the need for integrated control.

Threats identified in the threat abatement plan for competition and land degradation by unmanaged goats relevant this species include:

- Overgrazing by goats and resulting soil erosion
- Introduction of weeds through seeds carried in their dung.

The primary focus of the abatement plan is the control of unmanaged goat populations. The main objectives of controlling unmanaged goats are:

- Prevent unmanaged goats from occupying new areas in Australia and eradicate them from high-conservation value areas
- Promote the maintenance and recovery of native species and ecological communities that are affected by competition and land degradation by unmanaged goats
- Improve knowledge and understanding of unmanaged goat impacts and interactions with other species and other ecological processes
- Improve the effectiveness, target specificity, integration and humaneness of control options for unmanaged goats
- Increase awareness of all stakeholders of the objectives and actions of threat abatement plan, and of the need to control unmanaged goats.

The conservation strategy for National Recovery Plan for the Brush-tailed Rock-wallaby Petrogale penicillata identifies the following priority management sites:

- Victoria: Grampians Range - Moora Moora Creek (Grampians National Park)
- Victoria: East Gippsland – Little River Gorge (Snowy River National Park)
- New South Wales: Warrumbungle Range
- New South Wales: Mt Kaputar
- New South Wales: Wollemi National Park and Jenolan Caves
- New South Wales: Nattai National Park
- New South Wales: Shoalhaven
- New South Wales: Macleay Gorges region.

Threats outlined in the conservation strategy for National Recovery Plan for the Brush-tailed Rock-wallaby *Petrogale penicillate* include:

- Historical hunting and persecution for fur and meat
- Habitat degradation and loss
- Predation from native and feral species
- Competition with native and introduced herbivores
- Decline in genetic diversity.

Objectives and actions outlined in the conservation strategy for National Recovery Plan for the Brush-tailed Rock-wallaby *Petrogale penicillate* include:

- Determine threats faced by the species

- Determine current distribution, abundance and population trends
- Establish and maintain a captive population
- Perform translocations to improve the genetic robustness of existing populations
- Investigate key ecological and biological aspects of the species for conservation management
- Increase community awareness and support for the species' conservation.

4.1.7 References

Atlas of Living Australia (2018), *Petrogale penicillata.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7a7a2817-26e7-44bd-bb34-1dc9c1ed4d38 [Accessed 21 August 2018].

Bayne, P. (1994). Behaviour of the Brush-tailed rock-wallaby, *Petrogale penicillata*, and the recognition of individuals. *Master of Natural Resources*. M.Sc. Thesis. University of New England.

Bryant, A. (2019). Petrogale penicillate – Brush-tailed rock-wallaby. [image] [online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7a7a2817-26e7-44bd-bb34-1dc9c1ed4d38#gallery. [16 September 2019].

Bugg, A. (1995). Brush-tailed Rock-wallaby *Petrogale penicillata*. Habitat Assessment using Spatial analysis: The application of Geographic Information Systems and Remote Sensing to Wildlife Survey and Management. *BSc (Hons) Thesis*. Australian National University, Australia.

Capararo, S.M. and Beynon F. (1996). Ground Surveys of Brush-tailed Rock-wallaby (*Petrogale penicillata*) colonies in southern NSW. *Unpublished report to NSW National Parks and Wildlife Service.*

Carter, K and Goldizen A. W. (2003). Habitat choice and vigilance behaviour of brush-tailed rock-wallabies (*Petrogale penicillata)* within their nocturnal foraging ranges. Wildlife Research. 30 4:355-364.

Clancy, T.F. and Close R.L. (1997). The Queensland rock-wallabies - an overview of their conservation status, threats and management. Australian Mammalogy. 19: 169-174.

Close, R.L. (1993). *Brush-tailed rock-wallaby*. Royal Zoological Society Series on NSW Mammals.

Department of Environment and Conservation (2005). Draft Recovery Plan for the Brush-tailed rock-wallaby, *Petrogale penicillata*. Sydney, NSW: Department of Environment and Conservation.

Department of the Environment and Energy (2018). *Petrogale penicillata* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=225 [Accessed 21 August 2018].

Eldridge, M.D.B. and Close R.L. (1992). 'Taxonomy of Rock Wallabies, Petrogale (Marsupialia: Macropodidae). I. A Revision of the Eastern Petrogale with the Description of Three New Species'. Australian Journal of Zoology. 40:605-625.

Eldridge, M.D.B. and Close R.L. (1998). *'Brush-tailed rock-wallaby, Petrogale penicillata'*. R Strahan, ed. The Mammals of Australia (rev. edn). NSW: New Holland Publishers Pty Ltd.

Fergus, G (1994). *Brush-tailed rock-wallaby* (Image) [Online] Available from: http://thewebsiteofeverything.com/animals/mammals/Diprotodontia/Macropodidae/Petrogale/Petrogale-penicillata.html [Accessed 21 August 2018].

Jarman, P.J. and Phillips C.M. (1989). Diets in a community of macropod species. In: Grigg, G., P. Jarman and I. Hume, eds. Kangaroos, Wallabies and Rat-kangaroos. 1:143-149. Chipping Norton, NSW: Surrey Beatty and Sons.

Joblin, K.P.W. (1983). *Behaviour and ecology of the brushtailed rockwallaby, Petrogale penicillata, in the New England Region*. MNatRes Thesis. M.Sc. Thesis. Department of Ecosystem Management, University of New England, Armidale.

Lee, A.K. and Ward S.J. (1989). *'Life histories of macropodoid marsupials'*. GC Grigg et al, ed. Kangaroos, Wallabies and Rat-kangaroos. 1. Sydney: Surrey Beatty and Sons.

Maxwell, S., Burbidge A.A. and Morris K. (1996). *The 1996 Action Plan for Australian Marsupials and Monotremes*. [Online]. Wildlife Australia, Environment Australia. Available from: http://www.environment.gov.au/resource/action-plan-australian-marsupials-and-monotremes [Accessed 21 August 2018].

Murray, J.V., Low Choy S., McAlpine C.A., Possingham H.P., Goldizen A.W. (2008). The importance of ecological scale for wildlife conservation in naturally fragmented environments: A case study of the Brush-tailed rock-wallaby (*Petrogale penicillata*). Biological Conservation. 141 (1):7-22.

New South Wales National Parks and Wildlife Service (2003). Warrumbungle Brush-tailed rock-wallaby Endangered Population Recovery Plan.

Sharman, G.B. and Maynes G.M. (1983). Rock-wallabies. In: Strahan R., ed. Complete Book of Australian Mammals. Sydney: Angus and Robertson.

Short, J. (1980). Ecology of the Brush-tailed rock-wallaby (*Petrogale penicillata*, Griffith, Smith and Pidgeon). Unpublished Msc Thesis. M.Sc. Thesis. University of Sydney.

Short, J. (1982). Habitat requirements of the Brush-tailed rock-wallaby, *Petrogale penicillata*, in New South Wales. Australian Wildlife Research. 9: 239-246.

Short, J. (1989). The diet of the Brush-tailed rock-wallaby in New South Wales. *Australian Wildlife Research*. 16:Nov-18.

Wong, V. (1993). 'The Brush-tailed rock-wallaby (*Petrogale penicillata*) in western Victoria'. *Victorian Naturalist*. 88:92-102.

Wong, V. (1997). *The Shoalhaven Brush-tailed Rock-wallabies; surveys and monitoring*, Jan-Mar 1997. Unpublished report to the NSW National Parks and Wildlife Service.

4.2 Greater glider (*Petauroides volans*)

4.2.1 Status

EPBC Act – Vulnerable

4.2.2 Biology and ecology

4.2.2.1 Characteristic

The Greater glider (*Petauroides volans*) is the largest species of gliding possum with a head-body length of 350 to 460 mm and a long furry tail measuring 450 to 600 mm. It has large ears fringed with thick fur and a gliding membrane which attaches to the elbows and ankles. Its thick fur is white or cream below but the upperparts can vary from dark grey to dusky brown through to light mottled grey and cream (refer Photograph 4.2). It also has strongly reflective eyeshine in the beam of a spotlight (Menkhorst and Knight 2011; OEH 2018).



Photograph 4.2 Greater glider (*Petauroides volans*)

Source: Bowell (2019)

4.2.2.2 Known distribution

The Greater glider occurs in Eucalypt forests along the ranges and coastal plains of eastern Australia from Central Victoria near Daylesford to the Windsor Tablelands in far northern Queensland (refer Figure 4.3). It has an elevational range from sea level to 1,200 m above sea level (OEH 2018; TSSC 2016).



Figure 4.3 Distribution range of the Greater glider

Source: ALA (2018)

4.2.2.3 Distribution in relation to the project

Petauroides volans volans has not been recorded during Project-associated surveys or surveys for the TSRC project. There are no database records (AoLA) within the MNES study area. The nearest records are from 2010 and 2016 and located north of Towoomba (5 km and 10 km north of the Project) (refer Figure 4.4). There are several records (all from the 1990s) located in the Lockyer Forest Reserves (all between 7.5 km and 19 km north-east of the Project). There are no records to the south of the Project in the Toowoomba Range. The species occurs from south-east Australia to central and north-east Queensland. The northern subspecies (*Petauroides volans minor*) occurs on the Atherton Tablelands.

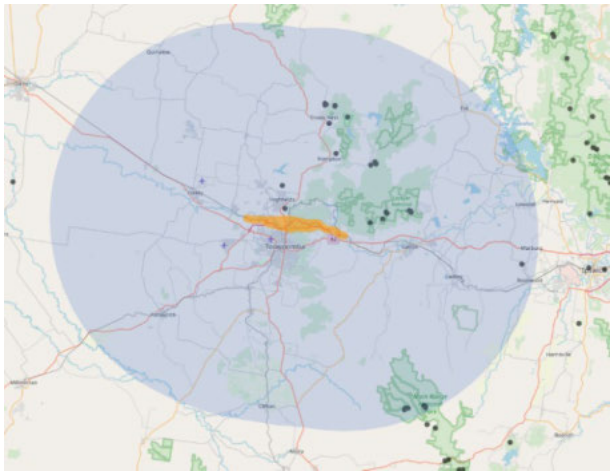


Figure 4.4 **Distribution range of the Greater glider in relation to the Project**

Source: ALA (2020)

4.2.2.4 Biology and reproduction

The Greater glider is nocturnal and feeds solely on young leaves and flower buds of specific eucalypts. Similarly to koalas, what eucalypt species Greater gliders feed on depends on what species are available to the specific populations in the immediate area. For example, in the Redlands, Queensland, their species of preference are *Eucalyptus tereticornis, Eucalypyus pilularis, Eucalyptus racemosa, Eucalyptus sideroploia, Eucalyptus resinifera, Eucalyptus carnea, Eucalyptus crebra, Eucalyptus major, Eucalyptus propinqua, Eucalyptus microcorys* and *Corymbia maculate* (Menkhorst and Knight 2011; RCC 2008)

They are usually solitary, though mated pairs and offspring will share a den during the breeding season and until the young are independent. Mating occurs from March to June and the female gives birth to a single young in late autumn or early winter. The young remains in the pouch for approximately 4 months and then rides on the mothers back until the age of 9 months when it is considered independent. Sexual maturity is reached in the second year. Longevity is estimated at 15 years and they have a relatively low reproductive rate (Menkhorst and Knight 2011; OEH 2018; TSSC 2016; Tyndale-Biscoe and Smith 1969).

4.2.3 Habitat

The Greater glider is largely restricted to eucalypt forests and woodlands. It is typically found in highest abundance in taller, montane, moist eucalypt forests with relatively old trees and abundant hollows but the distribution may be patchy even in suitable habitat. The greater glider favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species. They tend to prefer more open woodlands with larger spaces between trees so they have room to glide (Andrews et al. 1994; Kavanagh 1984; 2000).

During the day they shelter in large hollows in large, old trees. In southern Queensland, greater gliders require at least 2 to 4 live den trees for every 2 ha of suitable forest habitat. Home ranges are relatively small (1 to 4 ha), with male home ranges being largely non-overlapping. They are known to be very loyal to their territory (Eyre 2002; Henry 1984).

4.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Greater glider:

- Habitat loss and fragmentation from development and clear fell operations are major issues for the Greater glider
- Fires that are too frequent or intense and unsustainable timber production can lead to direct impacts and or loss of habitat
- Changes in vegetation due to climate change, barbed wire fencing and increased predation from native and introduced predators are also threats facing the Greater glider populations (TSSC 2016).

4.2.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species (DoEE 2018).

4.2.6 References

Andrews, S. P., Gration, G., Quin, D., and Smith, A. P. (1994). Description and assessment of forestry impacts on fauna of the Urbenville Forestry Management Area. Report for State Forests of New South Wales Austeco Environmental Consultants, Armidale.

Atlas of Living Australia (2018). *Petauroides volans*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:7e891f26-c72e-4b29-98db-1cd10c4eaa6d#overview [Accessed 24 August 2018].

Bowell, J. (2019). *Petauroides volans* – Greater glider. [image] [online] Available from: https://images.ala.org.au/image/details?imageId=d277f106-c1fe-4d0d-a625-f0c424190f70. [16 September 2019].

Eyre, T. J. (2002). Habitat preferences and management of large gliding possums in southern Queensland. Ph.D. thesis, Southern Cross University, Lismore.

Thomson B. (2002). *Petauroides volans* (greater glider). (Image) [Online] Available from: https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/species/?petauroides-volans#prettyPhoto [Accessed 24 August 2018].

Henry, S. R. (1984). Social organisation of the greater glider (*Petauroides volans*) in Victoria. In *Possums and Gliders* (eds A. P. Smith and I. D. Hume), pp. 221-228. Surrey Beatty and Sons, Chipping Norton.

Kavanagh, R. P. (1984). Seasonal changes in habitat use by gliders and possums in southeastern New South Wales. In *Possums and Gliders* (eds A. P. Smith and I. D. Hume), pp. 527-543. Surrey Beatty and Sons, Chipping Norton.

Kavanagh, R. P. (2000). Effects of variable-intensity logging and the influence of habitat variables on the distribution of the Greater Glider *Petauroides volans* in montane forest, southeastern New South Wales. *Pacific Conservation Biology* 6, 18-30.

Menkhorst P. and Knight F. (2011). *A Field Guide to the Mammals of Australia, 3rd Edition*. Oxford University Press.

Office of Environment and Heritage, NSW (2017). Greater Glider *Petauroides volans* in the Seven Mile Beach National Park area - profile. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20324 [Accessed 24 August 2018].

Redlands City Council (2008). Biodiversity Research Projects: Greater Gliders. Available from: http://www2.redland.qld.gov.au/EnvironmentWaste/EnvironmentPlans/Documents/Greater%20Gliders.pdf [Accessed 24 August 2018].

Threatened Species Scientific Committee (2016). Conservation Advice on greater glider (*Petauroides volans*). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/254-conservation-advice-05052016.pdf [Accessed 24 August 2018].

Tyndale-Biscoe, C. H., and Smith, R. F. C. (1969). Studies on the marsupial glider, *Schoinobates volans* (Kerr). II. Population structure and regulatory mechanisms. *Journal of Animal Ecology* 38, 637-650.

Van Dyck, S. and Strahan R. (2008). *The Mammals of Australia, Third Edition*. Page(s) 880. Sydney: Reed New Holland.

4.3 Grey-headed flying-fox (*Pteropus poliocephalus*)

4.3.1 Status

EPBC Act – Vulnerable

4.3.2 Biology and ecology

4.3.2.1 Characteristic

The Grey-headed flying-fox (*Pteropus poliocephalus*) weighs approximately 600 g to 1 kg, and typically measures 23 cm to 28 cm from head to body. The Grey-headed flying fox exhibits a collar of orange/brown around its neck, whilst its head is covered in light grey. The fur on the body is grey, often with flecks of white and ginger (refer Photograph 4.3). The fur on the back exhibits two morphs, which are possibly related to age, moult, or sub-population. Winter fur is typically darker than summer fur, and pronounced moulting is known to occur in June (DotEE 2018; Eby and Lunney 2002; Hall 1987; Hall and Richards 2000; Tidemann 1998).



Photograph 4.3 Grey-headed flying-fox (*Pteropus poliocephalus*)

Source: Leo (2010)

4.3.2.2 Known distribution

The Grey-headed flying-fox occurs in the coastal belt of Eastern Australia, typically ranging from Rockhampton in central Queensland to Melbourne in Victoria (refer Figure 4.5). It is noted that only a small portion of this range is used at any one time, as the species selectively forages where resources are available (DotEE 2018; Tidemann 1998).

The availability of food resources have a direct influence on the occurrence and relative abundance within the Grey-headed flying foxes distribution in various seasons and years (Pallin 2000; Hall 2002; van der Ree et al. 2006).



Figure 4.5 **Distribution range of the Grey-headed flying-fox**

Source: ALA (2018)

4.3.2.3 Distribution in relation to the project

Grey-headed flying-fox was not identified during Project-associated surveys. Five records (AoLA) exist for this species from within the Toowoomba Range from 2004 to 2011. Four of these (from 2007 and 2011) are associated with a flying-fox roost site located 540 m south of the disturbance footprint (to the east of the New England Highway). There is no recent data collected from this site. There are a number of database records in the surrounds largely to the south in Toowoomba city but also to the north on Murphy's Creek and the Highfields area (refer Figure 4.6). The species main distribution extends from Rockhampton south to Victoria and South Australia. The disturbance footprint is not at the limit of the species range. Based on quarterly flying-fox data collected by DES in the SEQ region there are two Flying-fox camps located within 15 km of the Project which regularly comprise Grey-headed flying-fox: Spring Street in Toowoomba (8.5 km south); and Jackson Close in Highfields (5 km north).

The *Referral guideline for management actions in grey-headed and spectacled flying-fox camps* (DotE 2015c) identifies 'nationally important' camps for Grey-headed flying-fox as:

- Camps that have contained ≥ 10,000 grey-headed flying-foxes in more than one year in the last 10 years, or
- Have been occupied by more than 2,500 grey-headed flying-foxes permanently or seasonally every year for the last 10 years

Neither of the identified camps have sustained numbers of Grey-headed flying-fox analogous to the definition of a 'nationally important' camp based on the available data (collected from 2007 to November 2019).

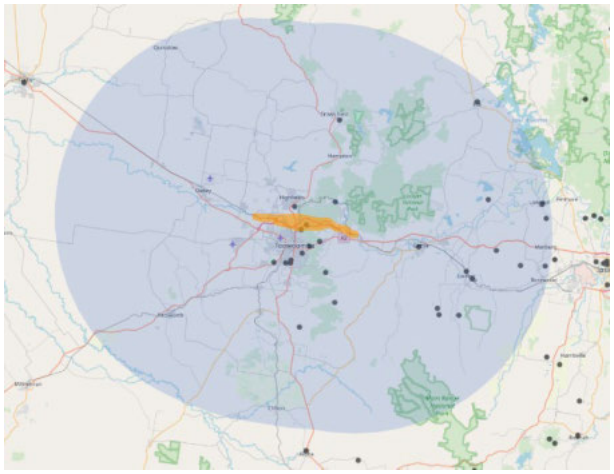


Figure 4.6 **Distribution range of the Grey-headed flying-fox in relation to the Project**

Source: ALA (2020)

4.3.2.4 Biology and reproduction

Nectar and pollen from *Eucalyptus*, *Corymbia, Angophora, Melaleuca*, and *Banksia* species are considered the primary food source for Grey-headed flying foxes. This species is known to supplement its diet with a wide range of rainforest fruits and introduced species (Duncan et al. 1999; Eby 1995; 1998; Hall and Richards 2000; Parry-Jones and Augee 1991).

Mating is known to occur in the early autumn months, after which time the larger camps begin to separate, reforming in late spring/early summer when food resources become more abundant. Males and females typically separate in October, when the young are born. Each year, following six months of gestation, females bear a single young. For one month after giving birth, the mother carries her offspring on her ventral surface to feeding sites. When completely furred, the young are left in maternal camps, and are nursed until they are independent, at approximately 12 weeks of age. Sexual maturity typically occurs at about three years of age (DotEE 2018; Hall and Richards 2000; Martin 2000; Nelson 1965; Tidemann 1998).

4.3.3 Habitat

The Grey-headed flying-fox is a canopy-feeding species that eats fruit and nectar. This species utilises a range of vegetated habitats, including rainforests, open forests, closed and open woodlands, *Melaleuca* swamps and *Banksia* woodlands. In an urban setting, this species is known to feed on commercial fruit crops, and on introduced tree species (DotEE 2018).

Roost sites are generally located near water bodies. This species is known to roost in vegetation ranging from rainforest, *Melaleuca* stands, mangroves and riparian vegetation. The species has a high level of roost site fidelity, although new sites have been known to be colonised (Lunney and Moon 1997; Nelson 1965; Ratcliffe 1931; Tidemann and Vardon 1997; van der Ree et al 2005).

4.3.4 Threatening processes

The following have been identified as potentially threatening processes to the Grey-headed flying-fox:

- Clearing of native vegetation for agriculture and forestry operations has accelerated the destruction and disturbance of roosting and foraging habitats of the species in eastern Australia (DotEE 2018; Duncan et al. 1999; SEAC 1996; Teagle 2002)
- Lack of foraging resources can also force Grey-headed flying-foxes into commercial fruit crops, increasing conflict with growers and subsequent culling of individuals (DotEE 2018)
- Urban-dwelling Grey-headed flying-foxes can accumulate lethal levels of lead from the environment and are prone to electrocution on powerlines (DotEE 2018; Hariono et al. 1992)

- Displacement leading to competition and hybridisation with the Black Flying-fox (*P. alecto*) is also a known threat (DotEE 2018; Duncan et al. 1999; SEAC 1996; Teagle 2002).

4.3.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2017). Saving our Species: Help save the Grey-headed Flying-fox. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=785&ReportProfileID=10697.

4.3.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Loss of roosting and foraging sites
- Human animal conflict
- Heat stress.

Management actions outline in the Saving our Species plan includes:

- Increase extent and viability of foraging and roosting habitat through habitat creation and restoration
- Liaise with landholders to strike agreements to protect and retain high quality foraging and roosting habitat
- Rehabilitate degraded nesting and foraging habitat managing invasive flora and understorey vegetation to provide suitable microclimate conditions establishing a buffer between bat camps to avoid conflict with people
- Provide education and awareness around the species to foster acceptance and reduce anti-sentiment
- Develop site-based heat stress management strategies recording and sharing data for future heat stress events.

4.3.7 References

Atlas of Living Australia (2018). *Pteropus poliocephalus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:a2553aed-383a-4c9b-9534-c6058bcee81b# [Accessed 24 August 2018].

Department of the Environment and Energy (2018). *Pteropus poliocephalus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186 [Accessed 24 August 2018].

Duncan, A., Baker, G.B and Montgomery, N. (1999), *The Action Plan for Australian Bats.* [Online]. Canberra: Environment Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/bats/index.html. [Accessed 24 August 2018].

Eby, P. and Lunney, D. (2002), *Managing the Grey-headed flying-fox as a threatened species in NSW*. In: Proceedings of the Royal Zoological Society of New South Wales. Mosman, Sydney: Royal Zoological Society of New South Wales.

Hall, L. and Richards, G. (2000), *Flying Foxes: Fruit and Blossom of Australia*. Sydney: University of New South Wales Press.

Hall, L. (1987), Identification, distribution and taxonomy of Australian flying-foxes (Chiroptera: Pteropodidae). Australian Mammalogy. 10 (2):75-81.

Hall, L.S. (2002), *Management of flying fox camps: what have we learnt in the last twenty five years?* In: Eby, P. and D. Lunney, eds. Managing the Grey-headed flying-fox as a Threatened Species in NSW. Page(s) 215-224. Mosman, NSW; Royal Zoological Society of NSW.

Hariono, B., Ng J. and Sutton R.H. (1992). Lead concentrations in tissues of fruit bats (*Pteropus* sp.) in urban and non-urban areas. *Wildlife Research*. 20.

Leo (2010). *Pteropus poliocephalus*. (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:a2553aed-383a-4c9b-9534-c6058bcee81b [Accessed 24 August 2018].

Martin, L. (2000), Aspects of the Reproductive Biology of the Grey-headed flying-foxes that explain documented population declines and support a threatened status. In: Proceedings of a Workshop to Assess the Status of the Grey-headed flying-fox in New South Wales. Unpublished report to the NSW Threatened Scientific Committee.

Nelson, J.E. (1965), Movements of Australian flying foxes (Pteropodidae: Megachiroptera). Australian Journal of Zoology. 13:53-73.

Pallin, N. (2000), Ku-ring-gai Flying-fox Reserve: habitat restoration project, 15 years on. Ecological Management and Restoration. 1:10-20.

Ratcliffe, F.N. (1931), *The flying fox (Pteropus) in Australia*. CSIRO Bulletin. 52:1-133.

State of the Environment Advisory Council (1996). *Australia: State of the Environment, 1996.*

Teagle, S. (2002). Flying fox Consultative Committee - Formation, Outcomes and Future Strategies. In: Eby, P. and D. Lunney, eds. *Managing the Grey-headed Flying-fox as a Threatened Species in NSW*. Page(s) 109-116. Mosman, NSW: Royal Zoological Society of NSW.

Tidemann, C. and Vardon, M. (1997), *Pests, pestilence, pollen and pot-roasts: the need for community-based management of flying foxes in Australia*. Australian Biologist. 10(1):77-83. hs Forest: New Holland Publishers Pty Ltd.

Tidemann, C.R. (1998), *Grey-headed flying-fox, Pteropus poliocephalus,* Temminck, 1824. In: Strahan, R., ed. The Mammals of Australia. Frenc.

van der Ree, R., McDonnell, J. Temby, I. Nelson, J. and Whittingham, E. (2005), The establishment and dynamics of a recently established urban camp of flying foxes (*Pteropus poliocephalus*) outside their geographic range. Journal of Zoology. 268:177-185. The Zoological Society of London.

van der Ree, R., McDonnell, M.J. Temby, I. Nelson, J. and Whittingham, E. (2006), The establishment and dynamics of a recently established urban camp of Pteropus ploiocephalus outside their geographic range. Journal of Zoology London. 268:177-185.

4.4 Koala (*Phascolarctos cinereus*)

4.4.1 Status

EPBC Act – Vulnerable

4.4.2 Biology and ecology

4.4.2.1 Characteristics

The Koala (*Phascolarctos cinereus*) is an arboreal marsupial, with a stocky body, large rounded ears, sharp claws and has grey-coloured fur (refer Photograph 4.4). This species displays sexual dimorphism (males generally are larger than females), with male Koalas weighing approximately 6.5 kg (DotEE 2018).



Photograph 4.4 **Koala (*Phascolarctos cinereus*)**

Source: Walker (2017)

4.4.2.2 Known distribution

The Koala is distributed along the east coast of Australia extending from Queensland to NSW (refer Figure 4.7). In Queensland, the Koala's distribution extends across several bioregions, encompassing a great diversity of habitats with the greatest concentration on southeast Queensland. In NSW, the species occurs mostly in central and north coasts with populations known to inhabit the area west of the Great Dividing Range (DES 2018; OEH 2018).



Figure 4.7 **Distribution range of Koala**

Source: ALA (2018)

4.4.2.3 Distribution in relation to the project

Koala individuals and signs of presence (scats/scratches) have been detected within during site surveys for the Project (refer Figure 4.8). Scat surveys noted high densities in some survey areas (Arup in 2016). There are numerous records (AoLA 2020) from the Toowoomba region including a 2019 record within the MNES study area to the north of the Project. There are a large number of records within the MNES study area from 2018 and 2019 which are associated with Koala tracking surveys carried out by the DTMR for the TSRC. The records likely include multiple records of the same individual/s. Many records exist in all directions around the disturbance footprint within a 50 km buffer (refer Figure 4.8).

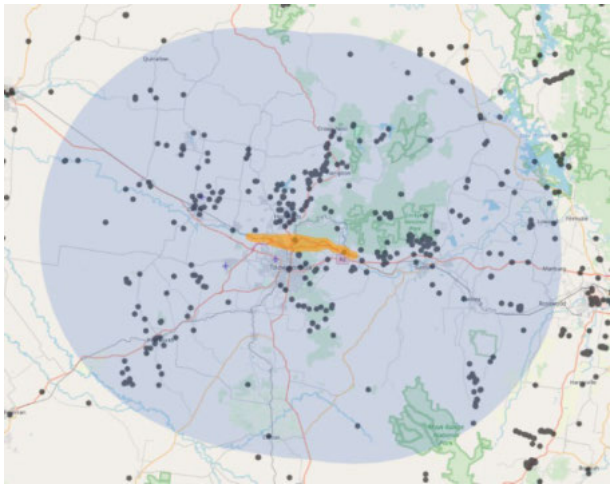


Figure 4.8 **Distribution range of Koala in relation to the Project**

Source: ALA (2020)

4.4.2.4 Biology and reproduction

The Koala is a leaf-eating specialist feeding primarily during dawn, dusk or during the night. Its diet is restricted mainly to foliage of Eucalyptus spp.; however, it may also consume foliage of related genera, including *Corymbia* spp.*, Angophora* spp. and *Lophostemon* spp. The Koala may, at times, supplement its diet with other species, including Leptospermum spp. and Melaleuca spp. (Crowther et al. 2013, Martin and Handasyde 1999; Moore and Foley 2000).

Female Koalas can potentially produce one offspring each year with births occurring between October and May. The newly-born Koala lives in its mother's pouch for six to eight months and, after leaving the pouch, remain dependent on the mother, riding on her back. Young Koalas are independent from about 12 months of age (DotEE 2018).

4.4.3 Habitat

Koala habitat can be broadly defined as any environment containing Koala food tree species (*Eucalyptus* spp., *Corymbia* spp., *Angophora* spp. and *Lophostemon* spp.) or shelter trees. Preferred food and shelter trees are naturally abundant on fertile clayey soils (DotEE 2018).

Along the Great Dividing Range and the coastal belt throughout the species' range, Koalas inhabit moist forests and woodlands mostly dominated by Eucalyptus species. Koalas are also known to occur in highly modified (e.g. urbanised) or regenerating native vegetation communities (DotEE 2018).

4.4.4 Threatening processes

The following have been identified as potentially threatening processes to the Koala:

- Habitat loss, modification or fragmentation as a result of urbanisation
- Secondary threats such as predation by domestic dogs, vehicle strikes and stress
- *Chlamydia* which reduces the life expectancy of the species (OEH 2018; DES 2018).

4.4.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified for this species. The following management strategy has been identified as being relevant for this species:

- National Koala Conservation and Management Strategy 2009-2014 (Natural Resource Management Ministerial Council (NRMMC), 2009) [Information Sheet]. Available from: http://www.environment.gov.au/system/files/resources/165139fc-3ab5-4c96-8b15-d11a1ad882ab/files/koala-strategy.pdf.

4.4.6 Summary of threat abatement/recovery plan

Threats identified in the conservation and management strategy includes:

- Habitat loss, fragmentation and degradation
- Over-browsing
- Natural disasters
- Disease
- Vehicle collisions
- Predation by dogs
- Climate change.

Management actions outline in the conservation and management strategy includes:

- Identify key habitat with a high priority for protection
- Prioritise populations under immediate pressure
- Revegetate corridors between fragments to facilitate natural dispersal
- Establish a national database mapping habitat, distribution and density
- Establish and support existing surveying and monitoring programs
- Incorporate causes of habitat loss outside of land clearing into planning for habitat conservation
- Identify areas susceptible to severe tree defoliation early and regulate koala density
- Develop a national guideline for road design
- Implement strategies that minimise the impacts of dogs on koala populations
- Assess and develop appropriate methods to reduce vulnerability of populations to disease
- Encourage retention and restoration of koala habitat on private land
- Develop and distribute educational material
- Develop national guidelines that outline appropriate care, handling and management of captive koalas, sick, injured or orphaned koalas
- Identify the direction of research required to address the impacts of climate change on the species.

4.4.7 References

Atlas of Living Australia. (2018). Phascolarctos cinereus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:e9d6fbbd-1505-4073-990a-dc66c930dad6 [Accessed 22 August 2018].

Crowther, M., D. Lunney, J. Lemon, E. Stalenberg, R. Wheeler, G. Madani, K. Ross and M. Ellis. (2013). Climate-mediated habitat selection in an arboreal folivore. Ecography. 36:001-008.

Department of Environment and Energy (2018). Phascolarctos cinereus (Koala) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=85104 [Accessed 22 August 2018].

Department of Environment and Science (2017). Koala facts. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/koalas/koala-ecology.html [Accessed 22 August 2018].

Martin, R. and K. Handasyde. (1999). The Koala: Natural history, conservation and management. Sydney, NSW: UNSW Press.

Moore, B.D. and W.J. Foley. (2000). A review of feeding and diet selection in koalas (Phascolarctos cinereus). Australian Journal of Zoology. 48:317-333.

Office of Environment and Heritage (2018). Koala - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10616 [Accessed 22 August 2018].

Walker, B. (2017). Phascolarctos cinereus - Koala. [image] [online] Available from: https://images.ala.org.au/image/details?imageId=72044d32-05fc-47ef-96fd-cd5968d0ed03 [16 September 2019].

4.5 Large-eared pied bat (*Chalinolobus dwyeri*)

4.5.1 Status

EPBC Act – Vulnerable

4.5.2 Biology and ecology

4.5.2.1 Characteristic

The Large-eared pied bat (*Chalinolobus dwyeri*) is a medium-sized insectivorous bat measuring approximately 100 mm in length, and weighing 7 to 12 g. This species exhibits a shiny black coat, with a white stripe on the flank (underside) of each wing. The ears are large and the facial lobes are located on the lower lip, between the corner of the mouth and the bottom of the ear (refer Photograph 4.5). Its short, broad wings suggest that this species flies slowly, and with considerable manoeuvrability (DERM 2011; DotEE 2011; Hoye and Dwyer 1995; Ryan 1966).



Photograph 4.5 **Large-eared pied bat (*Chalinolobus dwyeri*)**

Source: Musser (2017)

4.5.2.2 Known distribution

The former and current distribution of the Large-eared pied bat is poorly known. Records for current distribution exist from Shoalwater Bay and inland to Carnavon in Queensland, through to Ulladulla, in NSW (refer Figure 4.9). It is thought that this species is uncommon and has a patchy distribution (DotEE 2011).



Figure 4.9 **Distribution range of the Large-eared pied bat**

Source: ALA (2018)

4.5.2.3 Distribution in relation to the project

Chalinolobus dwyeri has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that no records of *Chalinolobus dwyeri* exist within the ecology study area. The closest record is located approximately 5 km to the south of the disturbance footprint in Toowoomba and is dated 2011. The next closest record is located approximately 45 km southeast of the alignment near Townson. No other records exist within a 50 km radius of the disturbance footprint (refer Figure 4.10).

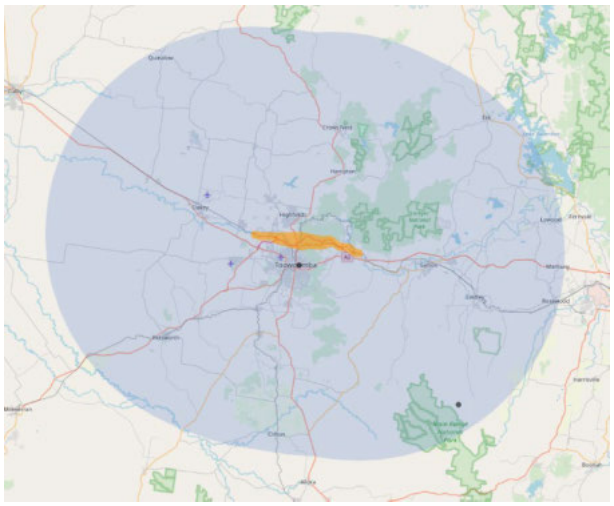


Figure 4.10 **Distribution range of the Large-eared pied bat in relation to the Project**

Source: ALA (2020)

4.5.2.4 Biology and reproduction

The Large-eared pied bat feeds on insects flying at 6 to 10 m off the ground and along creek lines. It is unknown if it targets particular groups of insects (Curtis et al. 2012; DERM 2011).

Females can give birth at one year of age, and males also appear capable of breeding at this age. Mating appears to occur in early winter. A nursery colony is typically established in September by both adult females and males, with the majority of adult males leaving by the time the young are born in early summer. Females are known to give birth to one or two young per year. By the end of March the juveniles have left the roost. The adult females leave the roost after the juveniles, and the site is abandoned during the winter months. Life expectancy and natural mortality have not been determined (DotEE 2011; Dwyer 1966; Hoye and Dwyer 1995).

4.5.3 Habitat

Available roosts are unevenly distributed throughout the landscape. Large-eared pied bats require a combination of sandstone cliffs/escarpments to provide roosting habitat that is adjacent to higher fertility sites (particularly box gum woodlands or river/rainforest corridors which are used for foraging) (DotEE 2011).

Large-eared pied bats have been observed in disused mine shafts, caves, overhangs and disused Fairy martin (*Hirundo ariel*) nests for shelter and to raise young. This species possibly also roosts in tree hollows, within dry and wet sclerophyll forest, Cyprus-pine dominated forest, tall open eucalypt forest with a rainforest sub-canopy, sub-alpine woodland, Brigalow and sandstone outcrop country. In southeast Queensland, the species has primarily been recorded from higher altitude, among moist tall open forest adjacent to rainforest (DotEE 2011; Hoye and Dwyer 1995; Schulz 1998).

4.5.4 Threatening processes

The following have been identified as potentially threatening processes to the Large-eared pied bat:

- Disturbance and damage to primary nursery sites by animals (particularly goats) and humans (Hoye 2005; Duncan et al. 1999; TSSC 2012)

- Populations can be easily displaced as they roost in disused mines which often become active if commodity prices make them economical or they can be filled for safety reasons (Hoye 2005; Duncan et al. 1999; TSSC 2012).

4.5.5 Threat abatement/recovery plans

The following threat abatement/recovery plans have been identified as relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/Project.aspx?results=c&ProfileID=10157. In effect under the BC Act 2016.

The following recovery plan is relevant for this species:

- Department of Environment and Resource Management (2011). National recovery plan for the large-eared pied bat Chalinolobus dwyeri. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-large-eared-pied-bat-chalinolobus-dwyeri. In effect under the EPBC Act from 10-Feb-2012.

4.5.6 Summary of threat abatement/recovery plan

Chalinolobus dwyeri is assigned as a data-deficient species under the NSW *Saving our Species Program* as there is insufficient information on ecology and distribution for effective management. Vegetation clearing for agricultural purposes is identified as the key threat. The key priority action is to address key knowledge gaps for this species through survey and investigating threat dynamics.

Major threatening processes for this species have not been clearly established, however threats to the *Chalinolobus dwyeri* in the National recovery plan for the large-eared pied bat are:

- Destruction of and interference to subterranean roosts and maternity sites
- Mining of roosts and mine induced subsidence of cliff lines
- Disturbance from human recreational activities such as bushwalking, caving and abseiling
- Habitat disturbance by other animals, including livestock and feral animals such as goats
- Predation by introduced predators such as cats, foxes and possibly rats
- Vegetation clearance in proximity of roosts causing habitat loss and fragmentation and reducing foraging resources
- Fire in proximity to roosts, potentially causing direct mortality from heat stroke and smoke.

Recovery objectives of the plan are:

- Identify priority roosts and maternity sites for protection and map known colonies in NSW and QLD
- Implement conservation and management strategies for priority sites, including foraging habitats
- Install bat gates to protect populations and stabilise site entrances (e.g. old mines)
- Implement fire prescriptions for areas around each identified priority roost or maternity site
- Control introduced species such as goats
- Undertake monitoring to assess the success of management strategies
- Conduct research to improve knowledge on species habitat requirements, roost and maternity sites, diet and foraging strategy and threatening process.

4.5.7 References

Atlas of Living Australia (2018). *Chalinolobus dwyeri*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:cddd224d-40ed-49d9-bb88-dcbfe064a35e#gallery [Accessed 24 August 2018].

Curtis, L.K., Dennis, A.J., McDonald, K.R., Kyne, P.M. and Debus, S.J.S. (2012). *Queensland's Threatened Animals* CSIRO Publishing, Collingwood, Victoria, Australia

Department of Environment and Resource Management (2011). National recovery plan for the Large-eared pied bat *Chalinolobus dwyeri*. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Department of the Environment and Energy (2011). *Chalinolobus dwyeri* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=183 [Accessed 24 August 2018].

Duncan, A., Baker, G.B and Montgomery, N. 1999, *The Action Plan for Australian Bats.* [Online]. Canberra: Environment Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/bats/index.html. [Accessed 24 August 2018].

Dwyer, P.D. (1966). Observations on Chalinolobus dwyeri (Chiroptera: Vespertilionidae) Australia. Journal of Mammalogy. 47:716-718.

Hoye, G.A. and Dwyer P.D. (1995). Large-eared pied bat *Chalinolobus dwyeri*. In: Stahan, R, ed. *The Mammals of Australia*. Page(s) 510-511. Chatswood, NSW: Reed Books.

Hoye, G.A. (2005). *Recovery plan for the large-eared pied bat Chalinolobus dwyeri*. Fly By Night Bat Surveys Pty Ltd. Brisbane: Queensland Parks and Wildlife Service.

Musser, A. (2017). Large-eared pied bat (Chalinolobus dwyeri). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=d05ddeaf-7807-489b-9269-50f79951560d. [16 September 2019].

Ryan, R.M. (1966). A new and imperfectly known Australian Chalinolobus and the taxonomic status of African Glauconycteris. *Journal of Mammalogy*. 47:86-91.

Schulz, M. (1998). Bats and other fauna in disused Fairy Martin Hirundo arial nests. *Emu*. 98:184-191.

Threatened Species Scientific Committee (2012). *Commonwealth Listing Advice on* Chalinolobus dwyeri *(Large-eared Pied Bat)*. Department of Sustainability, Environment, Water, Population and Communities. Canberra, ACT: Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/183-listing-advice.pdf. In effect under the EPBC Act from 29 June 2012.

4.6 Long-nosed potoroo (SE mainland) (*Potorous tridactylus tridactylus*)

4.6.1 Status

EPBC Act – Vulnerable

4.6.2 Biology and ecology

4.6.2.1 Characteristic

The Long-nosed potoroo (*Potorous tridactylus tridactylus*) (SE Mainland) is a medium sized marsupial. Males weigh at most 1.6 kg whilst females are slightly lighter and shorter. They can be identified by a brown-grey upper body and paler underbody. They have small round ears and a long nose that tapers with a small patch of skin extending from the snout to the nose (refer Photograph 4.6). Their tail is sparsely furred, tapered and marked with a white tip. They have only two pads on their hindfeet (Menkhorts and Knight 2011; Van Dyck and Strahan 2008).



Photograph 4.6 **Long-nosed potoroo (*Potorous tridactylus tridactylus*)**

Source: Augier (2015)

4.6.2.2 Known distribution

In NSW and Queensland, the Long-nosed potoroo (SE Mainland) has scattered populations east of the Great Dividing Range extending from south-eastern Queensland through to NSW (refer Figure 4.11). In Queensland the species has been recorded from southeast of Gladstone to Lamington National Park and the Border Ranges. The species is also found in southern Victoria (Amos 1982; Lindenmayer and Viggers 1994).



Figure 4.11 **Distribution range of the Long-nosed potoroo (SE Mainland)**

Source: ALA (2018)

4.6.2.3 Distribution in relation to the project

Potorous tridactylus tridactylus has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that no records of *Potorous tridactylus tridactylus* exist within the ecology study area. The species has not been recorded during any Project-associated surveys or during surveys for the nearby TSRC project. There are five database records occurring within 50 km of the Project, although none of these occurs within the MNES study area. The nearest database record is from 2015 and located 13 km south of the Project in the Toowoomba Range. Other database records occur to the north and north-east including Crows Nest National Park (2012 – 20km north), Lockyer National Park (1990), Ravensbourne National Park (four records from 1977 to 1986 – 19 km north) and Deongwar State Forest (2014 – 24 km north). There is also a 1991 record from Lockyer National Park (19 km north-east of the eastern extent of the Project) (refer Figure 4.12 in Appendix B). Although there are few records from the wider area the species is known from montane areas and may be difficult to detect. There is abundant suitable habitat available within the MNES study area and it may utilise the dense Lantana thickets observed during Project surveys (refer Figure 4.12).

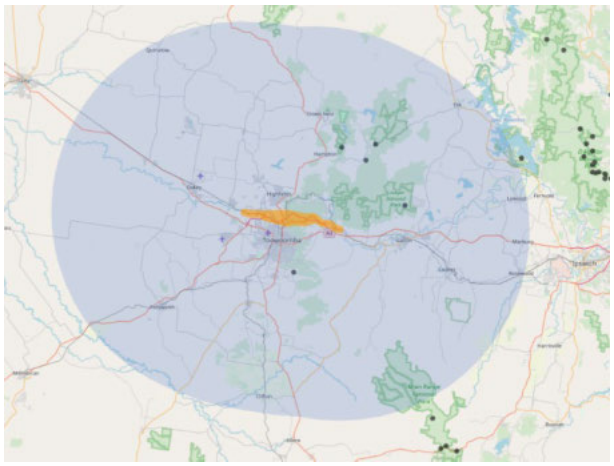


Figure 4.12 **Distribution range of the Long-nosed potoroo (SE Mainland) in relation to the Project**

Source: ALA (2020)

4.6.2.4 Biology and reproduction

The Long-nosed potoroo (SE Mainland) is known to consume flowers, fruits, seeds, leaves, stems, roots and bulbs. They also feed on both hypogeous and epigeous components of fungal fruit bodies as well as invertebrates (DotEE 2018).

The Long-nosed potoroo (SE mainland) breeds all year round a single joey is born after a gestation of 37 days and they remain in their mothers pouch for 100 to 125 days reaching sexual maturity at about 12 months. They have a lifespan of about 10 years (Bennett 1987; Hughes 1962).

4.6.3 Habitat

In NSW and Queensland, there is no consistent pattern to the habitat of the Long-nosed potoroo (SE Mainland); it can be found in wet eucalypt forests to warm temperate rainforest and coastal heaths and scrubs. The main habitat requirements appear to be some form of dense vegetation for shelter and the presence of light soils and an abundance of fungi (Bennett 1987; Claridge et al. 1992; DES 2017).

4.6.4 Threatening processes

The following have been identified as potentially threatening processes to the Long-nosed potoroo:

- The main threat to the Long-nosed potoroo (SE Mainland) is predation by European Red Foxes and Feral Cats (Seebeck et al. 2007)
- Residential and industrial development has also caused habitat loss, degradation and fragmentation (Seebeck et al. 2007).

4.6.5 Threat abatement/recovery plans

No recovery plan has been identified as being relevant for this species. The following threat abatement plans are relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.

4.6.6 Summary of threat abatement/recovery plans

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

4.6.7 References

Amos, P.J. (1982). The potoroo in Queensland. *Queensland Agricultural Journal*. 108: 5-6.

Atlas of Living Australia (2018). *Potorous tridactylus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:76cb4b83-1a55-4ff8-98ff-4e7eb6fc0c9b [Accessed 23 August 2018].

Augier, J. (2015). Long-nosed potoroo (Potorous tridactylus tridactylus). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=895e4d37-18f9-4c62-ae37-5af6803085c8. [16 September 2019].

Bennett, A.F. (1987). Conservation of mammals within a fragmented forest environment: the contributions of insular biogeography and autecology. In: Saunders, D.A., G.W. Arnold, A.A. Burbridge and A.J.M. Hopkins, eds. *Nature conservation: the role of remnants of native vegetation*. Page(s) 41-52. Chipping Norton, NSW: Surrey Beatty and Sons.

Claridge, A.W., Tanton M.T., Seebeck J.H., Cork S.J. and Cunningham R.B. (1992). Establishment of ectomycorrhizae on the roots of two species of Eucalyptus from fungal spores contained in the faeces of the long-nosed potoroo (*Potorous tridactylus*). *Australian Journal of Ecology*. 17: 207-217.

Department of the Environment and Energy (2018). *Potorous tridactylus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66645 [Accessed 23 August 2018].

Department of the Environment and Science (2017). Long-nosed potoroo. Available from: https://www.ehp.qld.gov.au/wildlife/threatened-species/vulnerable/longnosed_potoroo.html [Accessed 23 August 2018].

Hughes, R.L. (1962). Reproduction in the macropod marsupial *Potorous tridactylus* (Kerr). *Australian Journal of Zoology*. 10:192-224.

Lindenmayer, D.B. and Viggers K.L. (1994). Northern range limits of the long nosed potoroo, *Potorous tridactylus. Memoirs of the Queensland Museum*. 35:180.

Menkhorst P. and Knight F. (2011). *A Field Guide to the Mammals of Australia, 3rd Edition*. Oxford University Press.

Mulvaney, M. (1994). *Potorous tridactylus* (Image) [Online] Available from: https://canberra.naturemapr.org/Community/Sighting/3377980 [Accessed 21 August 2018].

Seebeck, J.H., Claridge A. and Rose R. (2007). *Bettongs, Potoroos and the Musky Rat-Kangaroo*. CSIRO Publishing, Collingwood, Australia.

Van Dyck, S. and Strahan R. (2008). *The Mammals of Australia, Third Edition*. Page(s) 880. Sydney: Reed New Holland.

4.7 New Holland mouse (Pseudomys novaehollandiae)

4.7.1 Status

EPBC Act – Vulnerable

4.7.2 Biology and ecology

4.7.2.1 Characteristics

The New Holland mouse (*Pseudomys novaehollandiae*) is a native small, burrowing rodent. The grey-brown mouse has a dusk-brown tail which is darker on the dorsal side with a head to body length of approximately 65 to 90 mm and a tail reaching 105 mm (DotEE 2018; OEH 2017) (refer Photograph 4.7).



Photograph 4.7 **New Holland mouse (*Pseudomys novaehollandiae*)**

Source: ALA (2018)

4.7.2.2 Known distribution

The known distribution of the New Holland mouse is fragmented along the east coast of Australian from Queensland through to Tasmania (refer Figure 4.13). The exact whereabouts of the New Holland mouse in Queensland, NSW, Victoria and Tasmania is still unknown however with further research currently being undertaken (DotEE 2018).



Figure 4.13 **Distribution range of New Holland mouse**

Source: ALA (2018)

4.7.2.3 Distribution in relation to the project

Pseudomys novaehollandiae has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that no records of *Pseudomys novaehollandiae* exist within the ecology study area. Two records (2000) exist in the Helidon Hills 6 km to the north-east of the eastern end of the Project. Other records within a 50 km buffer of the disturbance footprint occur 15 km to 30 km north of these records between Lockyer National Park and Crows Nest. Records also exist to the south-east of the disturbance footprint from 1997 at Main Range National Park (refer Figure 4.14).

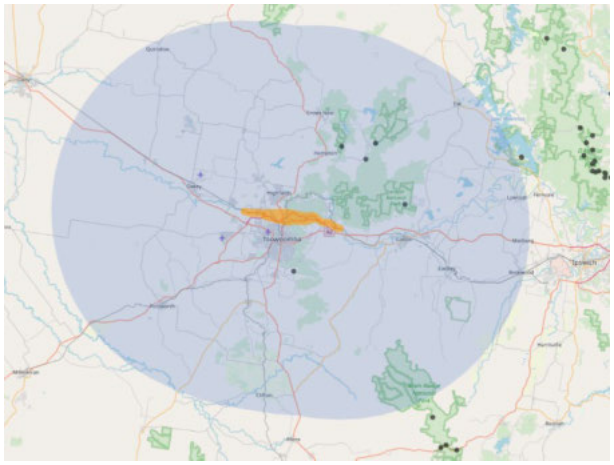


Figure 4.14 **Distribution range of New Holland mouse in relation to the Project**

Source: ALA (2020)

4.7.2.4 Biology and reproduction

The New Holland mouse is a nocturnal and omnivorous species feeding on seeds, insects, leaves, flowers as well as fungi. This social species lives in shared burrows, spending considerable time foraging above ground for food (DotEE 2018).

The known breeding period for the species occurs between August and January but can extend to autumn with slight variation between years producing litters ranging from 2 to 6. Female New Holland mouse are capable of producing two litters in a breeding season, with first year females produce one litter per season, and reach sexual maturity after 13 weeks than males, who take 20 weeks, with a generation length assumed to be 1.5 years. Reproduction however is strongly dependent on rainfall, resource availability, adult survival and recruitment (Woinarski and Burbidge 2016; DotEE 2018).

4.7.3 Habitat

The New Holland mouse is known to inhabit open heathlands, woodlands and forests with heathland understorey as well as vegetated sand dunes with peak abundance though to be early to mid-stages of vegetation succession typically induced by fire. However, in areas such as Tasmania and Victoria the species has been found living amongst landscapes not burnt for 16 to 30 years post fire in dunes vegetated by *Banksia allocasuarina* woodland with understorey dominated by sedges and low shrubs. The mouse also has a large home range between 0.44 to 1.4 ha (DotEE 2018; OEH 2017; Woinarski and Burbidge 2016).

4.7.4 Threatening processes

The following have been identified as potentially threatening processes to the New Holland mouse:

- Inappropriate fire regimes, as the species heavily depends on early to mid-stages of vegetation recovery post fire
- Predation by feral and domestic cats
- Fragmentation caused by clearing and reduced rainfall activity (Woinarski and Burbidge 2016).

4.7.5 Threat abatement/recovery plans

No recovery plan has been identified as being relevant for this species. The following threat abatement plans are relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

- Department of the Environment and Energy (2018). Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi. Canberra: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018. In effect under the EPBC Act from 22-Feb-2019.

4.7.6 Summary of threat abatement/recovery plans

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

The consequences of potential infection outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:

- Inability of infected plants to develop new shoots, flowers, fruit and seed
- Complete loss of some flora populations
- Dramatic alteration to the structure and composition of native plant communities
- A severe reduction in primary productivity and functionality
- Irreversible habitat loss and degradation of dependent flora and fauna
- Loss of shelter and nesting sites and food sources resulting in major declines of fauna.

Objectives and actions outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:

- Identifying and prioritising the protection of biodiversity assets that are, or may be, impacted by Phytophthora including listed threatened species, ecological communities and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act occur
- Reduce the spread and mitigate the impacts of Phytophthora to protect priority biodiversity assets and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act
- Inform the community through education on the impacts that Phytophthora has on biodiversity and actions to mitigate these impacts
- Encourage research on Phytophthora species and option to manage infestations and protect biodiversity assets.

4.7.7 References

Atlas of Living Australia (2018). Pseudomys novaehollandiae. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:47a50ee8-7678-4d8e-8f8a-e11d12a46ec5 [Accessed 22 August 2018].

Department of Environment and Energy (2018). Pseudomys novaehollandiae (New Holland Mouse, Pookilain) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=96 [Accessed 22 August 2018].

Office of Environment and Heritage (2017). New Holland Mouse - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20253 [Accessed 22 August 2018].

Woinarski, J. and Burbidge, A.A. (2016). Pseudomys novaehollandiae. The IUCN Red List of Threatened Species 2016. Available from: http://www.iucnredlist.org/details/18552/0. [Accessed 26 August 2018].

4.8 Northern quoll (*Dasyurus hallucatus*)

4.8.1 Status

EPBC Act – Endangered

4.8.2 Biology and ecology

4.8.2.1 Characteristic

Male Northern quolls (*Dasyurus hallucatus*) have a head-body length of 270 to 370 mm, weighing between 340 to 1,120 g. Females are smaller with a head-body length of 250 to 310 mm, and weighing between 240 to 690 g. Northern quolls have reddish brown fur with white spots on their back and a cream underside. It has a long, sparsely-furred, unspotted tail (refer Photograph 4.8). Their tail length ranges between 202 and 345 mm and their hindfeet have striated pads and five toes (Oakwood 2008).



Photograph 4.8 Northern quoll (*Dasyurus hallucatus*)

Source: Aurecon (2019)

4.8.2.2 Known distribution

Historically common across northern Australia, occurring almost continuously from the Pilbara, Western Australia, to near Brisbane, Queensland, the Northern quoll now occurs in five regional populations across Queensland, the Northern Territory and Western Australia (refer Figure 4.15). Known Queensland populations occur as far south as Gracemere and Mt Morgan, to Weipa in the north and west into central Queensland near Carnarvon Range National Park. The species is highly fragmented with severe reductions from the species' former distribution. There are occasionally records as far south as Maleny on the sunshine coast hinterland and the species and or species habitat is likely to extend as far south as Millmerran (Braithwaite and Griffiths 1994; DES 2018; McGoldrick 2013; Woinarski et al. 2008).



Figure 4.15 **Distribution range of the Northern quoll**

Source: ALA (2018)

4.8.2.3 Distribution in relation to the project

Dasyurus hallucatus has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that no records of *Dasyurus hallucatus* exist within the ecology study area. The closest record is located approximately 15 km north of the disturbance footprint towards Goombungee and is dated 1965. The next closest record is located approximately 20 km north of the alignment, east of Hampton, and is dated 1966. Two other records are located within a 50 km buffer of the disturbance footprint. These are located to the north near Crows Nest and to the south near Clifton (refer Figure 4.16).

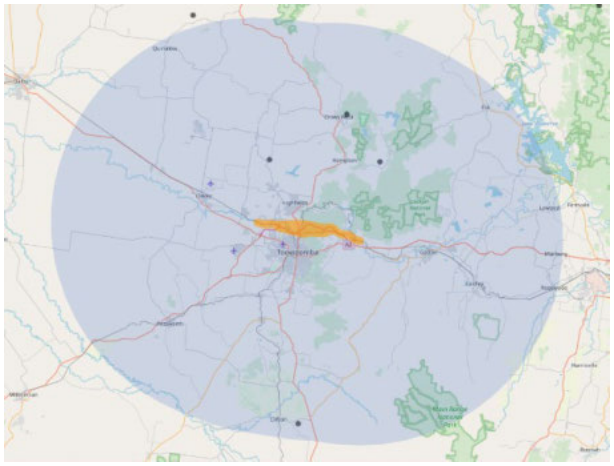


Figure 4.16 **Distribution range of the Northern quoll in relation to the Project**

Source: ALA (2020)

4.8.2.4 Biology and reproduction

Northern quolls are nocturnal predators of invertebrates such as beetles, grasshoppers, spiders, scorpions and centipedes, but they also eat small mammals, reptiles, amphibians, birds, carrion, nectar and fruit (Oakwood 2008).

Northern quolls become sexually mature at one year of age. Around June to August, during the mating season, persistent fighting means males do not survive to breed a second year whilst females may live for two or three years. As a result, the Northern quoll population is comprised almost entirely of mature females and their young by the end of the breeding season. Females can raise a litter of up to eight young in tree hollows, hollow logs and rock crevices (Oakwood 2000).

4.8.3 Habitat

The Northern quoll can be found in various habitats across its range including rocky areas, eucalypt forest and woodlands, sandy lowlands and beaches, rainforests, shrubland, grasslands and desert. They tend to require a habitat with some form of rocky area for denning purposes and surrounding vegetation used for foraging and dispersal. They are also known to inhabit areas around human dwellings and campgrounds (TSSC 2005).

4.8.4 Threatening processes

The following have been identified as potentially threatening processes to the Northern quoll:

- Lethal toxic ingestion caused by Cane toads (Oakwood 1997)
- The removal, degradation and fragmentation of Northern quoll habitat - transport infrastructure, mining, offshore petroleum or gas processing facilities or agricultural activities such as land clearing, pasture improvement or grazing (DotEE 2018)
- The decline in shelter availability and habitat heterogeneity by fire (Hill and Ward 2009)
- The invasion of northern Australia by Gamba grass (*Andropogon gayanus*) and other introduced grasses and increased fuel loads (Hill and Ward 2009; TSSC 2009)
- Predation by Feral cats (*Felis catus*) and European red foxes (*Vulpes vulpes*) and competition for food (DEWHA 2008; EA 1999; Oakwood 2004).

4.8.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Hill, B.M. & S.J. Ward (2010). National Recovery Plan For the Northern Quoll *Dasyurus hallucatus*. Department of Natural Resources, Environment, The Arts and Sport, Darwin. Available from: http://www.environment.gov.au/resource/national-recovery-plan-northern-quoll-dasyurus-hallucatus. In effect under the EPBC Act from 16-Dec-2010.

The following threat abatement plans are relevant for this species:

- Department of Sustainability, Environment, Water, Population and Communities (2011). Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-biological-effects-including-lethal-toxic-ingestion-caused-cane-toads. In effect under the EPBC Act from 06-Jul-2011.
- Department of Sustainability, Environment, Water, Population and Communities (2012). Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses. Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-reduce-impacts-northern-australias-biodiversity-five-listed-grasses. In effect under the EPBC Act from 11-Dec-2012.

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

4.8.6 Summary of threat abatement/recovery plan

Cane toads are identified as the main threat to the Northern quoll in the National Recovery Plan. Other threats identified include:

- Feral predators through direct predation and competition for food
- Inappropriate fire regimes
- Habitat degradation and destruction
- Weeds, particularly exotic pasture grasses
- Increased risk of disease due to isolation of populations
- Illegal hunting by humans
- Population isolation

Recovery actions outlined in the National Recovery Plan include:

- Protect populations on offshore islands from invasion and establishment of invasive pests including cane toads and cats
- Support the recovery of sub-populations that have survived cane toad establishment
- Maintain secure populations and source animals for potential reintroductions/introductions, including maintaining captive breeding populations
- Reduce risk of disease by improving knowledge of and monitoring for disease
- Improve public awareness of the species and the need for biosecurity control.

The threats outlined in the threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads include:

- Predation by cane toads
- Larval competition with frog tadpoles or mosquitoes
- Parasite transfer
- Competition for terrestrial food
- Competition for shelter sites.

Threat abatement actions for cane toads (*Rhinella marina*) include:

- $11 million in funding from the Australian Government provided for the development of a broad-scale control method
- $9 million in funding from the Australian Government for research and management activities
- Identification of native species, ecological communities and off-shore islands that are known to have a high to moderate risk
- Identify the impacts that toads have on listed native species and ecological communities
- Where the impact is expected to be high on native species and ecological communities establish support research techniques in aiding the recovery of priority native species and ecological communities
- Develop a prioritisation tool to aid in the direction of resources for the protection of native species and ecological communities.

Threats identified in threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses includes:

- These highly invasive grasses can increase fuel loads
- Alter nitrogen cycling and water availability
- Degrade ecosystems through loss of habitat and biodiversity declines.

Management actions outlined in the threat abatement plan include:

- Determine the extent and spread pathways of infestation by the five listed grasses outlined in the plan
- Support and facilitate coordination management strategies through the design of tools, systems and guidelines
- Identify and prioritise key asset and areas for the implementation of management strategies
- Implement on the ground management strategies that are cost effective in high priority areas
- Monitor, evaluate and report back on the effectiveness of management programs.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

4.8.7 References

Atlas of Living Australia (2018). *Dasyurus hallucatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:c4be3b87-b482-4b23-8086-a6634882fce1#overview [Accessed 21 August 2018].

Australian Wildlife Conservancy (2018). *Dasyurus hallucatus*. (Image) [Online] Available from: http://www.australianwildlife.org/wildlife/northern-quoll.aspx [Accessed 21 August 2018].

Braithwaite R.W. and A.D. Griffiths (1994). Demographic variation and range contraction in the Northern Quoll, *Dasyurus hallucatus* (Marsupialia: Dasyuridae). *Wildlife Research*. 21:203-218.

Department of Environment and Science (2018). *Queensland's quolls*. Available from: https://www.ehp.qld.gov.au/wildlife/threatened-species/endangered/endangered-animals/queenslands_quolls.html [Accessed 21 August 2018].

Department of the Environment, Water, Heritage and the Arts (2008). *Threat abatement plan for predation by the European red fox*. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01 October 2008.

Environment Australia (1999). *NON-CURRENT Threat Abatement Plan for Predation by Feral Cats*. Biodiversity Group, Environment Australia. Available from: http://www.environment.gov.au/archive/biodiversity/threatened/publications/tap/cats/index.html. In effect under the EPBC Act from 16 July 2000. [Accessed 21 August 2018]

Hill B.M. and Ward S.J. (2010). *National Recovery Plan For the Northern Quoll* Dasyurus hallucatus. Department of Natural Resources, Environment, The Arts and Sport, Darwin. Available from: http://www.environment.gov.au/resource/national-recovery-plan-northern-quoll-dasyurus-hallucatus. In effect under the EPBC Act from 16 December 2010. [Accessed 21 August 2018]

McGoldrick, I. (2013). *Weipa commissions Northern Quoll surveys*. Media Release. Rio Tinto Alcan.

Oakwood, M. (1997). The ecology of the northern quoll, *Dasyurus hallucatus. PhD Thesis, Australian National University*. Ph.D. Thesis.

Oakwood, M. (2000). Reproduction and demography of the northern quoll, *Dasyurus hallucatus*, in the lowland savanna of northern Australia. *Australian Journal of Zoology*. 48:519-539.

Oakwood M. (2004). *The effect of cane toads on a marsupial carnivore, the northern quoll,* Dasyurus hallucatus. Report to Parks Australia.

Oakwood, M. (2008). Northern quoll *Dasyurus hallucatus*. In: Van Dyck, S. and R. Strahan, eds. *The Mammals of Australia (3rd ed).* Page(s) 57-59. Sydney, NSW: Reed New Holland.

Threatened Species Scientific Committee (2005). *NON-APPROVED Conservation Advice on Northern Quoll (Dasyurus hallucatus)*. Available from: http://www.environment.gov.au/biodiversity/threatened/species/dasyurus-hallucatus.html#conservation. [Accessed 21 August 2018]

Threatened Species Scientific Committee (2009). *Commonwealth listing advice on invasion of northern Australian by gamba grass and other introduced grasses*. Available from: www.environment.gov.au/biodiversity/threatened/ktp/pubs/northern-australia-introduced-grasses.pdf [Accessed 21 August 2018].

Woinarski, J.C.Z., Oakwood M., Winter J., Burnett S., Milne D., Foster P., Myles H. and Holmes B. (2008). Surviving the toads: patterns of persistence of the northern quoll *Dasyurus hallucatus* in Queensland. *Report submitted to the Natural Heritage Trust Strategic Reserve Program*.

4.9 Southeastern long-eared bat (*Nyctophilus corbeni*)

4.9.1 Status

EPBC Act – Vulnerable

4.9.2 Biology and ecology

4.9.2.1 Characteristics

The Southeastern long-eared bat (*Nyctophilus corbeni*) is a relatively large microchiropteran bat species with a head and body length approximating 50 to 75 mm in length and tail length approximately 35 to 50 mm. The bat has long ears and a shallow muzzle ridge groove with dark-grey brown fur and slightly lighter tips (refer Photograph 4.9). The weight varies between genders with females weighing 14 to 21 g and being heavier than males who weigh 11 to 15 g. The body of the bat is covered with light brown fur (DES 2018; DotEE 2018).



Photograph 4.9 **Southeastern long-eared bat (*Nyctophilus corbeni*)**

Source: Zell (2019)

4.9.2.2 Known distribution

The South-eastern long-eared bat has a limited distribution restricted to the Murray-Darling Basin in south-eastern Australia (DotEE 2018) (refer Figure 4.17).

In Queensland, the majority of records for this species are from the Brigalow Belt South Bioregion, with the most easterly record from the Bunya Mountains National Park. The most northerly records are from the Expedition Range and Dawson River areas with the most westerly records from west of Bollon in the Mulga lands Bioregion. In NSW, the species is often found in north-eastern NSW (DES 2017; DotEE 2018; OEH 2017; Schulz and Lumdsen 2010).

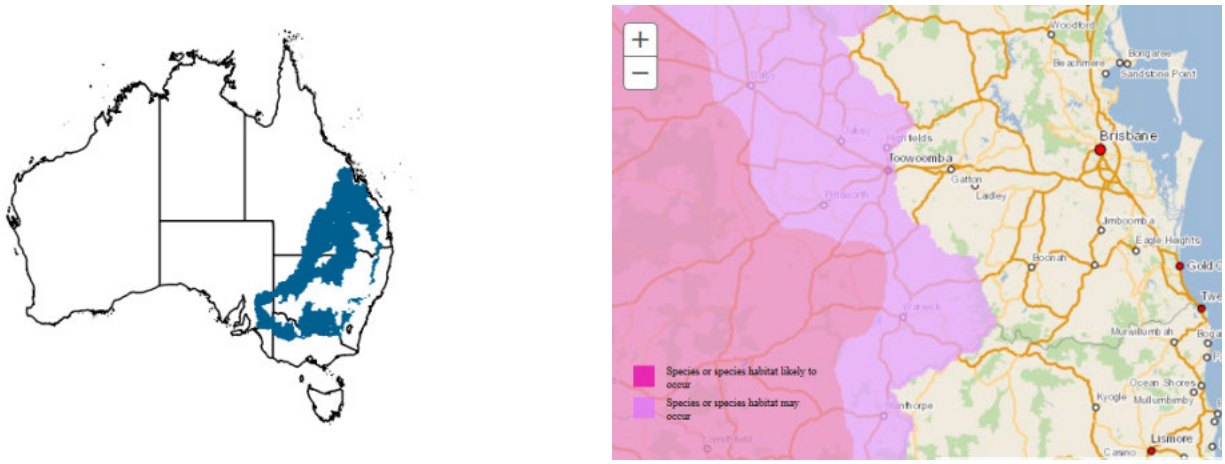


Figure 4.17 **Distribution range of the Southeastern long-eared bat**

Source: ALA (2018), DotEE (2018)

4.9.2.3 Distribution in relation to the project

Nyctophilus corbeni has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that no records of *Nyctophilus corbeni* exist within the ecology study area or within a 50 km buffer of the disturbance footprint. The closest record is located approximately 70 km southwest of the disturbance footprint in Millmerran and is dated 1927. The next closest record is located approximately 72 km north of the alignment in Bunya Mountains National Park and is dated 2003 (refer Figure 4.18).

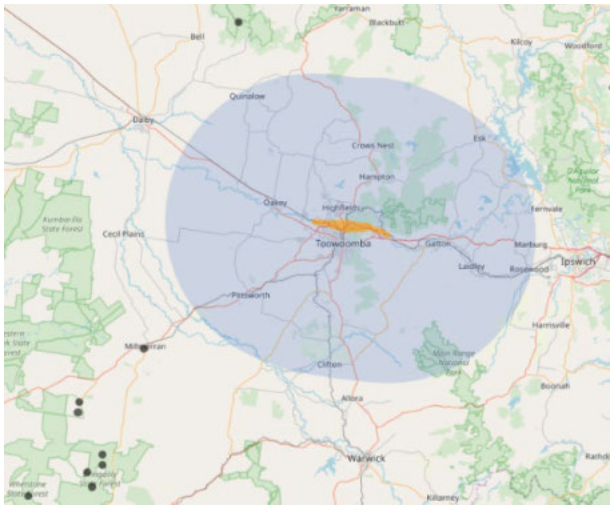


Figure 4.18 **Distribution range of the Southeastern long-eared bat in relation to the Project**

Source: ALA (2020)

4.9.2.4 Biology and reproduction

The bat species feeds on insects which they hunt in the, from foliage and on the ground eating beetles, bugs, moths, grasshoppers and crickets (DES 2018).

There is little information currently available on this species reproductive biology, although it is thought that mating takes place during autumn and winter. Females are thought to store sperm until spring, when fertilisation and gestation occurs. Up to two young are born during late spring/early summer with young not fully weaned until mid-summer (OEH 2017; Curtis et al. 2012).

4.9.3 Habitat

This species is known to inhabit a range of inland woodland vegetation types including; box, ironbark, cypress pine, mallee, bull-oak, brigalow and belah woodlands/forests. The species will roost in tree hollows, crevices and under loose bark within these communities (OEH 2017).

Essential habitat for the species is generally associated with large tracts of vegetation (100s to 1,000s of ha), including; open forest with open to dense understorey Semi Evergreen Vine Thicket/Brigalow/Belah communities and mixed Eucalyptus/Corymbia/Angophora communities. The species is known to fly large distances (>7 km in a night) from roosts to foraging areas (DES 2018; DotEE 2018).

4.9.4 Threatening processes

The following have been identified as potentially threatening processes to the South-eastern long-eared bat:

- Habitat loss and/or fragmentation
- Destruction of roosting sites and foraging habitat through fire
- Overgrazing and forestry activity
- Predation by feral species and competition for tree hollows
- Exposure to agrichemicals (DES 2018).

4.9.5 Threat abatement/recovery plans

No threat abatement has been identified as being relevant for this species. The following Saving our Species plan has been identified as being relevant to this species:

- Saving our Species: Help save the Corben's long-eared bat *Nyctophilus corbeni*. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=718&ReportProfileID=10568. Saving our Species delivers on the NSW Government's legislative requirements under the Biodiversity Conservation Act 2016.

4.9.6 Summary of threat abatement/recovery plans

Threats identified in the Saving our Species plan for the Corben's long-eared bat include:

- Loss of remnant semi-arid woodland and mallee habitat
- Use of pesticides in or adjacent to foraging areas for the species
- Inappropriate fire regimes
- Disturbance to winter roosting sites
- Loss of modification of habitat.

Recovery objectives of the plan include:

- Encouraging land managers to enter into agreements that protect and restore key areas for the species
- Provide awareness to landholders regarding the importance of retaining large live and standing dead hollow-bearing trees within the landscape as important habitat for the species
- Raise awareness regarding the impacts of herbicide, pesticide and other chemical use within close proximity to maternity or roosting sites and discourage their use
- Identify and ensure relevant stakeholders are aware of roosting and overwintering site locations before hazard reduction burns
- Ensure a 100 m buffer is established around sites considered a biodiversity asset for the species
- Fires planned near maternity or roosting sites should be implemented outside of breeding season or during winter when bats are in residence
- Hazard reduction burns should not be implemented within known associated vegetation communities more than once every 20-50 years
- If burns are to occur within key habitat areas relevant managing bodies should ensure that prescribed burns are cool burns that will not kill hollow bearing trees or remove smaller hollow bearing trees
- Modify existing and future use of lighting and noise outputs at sensitive sites that are key for feeding and roosting for the species
- Raise awareness around the damage caused to habitat by thinning, slashing, underscrubbing and inappropriate grazing along with firewood collection
- Encourage land managers to maintain tree density, floristically and structurally diverse and variable mid and understorey across the landscape.

4.9.7 References

Atlas of Living Australia (2018) *Nyctophilus corbeni.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:8a111847-ee8b-4739-935f-248d37eb63ae [Accessed 22 August 2018].

Department of Environment and Energy (2018). *Nyctophilus corbeni* (Corben's Long-eared Bat) Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=83395 [Accessed 22 August 2018].

Department of Environment and Science (2017). Eastern long-eared bat. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/micro-bats/eastern_longeared_bat.html [Accessed 22 August 2018].

Murphy (2005). Photograph: Southeast long-eared bat.

Office of Environment and Heritage (2017). Corben's Long-eared Bat - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10568 [Accessed 22 August 2018].

Schulz, M. and Lumsden, L. (2010). (Draft) National Recovery Plan for the Southeastern long-eared bat *Nyctophilus corbeni*, Victorian Department of Sustainability and Environment

Zell, M. (2019). Southeastern long-eared bat (Nyctophilus corbeni). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=2c438bfa-583a-4585-846c-135199ce39d6. [19 September 2019].

4.10 Spotted-tail quoll (southeastern mainland population) (*Dasyurus maculatus maculatus*)

4.10.1 Status

EPBC Act – Endangered

4.10.2 Biology and ecology

4.10.2.1 Characteristic

Male Spotted-tail quolls (south-eastern mainland population) (*Dasyurus maculatus maculatus*) have a head-body length of 380 to 759 mm, and females are 350 to 450 mm. Male tail lengths are between 370 to 550 mm and 340 to 420 mm for females. The average male Spotted-tail quoll weighs between 2.8 to 4.6 kg, whilst females average a weight of 1.5 to 2 kg. The fur on its back ranges in colour from rich red-brown to dark brown with white spots (refer Photograph 4.10). The Spotted-tail quoll is distinguished from other quolls by the spots running along the length of its tail. The fur on the underside is cream or white. They also have short, round ears which extend just above the outline of the head. Female Spotted-tail quolls have a poorly developed pouch (Belcher 2003; DotEE 2018; Green and Scarborough 1990; Jones 1997; Körtner et al. 2004; Queensland Museum 2015).



Photograph 4.10 Spotted-tail quoll (*Dasyurus maculatus maculatus*)

Source: Bennett (2012)

4.10.2.2 Known distribution

The Spotted-tail quoll (southern subspecies) was previously widely distributed from southeast Queensland, eastern NSW, Victoria, southeast South Australia and Tasmania (refer Figure 4.19), however, it is estimated that the range has reduced by 50 to 90%. Detailed distribution records and abundance estimates are lacking, due to the scale and intensity of survey effort that is required to detect the species across its entire range (Jones et al. 2001; Long and Nelson 2004).

In Queensland, the Spotted-tail quoll occurs in the southeast, coastally from Bundaberg to the NSW border, and inland to Monto and Stanthorpe. Spotted-tail quolls are known from five broad geographic: four from coastal ranges and the Great Dividing Range from the NSW border to Gladstone. The fifth is centred on the eastern Darling Downs-Inglewood Sandstone provinces of the Brigalow Belt South Bioregion. Unconfirmed reports suggest the subspecies may occur in the Clarke and Conway Range areas, eastern Queensland (Long and Nelson 2004; Van Dyck and Longmore 1991).

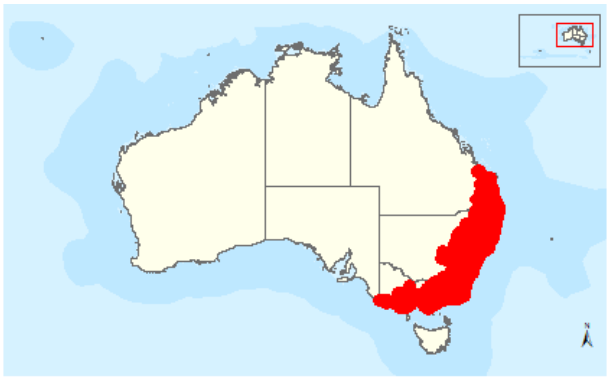


Figure 4.19 Distribution range of the Spotted-tail quoll (southern subspecies)

Source: DotEE (2018)

4.10.2.3 Distribution in relation to the project

Dasyurus maculatus maculatus has been identified as potentially occurring within the ecology study area. There are a number of older database records that occur from Crows Nest to Clifton to the north and south of the MNES study area. The nearest record is from 1979 to the south of Toowoomba located approximately 16 km south of the disturbance footprint. To the north the nearest record is from 1966 and located west of Ravensbourne National Park (20 km from the Project). The nearest post 1990 record within 50 km of the disturbance footprint is from 1991 and located approximately 14 km south-west of the disturbance footprint in the Biddeston area (west of Toowoomba). Further records from 1993 occur to the south in the Day Range area (over 30 km south of the Project) (refer Figure 4.20). The nearest recent record (2011) is from the Lake Wivenhoe area over 50 km north-east of the Project.

Habitat assessments carried out for the EIS studies identified very little suitable rocky denning habitat within the MNES study area and none within the Project alignment itself. The most likely habitat for the species the Project intersects is habitat within the Toowoomba Range and to a lesser extent the southern portion of Lockyer Forest Reserves area given the extensive habitat remaining in these areas.

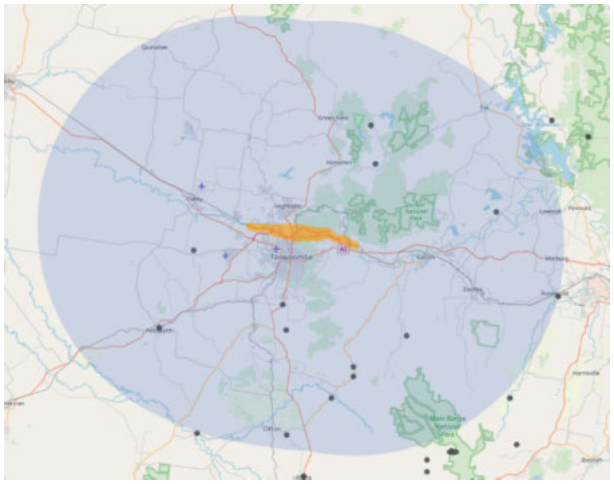


Figure 4.20 **Distribution range of the Spotted-tail quoll (southern subspecies) in relation to the Project**

Source: ALA (2020)

4.10.2.4 Biology and reproduction

Spotted-tail quolls are predominantly nocturnal and typically prey on medium-sized mammals. Typically, prey includes Ringtail possum (*Pseudocheirus peregrinus*), Common brushtail possum (*Trichosurus vulpecula*), Mountain brushtail possum (*Trichosurus caninus*), Greater gilder (*Petauroides volans*) and Rabbit. Additionally, this species consumes insects, lizards, crayfish, poultry, birds, small mammals, frogs, fish, plant material and refuse that has been discarded by humans (Belcher 1995; 2000; Dawson 2005; Edgar and Belcher 2008; Jones et al. 2001).

Mating and births for the Spotted-tail quoll occur over the winter months (June to August). It is possible for roaming males to mate with more than one female per year (Belcher and Darrant 2004; Dawson 2005; Fleay 1940).

After a gestation period of 21 days, litters of between four and six are born, in late-July to mid-August. Young are attached to the teat for about eight weeks from birth. Subsequently, young may be left in the maternal den while the mother is hunting for food to provide to her young. At 18 to 21 weeks the young are fully independent and 33% of the body size of the mother (Belcher 2003; DotEE 2018; Edgar and Belcher 2008; Fleay 1940; Green and Scarborough 1990; Jones et al. 2001).

4.10.3 Habitat

Spotted-tail quolls have been recorded from a wide range of habitats, including temperate and subtropical rainforests in mountain areas, wet schlerophyll forest, lowland forests, open and closed eucalypt woodlands, inland riparian and River red gum (*Eucalyptus camaldulensis*) forests, dry 'rainshadow' woodland, sub-alpine woodlands, coastal heathlands and occasionally in open country/other treeless areas. Habitat requirements include suitable den sites such as hollow logs, tree hollows, rock outcrops or caves. From a study in Kosciuszko National Park, home range estimates were 620 to 2560 ha for males, and 90 to 650 ha for females (Edgar and Belcher 2008; Green and Scarborough 1990; Maxwell et al. 1996; NPWS 1999).

The Spotted-tail quoll is known to prefer mature wet forest habitat especially areas with rainfall 600 mm/year. Unlogged forest or forest that has had limited disturbance by timber harvesting is also preferable (Belcher 2000; Catling et al. 1998; 2000; Edgar and Belcher 2008; Green and Scarborough 1990; Mansergh 1984; Watt 1993).

4.10.4 Threatening processes

The following have been identified as potentially threatening processes to the Spotted-tail quoll:

- The loss, fragmentation, disturbance and degradation of habitat through clearing of native vegetation, timber harvesting and other forest management practices (ACT Government 2005; Belcher et al. 2007; Catling and Burt 1995; Catling et al. 1998; Long and Nelson 2004)
- Predation from Red foxes, Dingos (Canis lupus dingo) and Domestic dogs. Dietary and habitat overlap with these species may also be leading to competitive effects (Körtner and Gresser 2002; Long and Nelson 2004; Murray and Poore 2004)
- Spot-tailed quolls have been killed by landholders in response to poultry coop raids. The large home ranges of the Spotted-tail quoll, particularly males, also makes them susceptible to road mortality in forested areas fragmented by roads, and a tendency to scavenge carrion may increase this threat (Dawson 2005; Green and Scarborough 1990; Nelson 2004; Jones 2000 cited in Long and Nelson 2004; Jones et al. 2003; Long and Nelson 2004).
- Following various baiting programs using 1080 baits for invasive predators, the dosage for foxes and dogs is potentially fatal to the Spotted-tail quoll, particularly for smaller individuals, such as females and juveniles (Körtner and Watson 2005).

4.10.5 Threat abatement/recovery plans

The following threat abatement plans have been identified as being relevant to this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.

The following recovery plan has been identified as being relevant for this species:

- Department of Environment, Land, Water and Planning (2016). National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus*. Australian Government, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/spotted-tailed-quoll. In effect under the EPBC Act from 06-May-2016.

4.10.6 Summary of threat abatement/recovery plans

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

Important populations outlined in the National Recovery Plan for the Spotted-tailed Quoll *Dasyurus maculatus* that could be relevant to the Project include:

- New South Wales: Marylands National Park and adjacent freehold property 'Mowamba'
- New South Wales: Northern Tablelands: Tenterfield, Glen Innes, Armidale/Walcha, Dorrigo Plateau and Barrington
- New South Wales: Yuragir and Mariah
- New South Wales: Greater blue mountains
- New South Wales: Barren Grounds/Budderoo, Escarpment forest from Morton National Park to Victorian border, Tallaganda/Badja
- New South Wales: Kosciuszko National Park/Snowy Mountains Byadbo
- Queensland: Stanthorpe to Wallangarra, Granite Belt/New England Tablelands
- Queensland: Cherrabah Homestead (between Warwick and Killarney)
- Queensland: Main Range-McPherson Range west
- Queensland: Lamington Plateau-McPherson Range east
- Queensland: Burnett Range
- Queensland: Dalby region.

Threats identified in the National Recovery Plan include:

- Habitat loss and modification
- Fragmentation of habitat and populations
- Timber harvesting

- Poison baiting
- Competition and predation from introduced predators
- Deliberate killing
- Road mortality
- Bushfire and prescription burning
- Poisoning by Cane toads
- Climate change.

Recovery actions outlined in the National Recovery Plan include:

- Determine the distribution and status of populations throughout the species' range
- Investigate key aspects of the biology and ecology to acquire targeted information to aid recovery
- Reduce habitat loss and fragmentation on private land
- Evaluate and manage risk posed by silviculture
- Determine and manage impacts from introduced predators
- Reduce deliberate killing of Quolls
- Assess the threat Can toads pose to the species and develop threat abatement actions
- Determine the likely impact of climate change on populations
- Increase community awareness and involvement in the recovery program.

4.10.7 References

ACT Government (2005). *Spotted-tailed Quoll* (Dasyurus maculatus) - *a vulnerable species, Action Plan No. 30*. Canberra: Environment ACT. Available from: http://www.environment.act.gov.au/cpr/conservation_and_ecological_communities/threatened_species_action_plans. [Accessed 21 August 2018]

Belcher, C.A. (1995). Diet of the tiger quoll *(Dasyurus maculatus)* in East Gippsland, Victoria. *Wildlife Research*. 22:341-357.

Belcher, C.A. (2000). *The Ecology of the Tiger Quoll,* Dasyurus maculatus*, in southeastern* Australia. Ph.D. Thesis. Melbourne, Victoria: Deakin University.

Belcher, C.A. (2003). Demographics of tiger quoll *(Dasyurus maculatus maculatus)* populations in southeastern Australia. *Australian Journal of Zoology*. 51:611-626.

Belcher, C.A. and Darrant J.P. (2004). Home range and spatial organization of the marsupial carnivore, *Dasyurus maculatus maculatus* (Marsupialia: Dasyuridae) in southeastern Australia. Journal of Zoology. 262:271-280.

Belcher, C., Nelson J. and Darrant J. (2007). Diet of the tiger quoll *(Dasyurus maculatus)* in southeastern Australia. *Australian Journal of Zoology*. 55:117-122.

Bennett, S. J. (2012). Spotted-tail quoll (southeastern mainland population) (Dasyurus maculatus maculatus). [image] [online] Available from: https://www.flickr.com/photos/quollism/8470326020/in/photolist-otMpsh-dUuCPN-8i5qZD-8FyqvQ-8Fyrj9-8i5v82-8i5fv2-8i5dAx-8i8tbh-dUuJyw-3ibXyv-6ohk1i-6ohoxX-dUp7A8-6ompZ1-6omrpj-a9ZctU-9agNYm-28zD4py-MzPVJP-2bkFCPX. [17 September 2019].

Catling, P.C., Burt R.J. and Forrester R.I. (1998). Models of the distribution and abundance of ground-dwelling mammals in the eucalypt forests of southeastern New South Wales. Wildlife Research. 25(5):449-466.

Catling, P.C., Burt R.J. and Forrester R.I. (2000). Models of the distribution and abundance of ground-dwelling mammals in the eucalypt forests of north-eastern New South Wales in relation to habitat variables. Wildlife Research. 27:639-654.

Claridge, A.W., Paull D., Dawson J., Mifsud G., Murray A.J, Poore R. and Saxon M.J. (2005). Home range of the spotted-tailed quoll (*Dasyurus maculatus*), a marsupial carnivore, in a rainshadow woodland. *Wildlife Research*. 32(1):7-14.

Dawson, J.P. (2005). *Impact of wildfire on the* Spotted-tail quoll Dasyurus maculatus *in Kosciuszko National Park*. M.Sc. Thesis. University College (Australian Defence Force Academy), University of New South Wales.

Department of the Environment and Energy (2018). *Dasyurus maculatus maculatus (SE mainland population)* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=75184. [Accessed 21 August 2018]

Edgar, R. and Belcher C. (2008). Spotted-tail quoll, *Dasyurus maculatus* (Kerr, 1792). **In:** Strahan, R., ed. *The Mammals of Australia*. Page(s) 61-62. Carlton, Victoria: Reed New Holland.

Fleay, D. (1940). Breeding of the Tiger Cat. *Victorian Naturalist*. 56:159-163.

Green, R.H. and Scarborough T.J. (1990). The Spotted-tail quoll *Dasyurus maculatus* (Dasyuridae, Marsupialia) in Tasmania. *The Tasmanian Naturalist*. 100:1-15.

Jones, M.E., Oakwood M., Belcher C.A., Morris K., Murray A.J., Woolley P.A., Firestone K.B., Johnson B. and Burnett S. (2003). Carnivore Concerns: Problems, issues and solutions for conserving Australasia's marsupial carnivores. In: Jones, M., Dickman C. and Archer M., eds. Predators with Pouches: The biology of carnivorous marsupials. Page(s) 422-434. Collingwood, Victoria: CSIRO Publishing.

Jones, M.E., Rose R.K. and Burnett S. (2001). Dasyurus maculatus. *Mammalian Species*. 676:1-9. American Society of Mammalogists.

Körtner, G. and Gresser S. (2002). *Impact of fox baiting on quoll populations. Final Report to Environment Australia and the New South Wales National Parks and Wildlife Service.*

Long, K.I. and Nelson J.L. (2004). *(Draft) Recovery Plan for* Dasyurus maculatus *(*Spotted-tail quoll*) 2005-2009*. Canberra: Department of the Environment.

Mansergh, I.M. (1984). The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia with particular reference to Victoria. *Australian Zoologist*. 21:109-122.

Maxwell, S., Burbidge A.A. and Morris K. (1996). *The 1996 Action Plan for Australian Marsupials and Monotremes*. Wildlife Australia, Environment Australia. Available from: http://www.environment.gov.au/resource/action-plan-australian-marsupials-and-monotremes [Accessed 21 August 2018].

Murray, A.J. and Poore R.N. (2004). Potential impact of aerial baiting for wild dogs on a population of spotted-tailed quolls *(Dasyurus maculatus). Wildlife Research*. 31:639-644.

National Parks and Wildlife Service (NPWS) (1999). Spotted-tail quoll*,* Dasyurus maculatus *(Kerr 1792)*. Hurstville, New South Wales: National Parks and Wildlife Service.

Threatened Species Scientific Committee (2004). Commonwealth Listing Advice on *Dasyurus maculatus maculatus* (Spotted-tail quoll, Spotted-tail quoll, Tiger Quoll). [Online]. Available from: http://www.environment.gov.au/biodiversity/threatened/species/tiger-quoll.html [Accessed 21 August 2018].

Van Dyck, S.M. and Longmore, N.W. (1991). The mammal records. **In:** Ingram, G.J. and Raven, R.J., eds. *Atlas of Queensland's Frogs, Reptiles, Birds and Mammals*. Page(s) 284-336. Brisbane: Queensland Museum.

Watt, A. (1993). Conservation status and draft management plan for *Dasyurus maculatus* and *D. hallucatus* in southern Queensland. Queensland: Department of Environment.

5 Fauna species – Conservation significant species – Birds

5.1 Australasian bittern (*Botaurus poiciloptilus*)

5.1.1 Status

EPBC Act – Endangered

5.1.2 Biology and ecology

5.1.2.1 Characteristics

The Australasian bittern (*Botaurus poiciloptilus*) is a large stocky, partially nocturnal heron which can reach up to a total body length of 75 cm with a wingspan just over 1 m. The species has a long narrow neck, a straight brownish-yellow bill which transitions into a dark brown feathering on the side of its neck and becomes pale at the throat. The mottled brown upper surface of the bittern is supported by a buff dark brown striped under surface and pale green legs (refer Photograph 5.1). Bittern juveniles differ from adults due to their paler feathering and heavier buff flecking on the back. Sexes can be differentiated through size as female bittern weigh about 900 g compared to male bittern, who are significantly heavier weighing up to 1,400 g. The physical appearance of the bittern makes it very well camouflaged within its natural habitat and often go unspotted (Birdlife 2018; SWIFFT 2018; TSSC 2011).



Photograph 5.1 Australasian bittern (*Botaurus poiciloptilus*)

Source: Brown (2014)

5.1.2.2 Known distribution

The Australasian bittern is known to occur in south-eastern Australia, extending from Bundaberg through to northern Tasmania (refer Figure 5.1). In NSW, Australasian bittern is predominantly found in the Murray-Darling basin which once formed a stronghold for the species (Birdlife 2018; Birdlife International 2016).

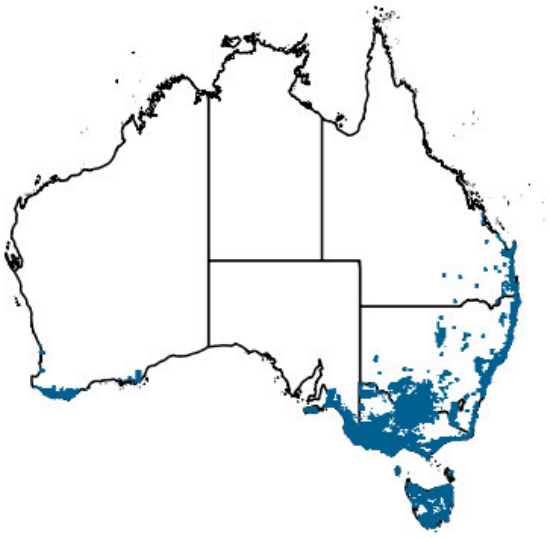


Figure 5.1 **Distribution range of the Australasian bittern**

Source: ALA (2018)

5.1.2.3 Distribution in relation to the project

Botaurus poiciloptilus was not recorded during any Project-associated surveys or surveys for the adjacent TSRC Project. The nearest records (AoLA) are two records from the 1980s located in the Lockyer Forest Reserves area (3 km and 14 km north of the eastern extent of the disturbance footprint). It is noted all records of the species have been generalised to protect the species and so may not reflect the actual occurrence location. The nearest recent record (2009) is from Lake Clarendon (near Gatton) approximately 24 km east of the disturbance footprint (AoLA 2020). Lake Clarendon is identified as a 'key area' for sightings of the species (TSSC 2019). To the west there is an older record (<1976) in the Jondaryan area (26 km north-west of the Project) (refer Figure 5.2).

There are no areas of remnant palustrine wetland or wetlands considered to be of high ecological value within the MNES study area. Wetland habitat is restricted to 0.19 ha within the Project footprint and is highly ephemeral. Dams and reservoirs are generally unlikely to provide suitable dense aquatic vegetation for the species. Riverine wetlands associated withGowrie Creek in the western portion of the alignment are ephemeral and typically highly modified with little native riparian cover and little aquatic vegetation present suitable for Australasian bittern.

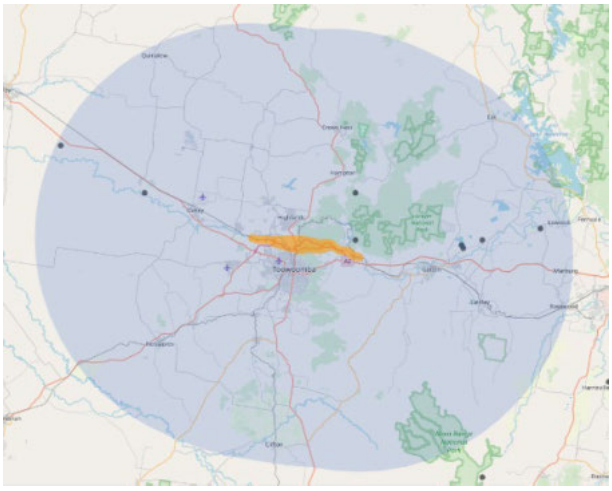


Figure 5.2 **Distribution range of the Australasian bittern in relation to the Project**

Source: ALA (2020)

5.1.2.4 Biology and reproduction

The Australasian bittern is crepuscular and known to hide during day time and come out after sun down. It feeds mainly on frogs, fish, crayfish, spiders, insects and snails. The species constructs a feeding platform over deeper water using reeds trampled by the bird and uses multiple hunting techniques to capture prey (Birdlife 2018; OEH 2017).

The species breed around summer, between October and January, as solitary pairs and begin building nests in secluded, densely vegetated wetlands on platforms of reeds approximately 30 cm above water level. The female Australasian bittern will lay six eggs of olive to brown colour to a clutch and known to have a short incubation period (Birdlife 2018; O'Donnell 2011; TSSC 2011).

5.1.3 Habitat

Preferred habitat for the Australasian bittern consists of permanent freshwater wetlands with tall dense vegetation including bulrushes (*Tyhpa* spp.), spikerushes (*Eleocharis* spp.) and tall emergent sedges. Rice paddies within the Murray-Darling basin are a known habitat for the species who disperse widely during periods of droughts to coastal wetlands and to ephemeral wetlands (Birdlife International 2016; OEH 2017).

5.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Australasian bittern:

- Wetland drainage for agriculture
- Changes brought on by high levels of grazing, drought and salinisation of swamps
- Long term habitat destruction exposing species to predation
- Abandoning nests due to slight disturbances as a result of their sensitive nature (Birdlife International 2016).

5.1.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2019). Draft National Recovery Plan for the Australasian Bittern *Botaurus poiciloptilus*. Available from: https://www.environment.gov.au/system/files/consultations/9a03b781-7f67-4874-a919-cf53cd1eee60/files/draft-recovery-plan-australasian-bittern.pdf.
- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10105. In effect under the BC Act 2016.

The following threat abatement plans have been identified as being relevant to this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.

5.1.6 Summary of threat abatement/recovery plan

Threats identified in the Draft National Recovery Plan for the Australasian Bittern *Botaurus poiciloptilus* include:

- Changes of water flow reducing the availability of wetland habitat
- Loss and alteration of wetland habitat from fire and livestock
- Climate change resulting in variability of environmental conditions, in particular a reduction in rainfall and increase in drought reducing water levels in wetland habitat
- Impacts to water quality from increased salinity, acidification, siltation and pollution
- Increased competition, habitat alteration and predation from hard hooved invasive herbivores and predators
- A lack of genetic diversity due to small population sizes.

Management actions outlined in the Draft National Recovery Plan for the Australasian Bittern *Botaurus poiciloptilus* include:

- Reduce threats to Australasian bittern and the species' habitat through the implementation of management strategies
- Better protect the species and provide improvements in the quality and extend of suitable habitat
- Gain an improved understanding of the species' ecology and biology and identify population trends through ongoing monitoring
- Increase the engagement of stakeholders in the conservation and management of the specie
- Ensure the recovery process is well coordinated, reviewed and reported on.

Threats identified by the *Saving our Species* program include:

- Drainage of wetlands and ponds and alteration of natural flow regimes
- Loss and degradation of wetland habitat, including artificial wetland habitat in rice growing areas, due to changes in water management and cropping practises
- Climate change driven seasonality changes such as amount of rainfall and associated changes in environmental water allocations
- Predation by foxes, pigs and cats.

Management activities in the *Saving our Species* program to protect this species are:

- Apply environmental water quality requirements (timing, depth, duration, frequency) in long-term environmental water plans (including Murrumbidgee, Murray, Lachlan, Macquarie, Gwydir) to maintain and restore habitat
- Develop and/or upgrade infrastructure to support environmental water delivery to priority bittern habitat areas
- Educate and encourage landholders to improve wetland management and awareness of bitterns, and report sightings (target landholders in Hunter, north and south coast, northern basin and Riverina/Murray areas)
- Undertake targeted control of predators at selected priority sites during breeding (summer) using techniques such as trapping and/or baiting
- Educate irrigation corporations in rice-growing areas and encourage sensitive management of canals
- Work with rice growers to develop a "bittern friendly" rice label that promotes best practice rice growing for maintaining bittern habitat
- Conduct targeted research into habitat use during non-breeding season and during drought.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups

- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

5.1.7 References

Atlas of Living Australia (2018). Botaurus poiciloptilus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:47dca80b-ac7c-4130-bef3-4afb4fad35ab [Accessed 22 August 2018].

Birdlife Australia (2018). Australasian Bittern. Available from: http://www.birdlife.org.au/bird-profile/australasian-bittern [Accessed 22 August 2018].

BirdLife International (2016). Botaurus poiciloptilus. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22697353/0 [Accessed 22 August 2018].

Brown, C. (2014). Australasian bittern (Botaurus poiciloptilus). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=540dc629-3998-48c0-848a-18e1514a39c5. [17 September 2019].

O'Donnell, Colin. (2011). Breeding of the Australasian Bittern (Botaurus poiciloptilus) in New Zealand. ResearchGate. Available from: https://www.researchgate.net/publication/263002340 [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Australasian Bittern – Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10105 [Accessed 22 August 2018].

State Wide Integrated Flora and Fauna Teams (2018). Australasian Bittern. Available from: http://www.swifft.net.au/cb_pages/australasian_bittern.php [Accessed 22 August 2018].

Threatened Species Scientific Committee (2011). Botaurus poiciloptilus in Species Profile and Threats Database. Department of Environment and Energy. Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/1001-listing-advice.pdf [Accessed 22 August 2018].

5.2 Australian painted snipe (*Rostratula australis*)

5.2.1 Status

EPBC Act – Endangered Marine (CAMBA)

5.2.2 Biology and ecology

5.2.2.1 Characteristic

The Australian painted snipe (*Rostratula australis*) is a stocky wading bird approximately 220 to 250 mm in length. It has a long pinkish bill and chestnut-coloured head, with a white ring around the eye and a crown stripe. The back and wings are metallic green and barred with black and chestnut. There is a pale stripe extending from the shoulder into a V down the individuals upper back (refer Photograph 5.2). The adult female is slightly larger and more brightly coloured than the male (DotEE 2018).



Photograph 5.2 Australian painted snipe male (*Rostratula australis*)

Source: eBird Australia (2015)

5.2.2.2 Known distribution

The Australian painted snipe has been recorded at wetlands in all states and territories of Australia but is most common in eastern Australia, where it has been recorded at scattered locations throughout much of Queensland, NSW, Victoria and southeastern South Australia (refer Figure 5.3). Known distribution has likely declined by approximately 50% in Australia since European settlement (Barrett et al. 2003; Blakers et al. 1984; DotEE 2018; Environment Australia 1997).

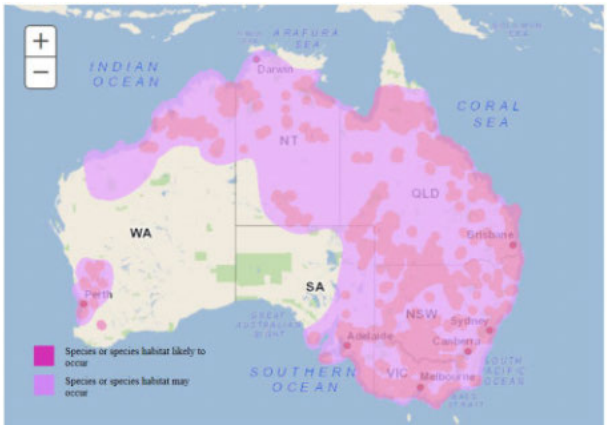


Figure 5.3 **Distribution range of the Australian painted snipe**

Source: DotEE (2018)

5.2.2.3 Distribution in relation to the project

Rostratula australis was not recorded during any Project-associated surveys or surveys for the adjacent TSRC Project. Australian painted snipe has been recorded at several sites to the east of the Project. This includes including two sightings (1982 & 1983) within the MNES study area 500 m from the eastern end of the disturbance footprint. Recent records from nearby include 2013 records in the Helidon area (2 km and 4 km south-east of the eastern extent of the Project disturbance footprint). Most other records for this species occur further east of the Project in the Lockyer Valley where numerous wetlands and large waterbodies occur. However, there is a 1995 record approximately 13 km to the north of the Gowrie area from Cooby Creek Dam (refer Figure 5.4).

There are no areas of remnant palustrine wetland or wetlands considered to be of high ecological value within the MNES study area. Wetland habitat is restricted to 0.19 ha within the Project footprint and is highly ephemeral. Dams and reservoirs are generally unlikely to provide suitable dense aquatic vegetation for the species. Riverine wetlands associated with Gowrie Creek in the western portion of the alignment are ephemeral and typically highly modified with little native riparian cover and little aquatic vegetation present suitable for Australian painted snipe.

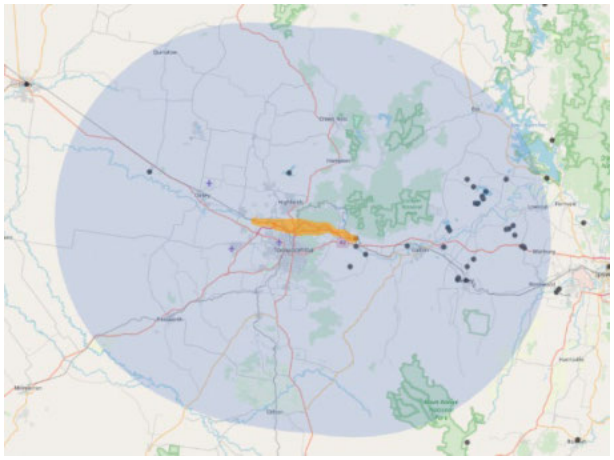


Figure 5.4 **Distribution range of the Australian painted snipe in relation to the Project**

Source: ALA (2020)

5.2.2.4 Biology and reproduction

The Australian painted snipe eats vegetation, worms, seeds, insects, molluscs, crustaceans and other invertebrates. They are mainly crepuscular and generally remain in dense cover when feeding, although they may forage over nearby mudflats and other open areas such as agricultural land or grassland (Marchant and Higgins 1993).

The Australian painted snipe may breed in response to wetland conditions rather than during a particular season. The species has been recorded breeding in all months in Australia. Their breeding habitat requires shallow wetlands with areas of bare wet mud and with canopy cover nearby. The species nests usually occur on or near small islands in freshwater habitats. Females are known to lay two to six (typically three or four) eggs and may lay up to four clutches in a year and incubation takes 15 to 21 days. The females usually breed every two years (DotEE 2018; Marchant and Higgins 1993).

This species is generally seen alone or in pairs or occasionally in small flocks. Flocking occurs during the breeding season, but are also known to form after the breeding season and at some locations where small groups regularly occur (DotEE 2018; Marchant and Higgins 1993).

5.2.3 Habitat

The Australian painted snipe generally inhabits shallow terrestrial freshwater wetlands, including temporary and permanent lakes, swamps and claypans. The species has also been observed to use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. The Australian painted snipe has been recorded nesting in and near swamps, canegrass swamps, flooded areas, including samphire, grazing land, among cumbungi, sedges, grasses, salt water couch, saltbush (*Halosarcia* sp.) and grass, in ground cover of water-buttons and grasses, at the base of tussocks and under low saltbush (DotEE 2018; Marchant and Higgins 1993).

The Australian painted snipe requires suitable wetland areas even in drought conditions but the species can move to suitable habitat if necessary (Marchant and Higgins 1993).

5.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Australian painted snipe:

- The loss and alteration of wetland habitat, particularly the drainage of wetlands and diversion of water to agriculture and reservoirs therefore reducing flooding and precluding the formation of temporary shallow wetlands (NSW NPWS 1999; Watkins 1993; White 1997)
- Grazing and trampling of wetland vegetation by livestock (NSW NPWS 1999)
- The colonisation of invasive, noxious weeds could render habitats less suitable for the snipe and changes to fire regimes might be affecting savannah vegetation around wetlands in northern Australia (del Hoyo et al. 1996; Garnett and Crowley 2000; NSW NPWS 1999; Rogers et al. 2005; Watkins 1993; White 1997)
- Australian painted snipe nesting sites may also be vulnerable to introduced terrestrial predators such as the European red fox or feral cat (DotEE 2018).

5.2.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as being relevant for this species:

- Department of the Environment and Energy (2019) Draft National Recovery Plan for the Australian Painted Snipe. Available from: https://www.environment.gov.au/system/files/consultations/5e6b3fbf-ef4d-4d0a-b9c8-c8e29bb11afc/files/draft-recovery-plan-australian-painted-snipe.pdf.
- Office of Environment and Heritage (2017). Saving our Species: Help save the Australian Painted Snipe. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1292&ReportProfileID=10734.

5.2.6 Summary of threat abatement/recovery plan

Threats identified in the Draft National Recovery Plan for the Australian Painted Snipe include:

- Historical threats include land use changes, particularly in the Murray-Darling Basin resulting in losses of temporary wetlands due to changes in water management

- Current threats include; degradation of wetlands resulting from drainage and water diversion
- Loss of breeding habitat due to reduced frequency of flooding
- Reduced fresh water availability through drainage, losses to irrigation and water diversion
- Increased cropping and fire regimes altering wetland vegetation in floodplains and wetlands
- Drought and changing climatic conditions intensifying impacts of degrading processes
- Dry season grazing in wetlands causing trampling of vegetation and nutrient enrichment
- Changes to the structure of wetland habitat and reduced water quality
- Encroachment from invasive weeds and changes in community structure of native vegetation reducing habitat suitability for the species
- Lack of genetic diversity

Management actions outlined in the Draft National Recovery Plan for the Australian Painted Snipe:

- Approach protection and management of breeding habitat from a landscape scale
- Implement measurement techniques to quantify population growth/decline to determine success of recovery actions
- Mitigate degradation of critical habitat for various life stages of the species
- Increase knowledge on the biology and ecology of the species and better understand habitat requirements
- Increase awareness of the species and conservation efforts being implemented amongst community stakeholders
- Compile and review results of the recovery process through coordinated efforts.

Threats identified in the Saving our Species plan includes:

- Drainage of wetland breeding sites
- Grazing and frequent fires in wetland habitat
- Herbicide, pesticide and other chemical use near wetlands
- Invasive native plants and exotic weeds reducing the health of wetland habitat
- Lack of knowledge on the reproduction of the species.

Management actions outline in the Saving our Species plan includes:

- Set environmental water quality parameters in long-term environmental water plans
- Control invasive vegetation
- Manage grazing and burning in wetlands creating a mosaic of habitat features
- Engage with landholders adjacent to wetlands providing education on the impact of chemical use, discuss non-toxic alternative and implement appropriate drainage management to avoid run-off
- Manage stock and fire regimes near wetlands
- Conduct research into the species to fill knowledge gaps
- Encourage the restoration of wetland habitat in an agricultural landscape
- Manage environmental water to ensure shallow muddy edge habitat during spring and summer.

5.2.7 References

Aviceda (2002). Photographic image of *Rostratula australis*. [Accessed 22 August 2018]

Barrett, G., Silcocks A., Barry S., Cunningham R. and Poulter R. (2003). *The New Atlas of Australian Birds*. Melbourne, Victoria: Birds Australia.

Blakers, M., Davies S.J.J.F. and Reilly P.N. (1984). *The Atlas of Australian Birds*. Melbourne, Victoria: Melbourne University Press.

del Hoyo, J., Elliott A. and Sargatal J. eds. (1996). *Handbook of the Birds of the World. Volume 3, Hoatzin to Auks*. Barcelona: Lynx Edicions.

Department of the Environment and Energy (2018). *Rostratula australis* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=77037 [Accessed 22 August 2018].

eBird Australia. (2015). Australian painted snipe male (Rostratula australis). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=80919ccc-36ac-463a-9bd9-1462b7a05d1d. [17 September 2019].

Garnett, S.T. and Crowley G.M. (2000). *The Action Plan for Australian Birds 2000*. Canberra, ACT: Environment Australia and Birds Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html [Accessed 22 August 2018]

Marchant, S. and Higgins P.J., eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds*. Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

New South Wales National Parks and Wildlife Service (1999). *Threatened Species Information - Painted Snipe.*

Rogers, D., Hance I., Paton S., Tzaros C., Griffioen P., Herring M., Jaensch R., Oring L., Silcocks A. and Weston M. (2005). The breeding bottleneck: breeding habitat and population decline in the Australian Painted Snipe. In: Straw, P., ed. *Status and Conservation of Seabirds in the East Asian-Australasian Flyway*. Pp. 15-23.

Watkins, D. (1993). A national plan for shorebird conservation in Australia. *RAOU Report Series*. 90.

White, M.E. (1997). *Listen, Our Land Is Crying. Australia's Environment: Problems and Solutions.* Kenthurst, New South Wales: Kangaroo Press.

5.3 Black-breasted button-quail (*Turnix melanogaster*)

5.3.1 Status

EPBC Act – Vulnerable

5.3.2 Biology and ecology

5.3.2.1 Characteristic

The Black-breasted button-quail (*Turnix melanogaster*) is a relatively large, plump and pale-eyed ground-dwelling bird. The males are about 18 cm long, with a wingspan of 32 to 35 cm, and weighing 65 g. The females weigh on average 100 g, are slightly larger than males and are the dominant sex. Female and male plumage also differs, with females having a black head and breast with white half-moon markings across the upper-breast and a chestnut marbled upper covered in black ladder markings and white streaks. Conversely, males have white markings on the face and neck covered with fine black dots and the upper-breast is a mottled chestnut and black (refer Photograph 5.3). Both sexes have grey bills, white-cream eyes and yellowish legs and feet (DotEE 2018; Pizzey and Knight 2007).



Photograph 5.3 Black-breasted button-quail (*Turnix melanogaster*)

Source: Dunis (2017)

5.3.2.2 Known distribution

Black-breasted button-quails are distributed across south-eastern Queensland from near Byfield in the north to the Border Ranges rainforests in the south, generally east of the Great Dividing Range (refer Figure 5.5); although there are records up to 300 km inland at locations at Palmgrove National Park and Barakula State Forest in Queensland. In north-eastern NSW, they are restricted to the Northern Rivers and Tablelands (DotEE 2018; Marchant and Higgins 1993).



Figure 5.5 Distribution range of the Black-breasted button-quail

Source: ALA (2018f)

5.3.2.3 Distribution in relation to the project

Black-breasted button-quail has not been recorded during any Project-associated surveys (including searches for foraging platelets) but was recorded during surveys for the nearby TSRC project (although the location of this record has been restricted due to probity issues). There are a number of records (AoLA) from the Toowoomba area, many of which are very old. There are two database records from within the Project disturbance footprint in the Gowrie area one of which is from 1901. The other record does not have an associated collection date and has a high spatial uncertainty. The nearest recent records are also from the Gowrie area (1999 and 1.8 km north of the disturbance footprint) and Redwood Park at the base of the Toowoomba Range (2006 and 5 km south). There are two 2018 records 9 km south in the Toowoomba Range and Lockyer Valley although the location of these records have been generalised to protect the species location. There is a large cluster of records to the north-east in the Ravensbourne National Park area (approximately 18 km north of the eastern extent of the Project) which includes relatively recent records from the 2000s. The closest of these is from 1995 and 16 km north of the eastern extent of the Project (refer Figure 5.6).

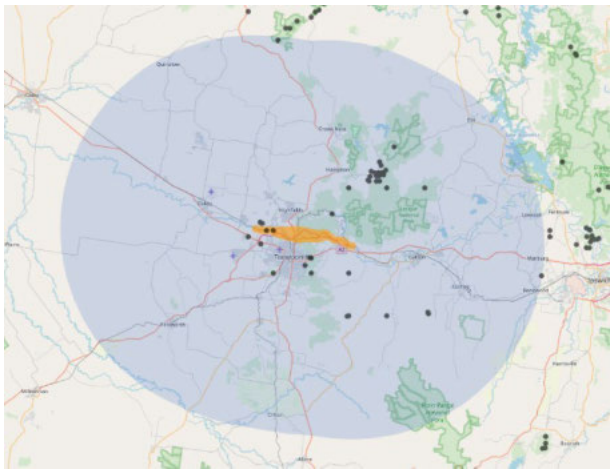


Figure 5.6 **Distribution range of the Black-breasted button-quail in relation to the Project**

Source: ALA (2020)

5.3.2.4 Biology and reproduction

Their principal food is invertebrates gathered from the leaf litter on the forest floor, however, seeds may also be consumed (DotEE 2018; Hughes and Hughes 1991).

The species is polyandrous (a single female mates with several males who incubate the eggs) and it has been seen in pairs or, more occasionally, in small groups. There is little known on the breeding habits of the Black-breasted button-quail, however they are assumed to breed throughout their range. Although they may exhibit limited migratory movements at night in response to resource availability. The breeding season occurs from September to April/May and between three and five eggs are laid. Nests consist of a scrape in the ground, lined with leaves, grass or moss. Nests are typically well-concealed and placed in the buttress root of a tree or sapling, the base of a fern or under a low bush or grass tussock (DotEE 2018; Smyth and Young 1996).

5.3.3 Habitat

The Black-breasted button-quail is restricted to rainforests and forests, mostly in areas with 770 to 1,200 mm rainfall per annum in areas characterised by highly fertile soils. They prefer drier low closed forests, particularly semi-evergreen vine thicket, low microphyll vine forest, araucarian microphyll vine forest and araucarian notophyll vine forest. They may also be found in low, dense Acacia thickets and, in vegetation behind coastal sand dunes. In south-eastern Queensland, the Black-breasted button-quail has been recorded on rare occasions in open Eucalypt forest; for example, birds have been recorded in Grey ironbark (*Eucalyptus siderophloia*) with a low sparse shrub layer of Eucalypt and Acacia seedlings, and a sparse ground cover of short tussock grasses and leaf litter. This species also heavily utilises areas infested with *Lantana camara*, particularly where this produces a dense leaf-litter below a thigh woody shrub layer. An dense leaf-litter layer is required for foraging and possibly also roosting (DotEE 2018; Hughes and Hughes 1991; Smith and Mathieson 2004).

5.3.4 Threatening processes

The following have been identified as potentially threatening processes to the Black-breasted button-quail:

- Massive clearance of forest for agriculture, forestry and urban development continues to be the biggest threat to the species. Sub-populations in the remaining fragmented habitats are affected by excessive grazing and trampling which may reduce the amount of understorey vegetation and deep leaf litter on which the species relies (Bennett 1985; Garnett and Crowley 2000).
- Frequent fire eliminates shrubby understorey in dry rainforest remnants and can also reduce the amount of leaf litter on the ground, rendering habitat unsuitable (Garnett and Crowley 2000)
- Being ground-nesters, they are also affected by predation by cats, foxes and pigs (Bennett 1985; Garnett and Crowley 2000; Hughes and Hughes 1991; Smith and Mathieson 2004).

5.3.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Mathieson, M.T. & G.C. Smith (2009). National recovery plan for the black-breasted button-quail Turnix melanogaster. Report to the Department of the Environment, Water, Heritage and the Arts, Canberra. Department of Environment and Resource Management, Brisbane. Available from: http://www.environment.gov.au/resource/national-recovery-plan-black-breasted-button-quail-turnix-melanogaster. In effect under the EPBC Act from 13-Nov-2009.

The following threat abatement plans have been identified as being relevant to this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment and Energy (2017). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017. In effect under the EPBC Act from 18-Mar-2017.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.

5.3.6 Summary of threat abatement/recovery plans

Threats specific to the Black-breasted button-quail in the strategy include:

- Very specific habitat requirements that are subject to development pressure
- Polyandrous breeding nature could result in genetic bottleneck given there are fewer females than males in the population
- Habitat loss, fragmentation and degradation
- Inappropriate fire regimes
- Predation by feral animals.

Objectives and actions outlined in the threat abatement plan for the Black-breasted button-quail include:

- Consolidate current information and define assessment and monitoring strategies determining where suitable habitat is occupied
- Protect key habitat for the species from human induced processes
- Maintain and improve the extent, condition and connectivity of suitable habitat
- Reduce the impacts of introduced predators and competitors
- Increase ecological knowledge of the species
- Review the operation of the recovery process.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

The threats outlined in the threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) include:

- Impacts on plant species composition and succession
- Alterations to nutrient, water cycling and water quality
- Predation of native fauna and flora including small mammals, birds, reptiles, frogs, crayfish, eggs, invertebrates, fungi and all part of plants including fruit, seeds, roots, tubers, bulbs and foliage
- Digging and disturbance to substrate resulting in the destruction of plants threatening their survival and recruitment of new plants altering the floral composition and soil structure
- Disturbance caused by pigs can increase the incursion and recruitment of weeds and provide reservoirs for endemic animal diseases.

Threat abatement actions for feral pics (*Sus scrofa*) include:

- Implementation of control measures including trapping, aerial and ground shooting, poisoning and fencing
- Using tracking dogs to detect and flush out feral pigs by commercial harvesters
- Manipulating habitat by reducing watering points and crop waste
- Manage feral pigs within a policy, legislative and planning framework.

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

5.3.7 References

Atlas of Living Australia (2018). *Turnix (Austroturnix) melanogaster*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:03a6ee3f-e227-41e2-b2f3-6f6aea694a83 [Accessed 23 August 2018].

Bennett, S. (1985). The distribution and status of the Black-breasted Button-quail *Turnix melanogaster. Emu*. 85:157-162.

Department of the Environment and Energy (2018). *Turnix melanogaster* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=923 [Accessed 23 August 2018].

Dunis, V. (2017). Black-breasted button-quail (Turnix melanogaster). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=ea3c5de8-f1f6-4c56-8567-f8a8db613669. [17 September 2019].

Garnett, S.T. and Crowley G.M. (2000). *The Action Plan for Australian Birds 2000*. Canberra, ACT: Environment Australia and Birds Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html.

Hughes, P. and Hughes B. (1991). Notes on the Black-breasted Button-quail at Widgee, Queensland. *Australian Bird Watcher*. 14:113-118.

Jones, G (2010). Photographic image of *Turnix melanogaster*. [Accessed 23 August 2018].

Marchant, S. and Higgins, P.J. eds. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings*. Melbourne, Victoria: Oxford University Press.

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Smith, G.C. and Mathieson M. (2004). Black-breasted button-quail. *Wingspan*. September:34-35.

Smyth, A.K. and Young J. (1996). Observations on the endangered Black-breasted Button-quail *Turnix melanogaster* breeding in the wild. *Emu.* 96:202-207.

5.4 Black-throated finch (*Poephila cincta cincta*)

5.4.1 Status

EPBC Act – Endangered

5.4.2 Biology and ecology

5.4.2.1 Characteristics

The Black-throated finch (southern sub-species) (*Poephila cincta cincta*) is a small stocky finch with a total body length of 12 cm and weighing about 15 g. The physical appearance of the finch is distinguishable by its bluish-grey head which features a short black stripe leading all the way through to the upper breast of the bird. The body of the finch is brown on the back, cinnamon on the breast and white on the rump which attaches to a black tail (refer Photograph 5.4). Plumage of both male and female finches are similar, however, female finches are smaller in size and have a slightly smaller throat patch compared to the male (DES 2018; OEH 2017).



Photograph 5.4 Black-throated finch (*Poephila cincta cincta*)

Source: Sherony (2016)

5.4.2.2 Known distribution

The known distribution of the Black-throated finch (southern sub-species) once extended from Inverell in northeast NSW, through eastern Queensland into the Atherton Tablelands as well as west to central Queensland (refer Figure 5.7). However, the species is considered to be locally extinct within the southern portion of its range. The species can now only be found in Queensland, near Townsville and in the Galilee Basin of Central Queensland, as the finch is likely extirpated in NSW (DES 2018; OEH 2017).



Figure 5.7 **Distribution range of the Black-throated finch**

Source: ALA (2018)

5.4.2.3 Distribution in relation to the project

Poephila cincta cincta has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that one record of *Poephila cincta cincta* exists within the disturbance footprint. This record is located approximately 2 km north of Cotswold Hills (not dated). No other records are located within a 50 km buffer of the disturbance footprint. The next closest record is located approximately 90 km east of the alignment in Brisbane and is dated 1897 (refer Figure 5.8).

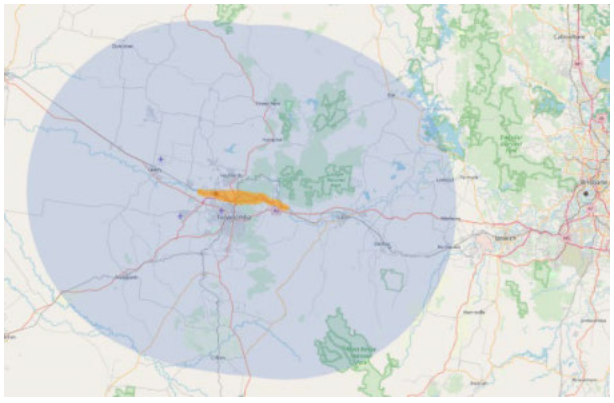


Figure 5.8 **Distribution range of the Black-throated finch in relation to the Project**

Source: ALA (2020)

5.4.2.4 Biology and reproduction

This finch species forages in small flocks, consuming seeds on the ground of native grasses as well as plucking seeds directly from the seedheads. During the breeding season, the finch is known to consume insects such as flying termites (Birdlife 2018; DES 2018).

Black-throated finches pair for life and separate from the flock during breeding season despite nesting in colonies due to their social nature. The species is known to reuse abandoned nests as well as build fresh dome shaped nests with a side entrance. Built nests are woven from grass stems and lined with soft seedheads, plant down and feathers which are placed in trees or tree hollows between spring into early autumn (Birdlife 2018; DES 2018).

The female will lay between five to nine eggs per brood and up to two broods may be produced per year, with an incubation period of up to 12 days. Fledging has been recorded to occur after 21 days with the young being independent only after 40 days (DES 2018; OEH 2017).

5.4.3 Habitat

This species of finch is a highly social bird, roaming in flocks of 40 or more. Black-throated finch (southern sub-species) require habitats that supply year-round seeds for feeding. Typical areas inhibited by the bird include grassy woodland dominated by eucalypts, paperbarks, tea-tree, Melaleuca or acacias along water courses (riparian habitats) due to their significance in providing shelter, specially within highly fragmented and modified environments. Despite being considered sedentary the species may move in response to droughts (DES 2018; OEH 2017).

5.4.4 Threatening processes

The following have been identified as potentially threatening processes to the Black-throated finch:

- Spread and intensification of pastoralism
- Changes to fire regimes
- Increases in the density of native woody weeds among grassy savannas (Birdlife International 2016; DES 2018).

5.4.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Black-throated Finch Recovery Team, Department of Environment and Climate Change (NSW) and Queensland Parks and Wildlife Service (2007). National recovery plan for the black-throated finch southern subspecies *Poephila cincta cincta*. Report to the Department of the Environment and Water Resources, Canberra. Department of Environment and Climate Change (NSW), Hurstville and Queensland Parks and Wildlife Service, Brisbane. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-black-throated-finch-southern-subspecies-poephila-cincta-cincta. In effect under the EPBC Act from 08-Jan-2008.

The following threat abatement plans have been identified as being relevant to this species:

- Department of Sustainability, Environment, Water, Population and Communities (2012). Threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses. Department of Sustainability, Environment, Water, Population and Communities. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-reduce-impacts-northern-australias-biodiversity-five-listed-grasses. In effect under the EPBC Act from 11-Dec-2012.
- Department of the Environment and Energy (2016). Threat abatement plan for competition and land degradation by rabbits. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.

5.4.6 Summary of threat abatement/recovery plans

Threats outlined in the National recovery plan for the black-throated finch southern subspecies *Poephila cincta cincta* include:

- Clearing and fragmentation of woodland, riverside, and wattle shrubland habitats
- Grazing impacts from livestock and rabbits
- Alteration of fuel load, vegetation structure and wet season food availability
- Fire causing alteration to habitat
- Invasive weed species including exotic grasses
- Illegal trapping of birds

- Predation by feral vertebrate pest species
- Hybridisation with escapees from sub-species.

Objectives and actions outlined in the National recovery plan for the black-throated finch southern subspecies *Poephila cincta cincta* include:

- Investigate and quantify threats faced by the species
- Determine distribution and abundance
- Protect and enhance habitat
- Investigate the viability of reintroducing captive breed stock
- Increase public awareness.

Threats identified in threat abatement plan to reduce the impacts on northern Australia's biodiversity by the five listed grasses includes:

- These highly invasive grasses can increase fuel loads
- Alter nitrogen cycling and water availability
- Degrade ecosystems through loss of habitat and biodiversity declines.

Management actions outlined in the threat abatement plan include:

- Determine the extent and spread pathways of infestation by the five listed grasses outlined in the plan
- Support and facilitate coordination management strategies through the design of tools, systems and guidelines
- Identify and prioritise key asset and areas for the implementation of management strategies
- Implement on the ground management strategies that are cost effective in high priority areas
- Monitor, evaluate and report back on the effectiveness of management programs.

Threats identified in the threat abatement plan for competition and land degradation by rabbits includes:

- Competition with native wildlife for food and shelter
- Prevention of plant regeneration
- Increased grazing pressure and damage to native vegetation
- Altering the regular process of plant succession
- Altering ecological communities and impacting soil structure and nutrient cycling contributing to serious erosion
- Increasing predation and reducing reproduction for native arboreal mammals and birds through the removal of critical habitat.

Threat abatement actions for rabbits include:

- Supress rabbit populations at the landscape scale below thresholds in identified priority areas
- Gain a better understanding of the impacts rabbits have and their interactions with other species and ecological processes
- Increase the effectiveness of rabbit control programs
- Increase engagement within the local community to provide awareness of the environmental impact of rabbits and the need for integrated control.

5.4.7 References

Atlas of Living Australia (2017). Poephila (Poephila) cincta. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:26d93abf-b5bf-43ea-91f3-4187e30619c5 [Accessed 22 August 2018].

Birdlife Australia (2018). Black-throated Finch. Available from: http://www.birdlife.org.au/bird-profile/black-throated-finch [Accessed 22 August 2018].

BirdLife International (2016). Poephila cincta. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22719692/0 [Accessed 22 August 2018].

Department of Environment and Science (2018). Black-throated finch (southern subspecies). Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/blackthroated_finch_southern_subspecies.html [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Black-throated Finch - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10641 [Accessed 22 August 2018].

Sherony, D. (2016). Black-throated finch (Poephila cincta cincta). [image] [online] Available from: https://www.flickr.com/photos/9765210@N03/31293004362/in/photolist-25zw5ov-LufB5o-PFfPXY. [17 September 2019].

5.5 Coxen's fig-parrot (*Cyclopsitta diophthalma coxeni*)

5.5.1 Status

EPBC Act – Endangered

5.5.2 Biology and ecology

5.5.2.1 Characteristics

Coxen's fig-parrot (*Cyclopsitta diophthalma coxeni*) is a small parrot measuring between 15 to 16 cm in body length (DES 2011).

The adults are predominantly bright green, with a prominent yellow line along the flanks and the sides of the breast. The primary feathers exhibit blue edges, and bright red markings occur on the tertial feathers. Broad cream bands and grey-black edging occur on the undersides of the wings, and dark grey edging around the underside of the tail. Coxen fig-parrots have a distinctive facial pattern that consists of a patch of light-blue on the forehead, a curving band of red (edged and mottled with yellow) below the eye, and a curving band of violet-blue that borders the lower edge of the curving red band (DES 2011; OEH 2017) (refer Figure 5.9).

Both male and female species of Coxen's fig-parrot are very similar in appearance, however the female has a smaller blue patch as well as few to no red feathers on the forehead and a duller, less extensive orange-red cheek patch (DES 2011).



Figure 5.9 **Coxen's fig-parrot (*Cyclopsitta diophthalma coxeni*)**

Source: Coxen's Fig-Parrot Recovery Team (2001)

5.5.2.2 Known distribution

The Coxen's fig-parrot's known distribution is still evolving due to their hard to spot nature. However, historical records have localised scattered populations of the species to an area between Bundaberg, in Queensland, to Hastings River in NSW (DES 2011; OEH 2017) (refer Figure 5.10).



Figure 5.10 **Distribution range of the Coxen's fig-parrot**

Source: Birdlife International (2018)

5.5.2.3 Distribution in relation to the project

Cyclopsitta diophthalma coxeni has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that no records of *Cyclopsitta diophthalma coxeni* exist within the ecology study area or within a 50 km buffer around the disturbance footprint. The closest records are located approximately 55 km southeast of the disturbance footprint in Main Range National Park and are dated 1994 and 1997 (refer Figure 5.11).

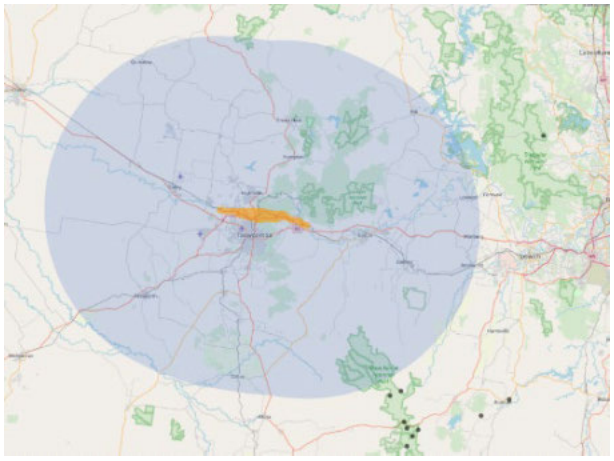


Figure 5.11 **Distribution range of the Coxen's fig-parrot in relation to the Project**

Source: ALA (2020)

5.5.2.4 Biology and reproduction

Coxen's fig-parrots are omnivorous, mainly feeding on seeds of near ripe or ripe fruits of native figs, and/or insect larvae, which may include the fig wasp. Favoured species include Moreton Bay fig (*Ficus macrophylla*), Green-leaved strangler fig (*F. watkinsiana*), but a variety of other *Ficus* sp. and other native fruits also eaten (DES 2011; Pizzey and Knight 1997).

The breeding biology of Coxen's fig-parrot is almost entirely unknown. The breeding season is thought to extend from October to December or January. The nest is established in a chamber that is excavated in the rotting wood of a decaying limb or trunk of a living or dead tree. The appearance of the nest and eggs is unknown, and no information is available on the incubation or fledging periods (Birdlife International 2018; DES 2011; DotEE 2018).

Coxen's fig-parrot is usually observed singly, in pairs or in small flocks of up to 12 birds (especially during winter). Communal roosting has not been recorded for this species, however it has been speculated that communal roosting may formerly have occurred, when the population size was greater. No information is available on the breeding dispersion in this species, but it is likely that they breed in solitary pairs, like other subspecies of the Double-eyed fig-parrot (Coxen's Fig-Parrot Recovery Team 2001; DES 2011).

5.5.3 Habitat

The Coxen's fig-parrot's preferred habitat are environments with thriving fig trees in lowland rainforest especially in alluvial areas. More recently however the species has adapted to a spectrum of rainforest types including coniferous, warm and cold subtropical as well as cool temperate rainforests between sea level and approximately 1,000 m above sea level (Birdlife International 2018; DES 2011).

The species have also been known to inhabit riparian corridors through woodlands, cleared land as well as isolated fruiting trees in gardens or farms consuming both fig and other fruiting rainforest species such as lichen, nectar and grubs (DES 2011; OEH 2017).

5.5.4 Threatening processes

The following have been identified as potentially threatening processes to the Coxen's fig-parrot:

- Rapid clearance of lowland rainforest which has led to increased fragmentation of habitats and isolated fig trees
- Invasion of habitats by invasive weeds
- Challenges in locating sufficient food sources
- Competition from other species with larger populations (Birdlife International 2018; Coxen's Fig-Parrot Recovery Team 2001).

5.5.5 Threat abatement/recovery plans

The following recovery plan s have been identified as being relevant for this species:

- Coxen's Fig-Parrot Recovery Team (2001). Coxen's Fig-Parrot *Cyclopsitta diophthalma coxeni* Recovery Plan 2001-2005. Report to Environment Australia, Canberra, by Queensland Parks and Wildlife Service, Brisbane. Available from: http://www.environment.gov.au/resource/coxens-fig-parrot-cyclopsitta-diophthalma-coxeni-recovery-plan-2001-2005. In effect under the EPBC Act from 13-Oct-2003 as Cyclopsitta diophthalma coxeni.
- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/Project.aspx?results=c&ProfileID=10195. In effect under the BC Act 2016.

The following threat abatement plans have been identified as being relevant to this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

5.5.6 Summary of threat abatement/recovery plan

The threats outlined in the Coxen's Fig-Parrot Recovery Plan include:

- Historical clearing of lowland subtropical rainforest for agricultural and housing in the 1860's causing decline in population numbers and range
- Inadequate extent and quality of habitat
- Fragmented habitat causing loss of connectivity between summer and winter areas, forcing birds to cross open areas and disjunct feeding grounds
- Disturbance to suspected breeding areas through logging and associated disturbance of subtropical rainforest/eucalypt ecotones
- Population decline resulting in a lack of social breading triggers, energy efficient communal food search effort and changes to social structures
- Higher susceptibility to disease and stochastic events such as drought
- Illegal robbing of nests for eggs, young and adults

Recovery plan actions plans include:

- Establish a survey protocol and implement an ecological assessment and monitoring strategy to improve knowledge on size, distribution, nesting and ecology
- Undertake predictive modelling of distribution to refine current understanding of the range and to indicate potential field survey targets
- Investigate wild red-browed fig-parrots for their direct relevant to Coxen's fig-parrot, including dietary preference, activity patterns, flock size, movement patterns and communal roosting behaviour
- Undertake captive breeding and release to reduce the chance of extinction to species
- Assess the quantity, distribution and spatial arrangement of remnant habitat through mapping and investigation of food plants
- Develop management prescriptions for logging and regulate land use within identified species habitat
- Implement a community awareness strategy, incorporating government agencies, forestry and farming industries, researchers, funding bodies and special interest groups

The Coxen's Fig-Parrot is assigned as a data-deficient species under the NSW *Saving our Species Program* and the objective of the strategy is to fill knowledge gaps in order to develop a targeted management strategy. State-wide conservation actions that have been identified for this species are:

- Encourage community participation to increase community awareness, opportunities for location of wild Coxen's Fig-Parrot populations and reduce opportunities for illegal trade of the species
- Develop a survey protocol with techniques to minimize disruption to individual birds
- Conduct training in and undertake nest surveys to increase survey skill, indicate existence of fig-parrots in areas, likely areas of home ranges
- Monitor fruiting fig trees with historical records of visiting fig-parrots, or abundant fruit in known or suspected localities for fig-parrots
- Analyse prey remains for evidence of fig-parrots
- Use decoy birds to assist in attempts to locate wild populations
- Collect ecological data to characterize known sites
- Develop a records database to facilitate analysis of ecological data and undertake predictive modelling of distribution
- Implement an ecological monitoring strategy at occupied sites
- Investigate Red-browed Fig Parrot biology/ecology to assist in understanding the likely biology/ecology of the Coxen's Fig-Parrot
- Develop captive breeding protocols and refine husbandry techniques for raising, maintaining and releasing
- Protect active nest locations disturbance and keep site locations confidential.
- Monitor nest post-acquisition of eggs or chicks for impact of eggs or chicks being removed for the captive breeding program.
- Protect known or probable habitat through land use planning legislation.
- Undertake habitat rehabilitation/expansion in areas of known or probable habitat
- Propagate known and presumed food trees and distribute to landholders and community.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

5.5.7 References

BirdLife International. (2018). Species factsheet: Cyclopsitta coxeni. Available from: http://www.birdlife.org [Accessed 22 August 2018].

Coxen's Fig-Parrot Recovery Team. (2001). Coxen's fig-parrot Cyclopsitta diophthalma coxeni recovery plan 2001-2005. Report to Environment Australia, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Department of Environment and Energy (2018). Cyclopsitta diophthalma coxeni (Coxen's Fig-Parrot) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59714 [Accessed 22 August 2018].

Department of Environment and Science (2011). Double-eyed fig-parrot (Coxen's). Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/doubleeyed_figparrot_coxens.html [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Coxen's Fig-Parrot - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10195 [Accessed 22 August 2018].

5.6 Curlew sandpiper (*Calidris ferruginea*)

5.6.1 Status

EPBC Act – Critically Endangered Marine and Migratory (CAMBA)

5.6.2 Biology and ecology

5.6.2.1 Characteristic

The Curlew sandpiper (*Calidris ferruginea*) is a small sandpiper approximately 18 to 23 cm long with a wingspan of 38 to 41 cm and weighing about 57 g. The head is small and round with a black bill that is long and decurved with a slender tip, sometimes with a brown or green tinge at the base (refer Photograph 5.5). The sexes are similar, but females have a slightly larger and longer bill and a slightly paler underbelly in breeding plumage (Higgins and Davies 1996).

In breeding plumage, the head, neck and underbody are a rich chestnut-red with narrow black bars on the belly and flanks. There are black streaks on the crown, a dusky loral stripe, and white around the base of the bill. The feathers on the mantle and scapulars are black with large chestnut spots and grayish-white tips. The back and upper rump are dark brown, with a prominent square white patch across the lower rump and uppertail-covert (Higgins and Davies 1996).

During the breeding season the cap, ear-coverts, hindneck and sides of neck are pale brownish-grey with fine dark streaks changing to white on the lower face and throat. There is a narrow dark loral stripe and white supercilium from the bill to above the rear ear-coverts. The mantle, back, scapulars, tertials and innerwing-covert are pale brownish-grey with fine dark streaks. The underbody is white with a brownish-grey wash and fine dark streaks on the breast (Higgins and Davies 1996).



Photograph 5.5 Curlew sandpiper (*Calidris ferruginea*)

Source: Emilio (2014)

5.6.2.2 Known distribution

In Australia, Curlew sandpipers occur around the coasts and are also quite widespread inland (refer Figure 5.12). Records occur in all states and territories during the non-breeding season as well as the breeding season when immature birds remain in Australia rather than migrating north towards Siberia (DotEE 2018).

In Queensland, widespread records occur along the coast south of Cairns with sparsely scattered records inland. In NSW, they are widespread east of the Great Divide, especially in coastal regions. They are occasionally recorded in the Tablelands and are widespread in the Riverina and southwest NSW, with scattered records elsewhere (Higgins and Davies 1996).



Figure 5.12 Distribution range of the Curlew sandpiper

Source: ALA (2018)

5.6.2.3 Distribution in relation to the project

Calidris ferruginea was not recorded during any Project-associated surveys or surveys for the adjacent TSRC Project. Curlew sandpiper has not been recorded within the MNES study area or surrounds. The nearest record (2018) is located 13 km north of the Project at Cooby Creek Reservoir (2018) with an older record (1971) located 23 km north. To the west there is a 1980 record from the Oakey area (16 km west). To the east there is a 2002 record at Lake Apex in Gatton (16 km east). There are further recent records in the Lockyer Valley to the east of Gatton (AoLA 2020) which are associated with several wetlands and large waterbodies in the area. Nevertheless, the majority of records from the region are coastal or from inshore islands in Moreton Bay (refer Figure 5.13).

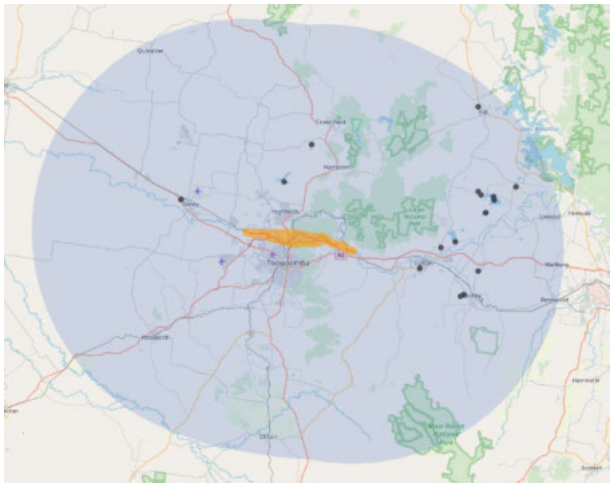


Figure 5.13 **Distribution range of the Curlew sandpiper in relation to the Project**

Source: ALA (2020)

5.6.2.4 Biology and reproduction

In Australia, the Curlew sandpiper forages mainly on invertebrates, including worms, molluscs, crustaceans, and insects, as well as seeds. Curlew sandpipers usually forage by pecking and probing in water, near the shore or on bare wet mud at the edge of wetlands. They glean from mud, from the surface of water, or in drier areas above the edge of the water. Curlew sandpipers may wade up to the belly, often with their heads submerged while probing. They often forage in mixed flocks, including with Red-necked stints (*Calidris ruficollis*). In tidal waters, the birds move onto the most recently exposed parts of the tidal flats and retreat in stages as the tide comes in. Supratidal feeding mainly occurs during the pre-migratory fattening periods (February- to April) (Dann 1999a; Dann 1999b).

This species does not breed in Australia and they move north to Siberia to breed and nest during June and July (Hayman et al. 1986).

5.6.3 Habitat

Curlew sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms. They have also been recorded inland around ephemeral and permanent lakes, dams, waterholes and bore drains, usually with bare edges of mud or sand. They occur in both fresh and brackish waters. Occasionally they are recorded around floodwaters and wet mats of algae or waterweed, or on banks of beachcast seagrass or seaweed (Higgins and Davies 1996).

Curlew sandpipers generally roost on bare dry shingle, shell or sand beaches, sandspits and islets around coastal and near-coastal lagoons and other wetlands. They occasionally roost in dunes and saltmarshes (Higgins and Davies 1996).

5.6.4 Threatening processes

The following have been identified as potentially threatening processes to the Curlew sandpiper:

- In non-breeding grounds in Australia, this species mostly occurs in highly populated areas and is therefore vulnerable to possible habitat alteration
- Threats to the Curlew sandpiper include the loss and fragmentation of feeding and roosting habitat from human development, human disturbance at roost and feeding sites, disturbance by wild dogs and pollution (DECC 2005; Gosbell et al. 2002; Lane 1987, DECC 2005).

5.6.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/Project.aspx?results=c&ProfileID=20166. In effect under the BC Act 2016.

The following marine bioregional plan has been identified as being relevant for this species:

- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012). *Marine bioregional plan for the North-west Marine Region*. Prepared under the *Environment Protection and Biodiversity Conservation Act 1999*. Available from: http://www.environment.gov.au/topics/marine/marine-bioregional-plans/north-west. In effect under the EPBC Act from 27-Aug-2012.

No threat abatement plan has been identified as being relevant for this species

5.6.6 Summary of threat abatement/recovery plan

Paspalidium grandispiculatum is assigned as a partnership (range-restricted) species under the NSW Saving our Species Program. The conservation strategy identifies five priority management sites:

- Richmond River Estuary in Ballina, Byron, Lismore, Richmond Valley LGA
- Clarence River Estuary in Clarence Valley LGA
- Manning River Estuary in Mid-Coast LGA
- Hunter Estuary and Port Stephens in Lake Macquarie, Maitland,
- Mid-Coast, Newcastle, Port Stephens LGA
- Shoalhaven Estuary in Goulburn Mulwaree, Shoalhaven LGA.

Threats identified at the management sites include:

- Human disturbance at roosting and foraging sites from fishing, baiting, pets, boating, horses, 4WDing, biking and surfing
- Mangrove incursion into saltmarsh habitat
- Habitat loss from development such as major port expansions and transport related development
- Habitat loss from erosion, climate change inundation and sea-level rise.

Management activities to protect this species at the sites are:

- Educate recreational users and land managers on the impact of disturbance on birds to minimise the impact of recreational activity
- Install signage and exclusion fencing at significant foraging and roosting sites
- Protect habitat from degradation using methods such as raising the height of dikes or armouring works around intertidal feeding sites

- Identify and protect opportunities for wader habitat expansion by liaising with relevant agencies and land managers
- Continue monthly population monitoring and liaise with other regions to assess trends in the species across its range
- Monitor habitat usage were management strategies have been implemented to assess their effectiveness.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Curlew sandpiper include:

- Increase the support from research organization
- Establish and manage a Commonwealth marine reserve network to provide protection and conservation of biodiversity
- Provide regional advice determining the significance of potential impacts
- Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts
- Improve monitoring, evaluation and reporting on ecosystem health.

5.6.7 References

Atlas of Living Australia (2018). *Calidris (Erolia) ferruginea*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:fa188c0e-68ba-4b3f-8e8f-48734608c7d1 [Accessed 23 August 2018].

Dann, P. (1999a). Feeding periods and supratidal feeding of Red-necked Stints and Curlew Sandpipers in Western Port, Victoria. *Emu*. 99:218-222.

Dann, P. (1999b). Foraging behaviour and diets of Red-necked Stints and Curlew Sandpipers in south-eastsoutheastern Australia. *Wildlife Research*. 27:61-68.

Department of the Environment and Energy (2018). *Calidris ferruginea* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=856 [Accessed 22 August 2018].

Emilio, J. (2014). Curlew sandpiper (Calidris ferruginea). [image] [online] Available from: https://www.flickr.com/photos/juan_e/14189744097/in/photolist-3Dg6vj-XhMbXb-rEiyqF-XnhsNC-rssdoW-AUdiMa-pdsrhP-dhR1NF-XPhgeP-MPQ8zZ-q6ScfT-3fHmMC-PrPzBY-c2Wp1A-qadmL4-dMuRJe-MPQ8s4-224r7hp-YNVDc5-rA499X-dMuRA8-d9oHrS-J5pVor-Dnv4mM-nBU9yi-4nUe3Y-3ZKHWu-rA9TAR-fUJf3r-DAhXUZ-3ZFvdM-21Wxs4h-CCLU2s-Ds1PXx-D2MNA2-6eZssG-4FMQa8-DnvAzZ-6eVizr-vYK8Ps-J5q4k8-2327Qcz-21Fxk46. [18 September 2019].

Gosbell, K, Collins P. and Christie M. (2002). *Wader Surveys in the Coorong and S.E. Coastal Lakes February 2002*. Australasian Wader Studies Group.

Hayman, P., Marchant J. and Prater T. (1986). *Shorebirds. An identification guide to the waders of the world*. London and Sydney: Croom Helm.

Higgins, P.J. and Davies S.J.J.F. eds (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons*. Melbourne, Victoria: Oxford University Press.

Lane, B.A. (1987). *Shorebirds in Australia*. Sydney, NSW: Reed.

Department of Environment and Climate Change, NSW (DECC) (2005). *Taren Point Shorebirds - profile*. NSW DECC. Available from: http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/profile.aspx?id=10800 [Accessed 22 August 2018].

New South Wales National Parks and Wildlife Service (1999). *Threatened Species Information - Painted Snipe.*

5.7 Eastern bristlebird (*Dasyornis brachypterus*)

5.7.1 Status

EPBC Act – Endangered

5.7.2 Biology and ecology

5.7.2.1 Characteristics

The Eastern bristlebird (*Dasyornis brachypterus*) is a small ground dwelling bird with a large tail accounting for half of its 20 cm body length. The sturdy, grey-brown passerine has a dark cinnamon-brown upperpart, rufous-brown upperwing and uppertail which transitions into a grey-brown underpart which is faintly scalloped. Grey-brown feathering features on the bristlebird's belly and flanks, with a red iris in adults distinguishing it from juveniles who have a pale brown iris (image not available). Female bristlebirds are very similar to males with the only distinguishable feature being there slightly smaller frame (Birdlife International 2016). The bristlebird is distinct in appearance due to its short wings, strong legs and bristles in front of the eyes that allow it to adapt perfectly to live amongst dense ground vegetation (DES 2013).

5.7.2.2 Known distribution

The Eastern bristlebird is endemic to the southeast of Australia and occurs in three geographically-separate regional populations in south-eastern Australia (refer Figure 5.14). One of the regional populations is known to roam habitats between the southern Queensland and northern NSW border with four populations comprising of 35 individual birds (OEH 2017; DES 2013; DotEE 2018).



Figure 5.14 **Distribution range of the Eastern bristlebird**

Source: ALA (2017)

5.7.2.3 Distribution in relation to the project

Dasyornis brachypterus has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that no records of *Dasyornis brachypterus* exist within the ecology study area or within a 50 km buffer of the disturbance footprint. The closest record is located approximately 55 km southeast of the disturbance footprint near Main Range National Park and is not dated. Several other records are located beyond a 50 km buffer of the alignment also around this area (refer Figure 5.15).

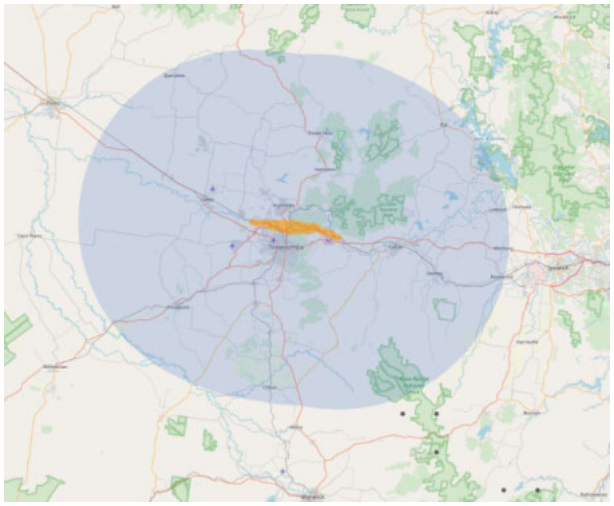


Figure 5.15 **Distribution range of the Eastern bristlebird in relation to the Project**

Source: ALA (2020)

5.7.2.4 Biology and reproduction

The Eastern bristlebird feed predominately on seeds, small fruits and invertebrates, but are also known to take fungi and occasionally nectar, food scraps and tadpoles. They are known to feed on the seeds or fruits of grasses and other plants (including *Acacia*, *Carex*, *Exocarpos* and, possibly, *Lycium ferocissimum*), and take nectar from *Banksia ericifolia* (Chapman 1999; Gibson and Baker 2004).

The Eastern bristlebird are known to breed from August to February. A small, globular nest is constructed with a side entrance, using grass, bark, sedges or reeds, and sometimes leaves. The nest is typically placed less than 1 m above the ground, in low dense vegetation, in or near the base of sedges, grasses, ferns and shrubs (DotEE 2018; Higgins and Peter 2002; Morris et al. 1981).

Clutches generally consist of two, or sometimes three, eggs. The eggs are incubated by a single parent (presumed to be the female), for at least three weeks. Both parents are known to feed the nestlings, during the fledging period of at least 16 days. Pairs readily desert their nests if disturbed, especially during the incubation period (Birdlife International 2016; Chapman 1999; Chaffer 1954, Hartley and Kikkawa 1994; Higgins and Peter 2002; McNamara 1946).

5.7.3 Habitat

The habitat of the bristlebird in Queensland has occurred within localised pockets of relatively open eucalypt forest located close to denser vegetation along creeks and rainforest, whilst in northern NSW, the bristlebird's known habitat is within open forest with understorey predominantly composed of dense tussock grass and sparse mid-storey, close to rainforest ecotone.The soil underlying these habitats are fertile and derived from basalts of the Main Range Volcanics (Birdlife International 2016; DES 2013; OEH 2017).

The species have also been known to inhabit shrubby montane heath vegetation on poorer soils consisting of *Melaleuca* spp., *Leptospermum grandifolium*, *Hakea teretifolia* and *Eucalyptus* woodland (Birdlife International 2016).

5.7.4 Threatening processes

The following have been identified as potentially threatening processes to the Eastern bristlebird:

- Inappropriate fire regimes leading to changes in habitat structure as the species requires frequent fires to ensure its preferred vegetation remains dense enough for cover and nesting, however, not frequent enough to eliminate tussocks, shrub and trees enabling invasion by weed species (Birdlife International 2016; DES 2013).

5.7.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this species:

- OEH (2012). National Recovery Plan for Eastern Bristlebird *Dasyornis brachypterus*. Office of Environment and Heritage, Department of Premier and Cabinet (NSW), Sydney. Available from: http://www.environment.gov.au/resource/national-recovery-plan-eastern-bristlebird-dasyornis-brachypterus. In effect under the EPBC Act from 30-Jan-2014.

The following threat abatement plans have been identified as being relevant to this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment and Energy (2017). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017. In effect under the EPBC Act from 18-Mar-2017.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.

5.7.6 Summary of threat abatement/recovery plans

Threats specific to the Eastern bristlebird in the strategy include:

- Habitat clearing
- Fire
- Predation
- Disturbance of habitat by exotic herbivores
- Habitat degradation due to dieback or invasive weeds
- Small population size and genetic bottlenecks
- Climate change
- Human disturbance.

Objectives and actions outlined in the threat abatement plan for the Eastern bristlebird include:

- Prescribe appropriate fire regimes
- Control feral pest animals
- Control invasive weeds and plant-soil disease
- Conduct survey, monitoring and mapping to improve knowledge of all populations
- Understand population dynamics and monitor habitat conditions
- Locate potential habitat for new colonies
- Estimate accurately the population size for all populations
- Build populations up to a point of self-sustaining viability
- Increase knowledge of the ecology, threats and habitat management requirements for the species
- Increase community awareness and stakeholder engagement
- Ensure effective organisation and administration of recovery effort to ensure plan objectives are met.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

The threats outlined in the threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) include:

- Impacts on plant species composition and succession
- Alterations to nutrient, water cycling and water quality
- Predation of native fauna and flora including small mammals, birds, reptiles, frogs, crayfish, eggs, invertebrates, fungi and all part of plants including fruit, seeds, roots, tubers, bulbs and foliage
- Digging and disturbance to substrate resulting in the destruction of plants threatening their survival and recruitment of new plants altering the floral composition and soil structure
- Disturbance caused by pigs can increase the incursion and recruitment of weeds and provide reservoirs for endemic animal diseases.

Threat abatement actions for feral pics (*Sus scrofa*) include:

- Implementation of control measures including trapping, aerial and ground shooting, poisoning and fencing
- Using tracking dogs to detect and flush out feral pigs by commercial harvesters
- Manipulating habitat by reducing watering points and crop waste
- Manage feral pigs within a policy, legislative and planning framework.

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

5.7.7 References

Atlas of Living Australia (2017). Dasyornis (Dasyornis) brachypterus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:d38d3f40-e9db-4acc-af04-d0ca566771c1 [Accessed 22 August 2018].

BirdLife International (2016). Dasyornis brachypterus. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22704507/0 [Accessed 22 August 2018].

Chaffer, N. (1954). The Eastern Bristle-bird. Emu. 54:153-162.

Chapman, G. (1999). Bristlebirds: see how they run. Wingspan. 9(1).

Department of Environment and Energy (2018). Dasyornis brachypterus (Eastern Bristlebird) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=533 [Accessed 22 August 2018].

Department of Environment and Science (2013). Eastern Bristlebird. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/threatened-species/endangered/endangered-animals/eastern_bristlebird.html [Accessed 22 August 2018].

Gibson, L. and J. Baker. (2004). Diet of the Eastern bristlebird Dasyornis brachypterus in New South Wales. Corella. 28:79-81.

Hartley, S.L. and J. Kikkawa. (1994) The population management of the Eastern bristlebird (Dasyornis brachypterus). Brisbane: Department of Environment and Heritage, Queensland Parks and Wildlife Service.

Higgins, P.J. and J.M. Peter. (2002). Handbook of Australian, New Zealand and Antarctic Birds Volume 6: Pardalotes to Shrike-thrushes. Melbourne: Oxford University Press.

McNamara, E. (1946). Field notes on the Eastern Bristle-bird. Emu. 45:260-265.

Morris, A.K. A.R. McGill and G. Holmes. (1981) Handlist of Birds in New South Wales. Sydney: NSW Field Ornithologists Club.

Office of Environment and Heritage (2017). Eastern Bristlebird - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10206 [Accessed 22 August 2018].

5.8 Eastern curlew (*Numenius madagascariensis*)

5.8.1 Status

EPBC Act – Critically Endangered Marine and Migratory (CAMBA)

5.8.2 Biology and ecology

5.8.2.1 Characteristic

The Eastern curlew (*Numenius madagascariensis*) is the largest wading bird that visits Australia, with the larger sex being the female which reaches up to 66 cm tall. The wingspan is about 110 cm, weighing approximately 900 g. It has an elongated, curved bill with a pinkish base for probing in mudflats, and long olive-grey legs. The feathers of the upper parts of the body are brown, with dark centres, and have broad pale rufous or olive-brown edges (refer Photograph 5.6). The tail is grey-brown with narrow dark banding on the feathers. The under parts are dark brownish-buff, becoming paler on the rear belly. There is fine dark streaking on the fore-neck and breast, which become thicker arrow-shaped streaks and barring on the fore-flanks. The upper belly and rear flanks have finer and sparser dark streaking. The underneath of the wing is whitish, but appears darker due to fine dark barring. Juveniles resemble adults but have a slightly shorter bill that grows with maturity and are typically paler with finer streaking on the breast. The Eastern curlew has a mournful, haunting yet melodious call (DES 2017; TSSC 2015).



Photograph 5.6 Eastern curlew (*Numenius madagascariensis*)

Source: Jollan (2019)

5.8.2.2 Known distribution

Within Australia, the Eastern curlew has a primarily coastal distribution. The species is found in all states and territories, particularly the north, east, and southeast regions, including Tasmania (refer Figure 5.16). Eastern curlews are rarely recorded inland. They migrate in late February to March to Russia and north-eastern China to breed (DES 2017, TSSC 2015).



Figure 5.16 Distribution range of the Eastern curlew

Source: ALA (2018)

5.8.2.3 Distribution in relation to the project

Numenius madagascariensis has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that records of *Numenius madagascariensis* exist within the ecology study area. The closest record is located approximately 5 km north of the disturbance footprint at Murphys Creek and is dated 1918. The next closest record is located approximately 6 km north of the alignment to the east of Murphys Creek and is not dated. A number of other records are located within a 50 km buffer of the disturbance footprint to the north and south of the alignment. Most are located to the north in the area between the alignment and Crows Nest (refer Figure 5.17).

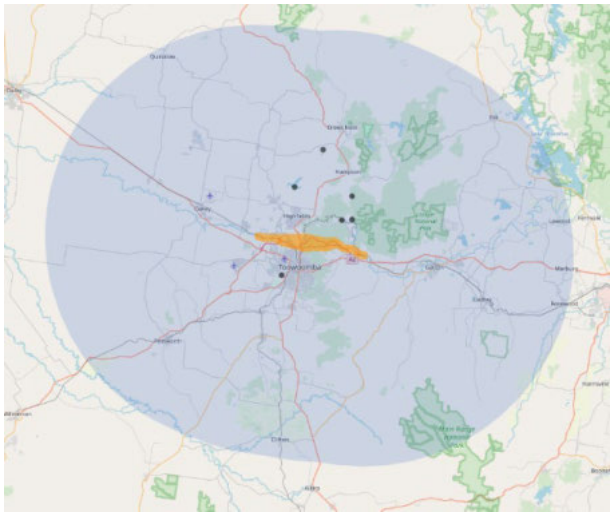


Figure 5.17 **Distribution range of the Eastern curlew in relation to the Project**

Source: ALA (2020)

5.8.2.4 Biology and reproduction

The Eastern curlew primarily eats crustaceans, small molluscs, mudskippers and some insects. Foraging by day and night, stalking slowly on sandy and muddy flats and picking from the surface or probing deep with its long bill (Birdlife Australia 2018).

The Eastern curlew does not breed in Australia. They breed in the Northern Hemisphere summer, from early May to late June, often in small colonies of two to three pairs (del Hoyo et al. 1996).

5.8.3 Habitat

The Eastern curlew can be found foraging and roosting in sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass (Zosteraceae). The species is known to inhabit ocean beaches, coral reefs, rock platforms, rocky islets, coastal saltworks and sewage farms. They are often recorded in saltmarshes and near mangrove forests (Marchant and Higgins 1993; TSSC 2015).

5.8.4 Threatening processes

The following have been identified as potentially threatening processes to the Eastern curlew:

- Human disturbance can cause shorebirds to interrupt their feeding or roosting and may influence the area of otherwise suitable feeding habitat. Disturbance to pre-migratory eastern curlews may adversely affect their capacity to migrate, as the birds will use energy reserves to avoid disturbance, rather than for migration (Close and Newman 1984).
- Coastal development, land reclamation, construction of barrages and stabilisation of water levels can disrupt water regimes and destroy feeding habitat (Australian Government 2009)
- Pollution and invasive plants around foraging areas may reduce the availability of food. These threats tend to be more extensive in eastern and southern Australia (Australian Government 2009; Close and Newman 1984; Garnett et al. 2011; Rogers et al. 2006).

5.8.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species (DoEE 2018).

5.8.6 References

Atlas of Living Australia (2018). *Numenius madagascariensis*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21ab21e4-5cd7-4e68-9268-1b6db1a9c3aa [Accessed 22 August 2018].

Australian Government (2009). Draft significant impact guidelines for 36 migratory shorebirds. Draft EPBC Act Policy Statement 3.21, Canberra, ACT: Department of the Environment and Heritage.

Birdlife Australia (2018). Eastern Curlew. Available from: http://www.birdlife.org.au/bird-profile/eastern-curlew [Accessed 22 August 2018].

Close, D.H., and Newman, O.M.G. (1984). The decline of the Eastern Curlew in south-eastern Australia. *Emu* 84, 38-40.

Department of the Environment and Science (2017). Eastern curlew. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/eastern_curlew.html. [Accessed 22 August 2018].

Garnett, S.T., Szabo, J.K., and Dutson, G. (2011). *The Action Plan for Australia Birds 2010*. Birds Australia, CSIRO Publishing, Melbourne.

Jollan, T. (2019). Eastern curlew (Numenius madagascariensis). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=aa6bbe24-205d-4079-ba39-b33f8eb4f8f1. [17 September 2019].

Jones, K (2011). *Numenius madagascariensis* (eastern curlew) (Image) [Online] Available from: https://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/components/species/?numenius-madagascariensis [Accessed 22 August 2018].

Marchant, S., and Higgins, P.J. (eds). (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings*. Melbourne, Victoria: Oxford University Press.

Rogers, D.I, Piersma, T., and Hassell, C.J. (2006). Roost availability may constrain shorebird distribution: exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation* 133, 225-235.

Threatened Species Scientific Committee (2015). Conservation Advice on eastern curlew (*Numenius madagascariensis*). Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/847-conservation-advice.pdf [Accessed 22 August 2018].

5.9 Painted honeyeater (*Grantiella picta*)

5.9.1 Status

EPBC Act – Vulnerable

5.9.2 Biology and ecology

5.9.2.1 Characteristic

Painted honeyeater (*Grantiella picta*) is a medium honeyeater, growing to a length of 14 to 15 cm in size. The Painted honeyeater weights around 20 to 25 g and has a black head and back, and bright yellow on the wings and upper tail and a bright pink bill (refer Photograph 5.7). The male is distinguished by white underparts with black streaks on flanks (above legs). The females are slightly smaller than the males and identified by brownish-black colouring with white underparts. Juveniles are browner and have a greyish coloured bill. The Painted honeyeater is known to use the same nest sites each season and are generally seen in pairs or singles, rarely in small flocks of up to six birds (DES 2018; Higgins et al. 2001; Simpson and Day 2004).



Photograph 5.7 Painted honeyeater (*Grantiella picta*)

Source: Knight (2009)

5.9.2.2 Known distribution

The Painted honeyeater is endemic to Australia and its distribution over summer and spring stretches from inland central Victoria through scattered parts of NSW, the ACT and southern Queensland (refer Figure 5.18). During winter the Painted honeyeater is known to migrate further to North Queensland, around Cape York Peninsula, and eastern areas of the Northern Territory. Opportunistic sightings have been recorded in far eastern parts of South Australia (Garnett et al. 2011; Higgins et al. 2001; Pizzey and Knight 2012).



Figure 5.18 Distribution range of the Painted honeyeater

Source: ALA (2018)

5.9.2.3 Distribution in relation to the project

Grantiella picta has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that no records of *Grantiella picta* exist within the ecology study area. There are several database records close to the MNES assessment area including a 2006 record at Gowrie (1 km north of the disturbance footprint), a 2013 record from Toowoomba (6 km south of the Project), and several 2019 records from the Highfields area (4.5 km north of the Project) which are very likely to be of the same bird (AoLA 2020). The majority of other records for this species occur substantially west of the Project (refer Figure 5.19). The disturbance footprint is not located near the limit of the species' range (ALA 2020). The species population is sparsely dispersed across south-east Australia to north-west Queensland and eastern Northern Territory. While vagrant individuals occur in the Toowoomba area and further east, the species distribution occurs on and west of the inland slopes of the Great Dividing Range (Higgins et al. 1991). Rowland (2012) notes non-breeding individuals are recorded occasionally from coastal areas along the eastern seaboard.

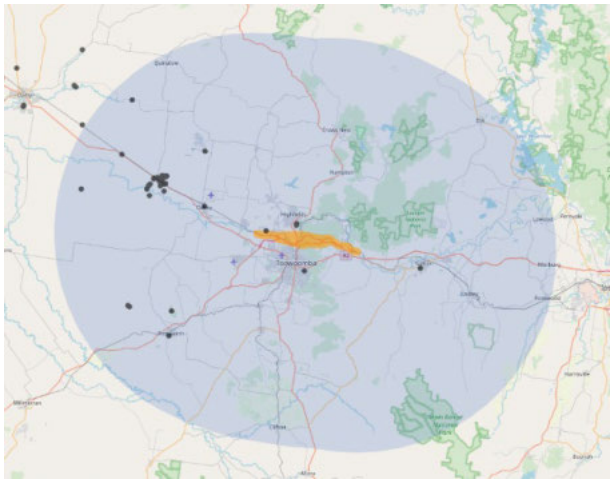


Figure 5.19 **Distribution range of the Painted honeyeater in relation to the Project**

Source: ALA (2020)

5.9.2.4 Biology and reproduction

The Painted honeyeater is typically seen individually or in pairs, less frequently seen in small flocks of up to six birds. This species is known to consume fruit. The species is predominantly observed in areas where mistletoe is abundant. The species is known to have a mixed diet consisting of nectar, berries and insects, defining them an omnivorous and an obligate nectarivore (Oliver et al. 2003).

The species nests in a variety of trees and have been documented to favour mistletoe as a nesting site. The foliage of mistletoe helps with concealment of the nest to protect from predators and subsequent nest failure (Barea 2008; Cooney et al. 2006).

The breeding season generally takes place between October through to March, and can be influenced by environmental conditions and the availability of food resources. Generally, the male Painted honeyeater will arrive at a nesting site several weeks before the female.

Both the male and female Painted honeyeaters maintain the nest, incubate the eggs, brood and feed the young. Nests are generally found approximately 15 m from the ground where the typical clutch consists of 2 eggs, but not uncommonly 1 to 3 eggs can be found. The species are known to raise 1 to 2 broods per season, where eggs are incubated for 13 to 15 days, and young fledge in 14 to 20 days. Box the female and male leave the nest at approximately the same time, generally five months after fledglings leave the nest and food resources decline (DES 2018; Garnett et al. 2011; Whitmore and Eller 1983).

5.9.3 Habitat

The Painted honeyeater is predominantly found in open forest, box-open woodland, eucalypt forest/woodlands, riparian woodlands and acacia woodlands. The Painted honeyeater inhabits environments that have a high prevalence of mistletoe which provides both nesting and food resources. Favourable species including needle-leaved mistletoe *(Amyema cabagei)* and grey mistletoe *(A. quandang)*. An identified key association between the Painted honeyeaters migration south-north is believed to be a result of mistletoe fruit availability and general mistletoe distribution and abundance (DOE 2015; Keast 1968; Simpson and Day 2004).

5.9.4 Threatening processes

The following have been identified as potentially threatening processes to the Painted honeyeater:

- Habitat loss and fragmentation
- Grazing inhibiting tree recruitment for feed trees (DotEE 2015).

5.9.5 Threat abatement/recovery plans

The following threat abatement/recovery plan has been identified as relevant for this species:

- Office of Environment and Heritage (2016), *Saving our Species Programme*. Available from https://www.environment.nsw.gov.au/savingourspeciesapp/Project.aspx?results=c&ProfileID=10357. In effect under the BC Act 2016.

5.9.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Degradation of open forest and woodland remnants along with the thinning of trees that bear mistletoe
- The loss of large, old trees that have heavy mistletoe infestations
- Habitat loss as a result of clearing woodlands and open forest
- Grazing pressure within grassy woodlands causing degradation and simplification of habitat
- Incursion from invasive weeds, particularly African boxthorn and invasive grasses
- Noisy minors causing aggressive exclusion in forest and woodland habitat.

Management actions identified in the Saving our Species plan includes:

- Encourage relevant landholders to enter into agreements that promote the protection, maintenance and recruitment of *Acacia* (*A. pendula* or *A. homalophylla*) woodland with mistletoe
- Incorporate into landholder agreements sensitive grazing regimes allowing suitable woodland habitat to regenerate
- Increase awareness with landholders of the importance of mistletoe as a resource for the Painted honeyeater and education around the fact that it is not harmful to healthy trees
- Revegetation of Brigalow, Boree and Yarran woodlands to provide connectivity between fragments, particularly in Painted honeyeater breeding habitat
- Encourage landholders to protect ground and mid-storey vegetation through the implementation of sensitive grazing techniques along with eliminating slashing or underscrubbing to retain floral and structural diversity
- Target removal of exotic grasses and promote regeneration of native grasses
- Measure the impact and abundance on Noisy miners implementing appropriate management strategies to reduce their impact

- Prioritise site protection in areas that function as drought refuges or source populations in programs that aim to protect, manage and restore habitat
- Implement research to fill knowledge gaps around restoring the structure and function of the ground layer, including soil structure in degraded habitat.

5.9.7 References

Atlas of Living Australia (2018), *Grantiella picta.* Viewed 17 August 2018, Available: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:de126daa-e11d-42e0-ace6-7873abe6c96b#.

Barea, L. P. (2008). Nest-site selection by the Painted Honeyeater (Grantiella picta), a mistletoe specialist. Emu, 108, 213-220.

BirdLife International (2018) Species factsheet: Grantiella picta. Downloaded from http://www.birdlife.org on 17/08/2018.

Chapman A (2017), *Grantiella picta*, viewed 17 August 2018, Available: https://images.ala.org.au/store/2/0/a/1/e183a4e1-b111-444b-b39d-59fd62b01a02/original

Cooney, S. J., Watson, D. M., and Young, J. (2006). Mistletoe nesting in Australian birds: A review. Emu, 106, 1-12.

Department of the Environment (2015). Conservation Advice Grantiella picta painted honeyeater. Canberra: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/threatened/species/pubs/470-conservation-advice.pdf. In effect under the EPBC Act from 08 July 2015.

Garnett, S., J. Szabo and G. Dutson (2011). *The Action Plan for Australian Birds 2010*. CSIRO Publishing. Available from: http://birdsindanger.net/taxatable.

Higgins, P. J., Peter, J. M., and Steele, W. K. (Eds.). (2001). Handbook of Australian, New Zealand and Antarctic birds: Vol. 5. Tyrant-flycatchers to Chats. Oxford University Press: Melbourne. ISBN 0195532589. http://eol.org/pages/919405/details#cite_note-Higgins.2CPeter.2CSteele-2.

Keast, A. (1968). Seasonal movements in the Australian honeyeaters (Meliphagidae) and their ecological significance. Emu, 67, 159-209. http://eol.org/pages/919405/details#cite_note-Keast-12.

Knight, R. (2009). Painted honeyeater (Grantiella picta). [image] [online] Available from: https://www.flickr.com/photos/sussexbirder/8079677675/in/photolist-8Fw6ib-diYsFv-LDPPEM. [17 September 2019].

Nature Conservation Act 1992 (Queensland): September 2017 list)

Oliver, D. L., Chambers, M. A., Parker, D. G. (2003). Habitat and resource selection of the Painted Honeyeater (Grantiella picta) on the northern floodplains regions of New South Wales. Emu, 103, 171-176. http://eol.org/pages/919405/details#cite_note-OliverChambers-13.

Department of Environment and Science (DES), Painted honeyeater – *Grantiella picta*, Wetland*Info*, Queensland, viewed 17 August 2018, https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/species/?grantiella-picta.

Pizzey, G., and Knight, G. (2012). The field guide to the birds of Australia (9th ed.). HarperCollins: Sydney. ISBN 978-0-7322-9193-8. http://eol.org/pages/919405/details#cite_note-Higgins.2CPeter.2CSteele-2.

Simpson, K., and Day, N. (2004), *Field Guide to the Birds of Australia*, 7th ed. Australia: Penguin, 210.

Whitmore, M. J., and Eller, C. M. (1983). Observations at a nest of Painted Honeyeaters. Emu, 83(3) 199-202

5.10 Red goshawk (*Erythrotriorchis radiatus*)

5.10.1 Status

EPBC Act – Vulnerable

5.10.2 Biology and ecology

5.10.2.1 Characteristics

The Red goshawk (*Erythrotriorchis radiatus*) is a large, swift and powerful rufous-brown goshawk. This species of raptor is estimated to be of 45 to 58 cm in total body length with a wingspan of 110 to 135 cm. The Red goshawk is boldly mottled and streaked, with rufous scalloping on the back and upper wings, and massive yellowish legs and feet. The head of the bird is pale and streaked with darker feathers (refer Photograph 5.8). Females are typically larger than males, more powerfully built, paler and more heavily streaked below, showing some white on the under body. Red goshawk juveniles are distinguished from adults due to their rufous head (DES 2017; DotEE 2018).



Photograph 5.8 Red goshawk (*Erythrotriorchis radiatus*)

Source: ALA (2016)

5.10.2.2 Known distribution

The Red goshawk is distributed along the east coast of Queensland, Cape York Peninsula and across into northern regions of Australia (refer Figure 5.20). In Queensland, is it estimated that the species population is limited to the bioregions of the Wet Tropics, Cape York Peninsula and Mount Isa Inlier. However, surveying of the species in another three bioregions has yet to occur. Some adults of Red goshawk in southeast Australia have been known to migrate annually from the ranges down into the lowlands during winter period. The species is thought to be extinct in southeast Queensland as well as being very rare in NSW extending south to about 30˚S (DES 2017; OEH 2017).



Figure 5.20 **Distribution range of Red goshawk**

Source: ALA (2016)

5.10.2.3 Distribution in relation to the project

Red goshawk has not been recorded during any Project-associated surveys or during surveys for the nearby TSRC project. General pre-clearance surveys within the Project footprint targeting bird nest locations have not located the species (Eco logical 2019). There are a number of records from the Toowoomba area, many of which are older records (<1990). There is a 1992 record (Wildlife online) located 600 m south of the Project footprint in the Toowoomba Range. It is noted all available AoLA records have all been generalised in order to protect the species and may not reflect the actual record location. The nearest database record is from 2008 located 3 km north of the eastern extent of the Project. The most recent record in the region is a 2012 record 15 km south of the disturbance footprint in the Toowoomba Range. There is a 2002 and 2003 record from the Grantham area 11 km south-east of the Project. Further records of varying age occur to the north-east, north and south of Toowoomba, as well as further east in the Lockyer Valley (refer Figure 5.21).

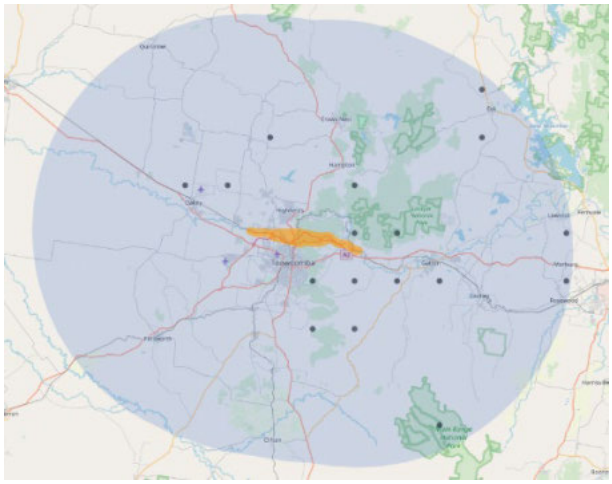


Figure 5.21 **Distribution range of Red goshawk in relation to the Project**

Source: ALA (2020)

5.10.2.4 Biology and reproduction

The solitary Red goshawk is known to prey on birds such as Australian brush-turkeys, Kookaburras and Rainbow lorikeet as well as small mammals, reptiles and insects. The species is known to attack its prey from the air, gliding straight down or chasing it down. The male of the species will build nests using dead sticks lined with twigs and green leaves within an exposed fork in the upper quarter of a tree between 10 to 20 m above ground and used each year (DES 2017; OEH 2017).

The breeding season for Red goshawk occurs from September to December with one to two eggs being laid by the females between August and October in the southeast regions. Females will incubate eggs for a period of 39 to 43 days with the young being fully fledged after eight weeks despite not being independent for at least another ten weeks (DES 2017).

5.10.3 Habitat

The Red goshawk typically occurs in both coastal and sub-coastal areas, in wooded and forested lands of tropical and warm-temperate Australia. Riverine forests are also used frequently. The Red goshawk nests in large trees, frequently the tallest and largest in a stand, which are typically within one kilometre of a permanent water source. This species typically avoids very dense, and very open habitats (Debus 1991; 1993; OEH 2017; Marchant and Higgins 1993).

In Queensland the species is known to inhabit cleared parts of eastern Queensland associated gorges and escarpment country whilst in NSW the preferred habitat includes mixed subtropical rainforest such as *Melaleuca* swamp forest as well as riparian *Eucalyptus* forest of coastal rivers (DES 2017; OEH 2017).

5.10.4 Threatening processes

The following have been identified as potentially threatening processes to the Red goshawk:

- Heavy habitat fragmentation caused by urban development, agriculture and forestry processes clearing extensive areas of forests
- Vulnerability of nests to storm damage and prey
- Development or noise dispersing food sources (DES 2017).

5.10.5 Threat abatement/recovery plans

No threat abatement plans have been identified as being relevant to this species.

The following recovery plan has been identified as being relevant for this species:

- Department of Environment and Resource Management (2012). National recovery plan for the red goshawk Erythrotriorchis radiatus. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra. Queensland Department of Environment and Resource Management, Brisbane. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-red-goshawk-erythrotriorchis-radiatus. In effect under the EPBC Act from 24-Jul-2012 as *Erythrotriorchis radiatus*.

5.10.6 Summary of threat abatement/recovery plan

Threats identified in the recovery plan for this species includes:

- Loss of habitat
- Fragmentation of existing habitat
- Reduction in nest sites through the loss of mature trees
- Reduction to the prey base
- Threats to prey availability

- Knowledge and communication gaps for this species
- Poor management practices.

Recover plan actions for this species include:

- Identify and map important Red goshawk habitat
- Protect and appropriately manage important habitat areas for the species to ensure its long-term survival
- Gain a better understanding regarding the reproductive success and survival for the Red goshawk
- Identify important populations for the species
- Increase community awareness and engagement in the conservation of the species.

5.10.7 References

Atlas of Living Australia (2016). Erythrotriorchis radiatus. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:1405a1d4-557c-40ac-9f44-a6d41e9136cd#overview [Accessed 22 August 2018].

Debus, S.J.S. (1991). An annotated list of NSW records of the Red goshawk. Australian Birds. 24:72- 89

Debus, S.J.S. (1993). The status of the Red goshawk (Erythrotriorchis radiatus) in New South Wales. Olsen, P., ed. Australasian Raptor Studies. Page(s) 182-191. ARA-RAOU, Melbourne

Department of Environment and Energy (2018). Erythrotriorchis radiatus (Red Goshawk) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=942 [Accessed 22 August 2018].

Department of Environment and Science (2017). Red Goshawk. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/threatened-species/endangered/endangered-animals/red_goshawk.html [Accessed 22 August 2018].

Marchant, S. and P.J. Higgins, eds. (1993). Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings. Melbourne, Victoria: Oxford University Press.

Office of Environment and Heritage (2017). Red Goshawk – Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10279 [Accessed 22 August 2018].

5.11 Grey falcon (*Falco hypoleucos*)

5.11.1 Status

EPBC Act – Vulnerable

5.11.2 Biology and ecology

5.11.2.1 Characteristics

The Grey falcon (*Falco hypoleucos)* is a solitary falcon that grows to a total body length between 33 to 43 cm with an average male weighing around 400 g whilst females are heavier, weighing 550 g. The pale coloured falcon has a heavy, thick-set, deep-chested appearance with a light grey body featuring black shading on the primaries forming dark wing tips. The chin, throat and cheeks are white whilst the tail has narrow blackish bars. The eye-ring, cere and base of the beak are an orange-yellow (refer Photograph 5.9). Juvenile Grey falcons have fine dark streaks and do not have the orange-yellow eye-ring and feet the adults have (AWC 2018; OEH 2017).



Photograph 5.9 **Grey falcon (*Falco hypoleucos*)**

Source: AWC (2018)

5.11.2.2 Known distribution

The known distribution of the Grey falcon is over Australia's arid and semi-arid zones. It is absent from the Cape York Peninsula, south of the Great Diving Range in Queensland and NSW and south of the Great Dividing Range in Victoria (refer Figure 5.22). Throughout the Murray-Darling Basin the species is sparsely found with breeding occurring in the arid parts of the range and extinct in areas of more than 500 mm rainfall in NSW (Birdlife International 2016; OEH 2017).



Figure 5.22 **Distribution range of the Grey falcon**

Source: ALA (2018)

5.11.2.3 Distribution in relation to the Project

Falco hypoleucos has been predicted to occur within the region and associated habitat within the Ecology study area. Database records (i.e. ALA) indicate that a record of *Falco hypoleucos* exists within the disturbance footprint. This record is located south of Gowrie Junction and is dated 2008. The next closest record is located approximately 10 km south of the disturbance footprint, east of Toowoomba, and is dated 2013. Three other records are located within a 50 km buffer of the disturbance footprint. One is located northwest of the disturbance footprint near Jondaryan, a second to the north towards Hampton, and a third to the east, east of Lockyer National Park (refer Figure 5.23).

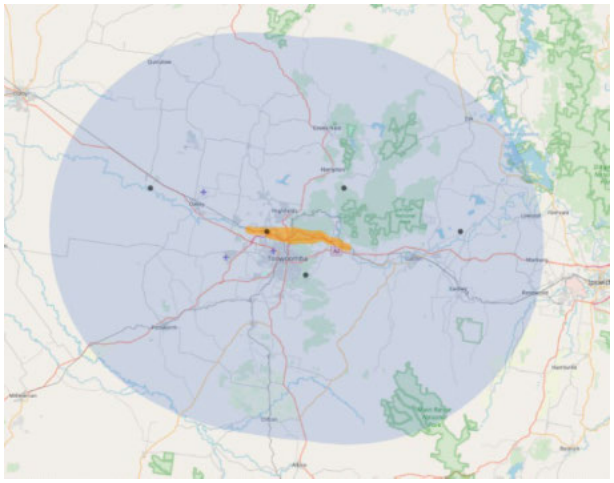


Figure 5.23 **Distribution range of the Grey falcon in relation to the Project**

Source: ALA (2020)

5.11.2.4 Biology and reproduction

The Grey falcon is often undetectable, perching amongst foliage or sitting on branches prior to hunting prey at tree-top height attacking mainly bird species. Targets for the falcon include finches, doves, parrots and pigeon but also know to consume insects and small mammals and carrion (Birdlife International 2016).

Grey falcon are solitary nesters, laying one to four eggs in late winter to early spring. This species, like most falcons, utilise old nests of other birds such as other species of raptor and ravens, usually positioned high in eucalyptus trees close to water. During times of drought the species has been known to not breed (AWC 2018; Johnson 2011).

5.11.3 Habitat

The habitat of the Grey falcon is restricted to shrubland, grassland and wooded watercourses of arid or semi-arid regions, however, wetlands where surface water attracts potential prey is also capitalised on by the falcon. The falcon has a high affinity to habitats with high temperature and low rainfall of less than 500 mm. During periods of drought, this species moves towards the coast regions, where is frequents wooded watercourses (Birdlife International 2016; OEH 2017).

5.11.4 Threatening processes

The following have been identified as potentially threatening processes to the Grey falcon:

- Clearing and grazing of arid and semi-arid zones
- Secondary poisoning through mouse and locust control programs
- Collection of young and eggs for falconry (OEH 2017).

5.11.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

5.11.6 References

Atlas of Living Australia (2018). Falco (Hierofalco) hypoleucos. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:5c4c5947-83a6-4a42-b861-8c408cfed4e7 [Accessed 2 September 2018].

Australian Wildlife Conservancy. (2018). Species Profile – Grey Falcon. Available from: http://www.australianwildlife.org/wildlife/grey-falcon.aspx [Accessed 22 August 2018].

BirdLife International (2016). Falco hypoleucos. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22696479/0 [Accessed 22 August 2018].

S, Johnson. (2011). Grey Falcon. Beauty of Birds. Available from: https://www.beautyofbirds.com/greyfalcons.html [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Grey Falcon - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10330 [Accessed 2 September 2018].

5.12 Regent honeyeater (*Anthochaera phrygia*)

5.12.1 Status

EPBC Act – Critically Endangered

5.12.2 Biology and ecology

5.12.2.1 Characteristic

The Regent honeyeater (*Anthochaera phrygia*) is approximately 20 to 23 cm in total length, and weighs between 31 to 50 g. This species is characterised by its striking black and yellow appearance. The head, neck and upper breast of the species features black feathering which transitions into a lemon-yellow back and leads to black wings with conspicuous yellow patches. The tail of the bird is predominantly black with yellow edging (refer Photograph 5.10). Males of the species are distinguished by yellowish warty bare skin surrounding the eye whilst females are noticeably smaller in size with a bare yellowish patch under the eye as well as less black on the throat. Young Regent honeyeaters resemble females, however have a browner and paler bill (Birdlife 2018; Curtis et al. 2012).



Photograph 5.10 Regent honeyeater (*Anthochaera phrygia*)

Source: eBird Australia (2015)

5.12.2.2 Known distribution

The Regent honeyeater is a species endemic to southeast Australia, ranging from southeast Queensland to central Victoria (refer Figure 5.24). Despite historic records indicating that the species ranged widely, from Rockhampton, Queensland to Adelaide, the species is now restricted to the western slopes of the Great Diving Range (Birdlife 2018).

In southeast Queensland, the Regent Honeyeater's distribution ranges from the Cooloola Plains in the north to inland areas such as Dalby, and further south into areas such as Narrabri NSW. Regent honeyeater breeding occurs by a smaller number of the species regularly west of Warwick in Queensland (Curtis et al. 2012; DES 2017).



Figure 5.24 **Distribution range of the Regent honeyeater**

Source: ALA (2018)

5.12.2.3 Distribution in relation to the project

Anthochaera phrygia was not recorded during any Project-associated surveys or surveys for the adjacent TSRC Project. Regent honeyeater is transient in the Toowoomba / Lockyer Valley area, being sporadically recorded in the winter months. Database records (i.e. AoLA) indicate that no records of Regenet honeyeater exist within the MNES study area. It is noted AoLA records of the species have been generalised to protect the species and so may not reflect the actual occurrence location. The closest record is located approximately 3 km north of the eastern extent of the Project disturbance footprint, north of Helidon, and is an older record (<1976). The next closest record is located approximately 15 km north of the disturbance footprint near Mount Lawson and is also an older record (<1976). The only other record (from 2000) within a 50 km buffer of the disturbance footprint is in main Range National Park (38 km south of the Project) (refer Figure 5.25). The nearest recent records are from Ipswich (over 60 km east) and the Durikai State Forest area (over 75 km south).

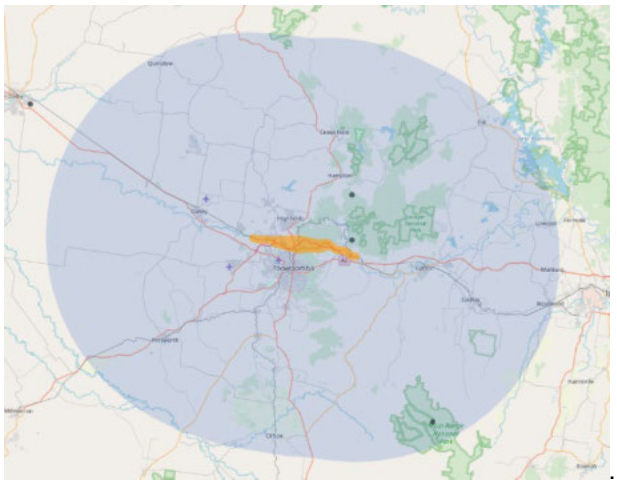


Figure 5.25 **Distribution range of the Regent honeyeater in relation to the Project**

Source: ALA (2020)

5.12.2.4 Biology and reproduction

The Regent honeyeater's diet consists of nectar from key species such as Yellow Box (*Eucalyptus melliodora*), White Box (*Eucalyptus albens*) and Mugga Ironbark (*Eucalyptus sideroxylon*) as well as sugary exudates. The species is also known to consume insects particularly when breeding (Birdlife International 2016).

The species breeds as individual pairs or sometimes in loose colonies with the female honeyeater incubating eggs whilst both parents feed the young. The eggs are often laid in cup-shaped nest 1 m to 20 m above the ground in tree forks of eucalypts and sometimes among mistletoe. The nests are usually constructed of bark with soft material lining the nest (Birdlife 2018; Birdlife International 2016).

5.12.3 Habitat

The preferred habitat of the Regent honeyeater is wet areas containing fertile soils that provide reliable nectar seasonally in areas of creek flats, river valleys and lower slopes. They are also found in dry eucalypt woodland and open forest in both rural and urban environments with mature eucalypts (DES 2018).

Other habitats of the species include Swamp mahogany (E. *robusta*), Spotted gum (*Corymbia maculata*) and River she-oak (*Casuarina cunninghamiana*) with associated Mistletoe (*Amyena cambagei*) (DES 2018).

5.12.4 Threatening processes

The following have been identified as potentially threatening processes to the Regent honeyeater:

- Habitat loss, fragmentation and degradation as a result of clearing for agriculture and development
- Suppression of natural regeneration of overstorey tree species and shrub species as a result of overgrazing
- Competition from larger, aggressive species such as the Noisy miner, Noisy friarbird and Red wattlebird
- Disturbance to nesting sites leading to abandonment (OEH 2017).

5.12.5 Threat abatement/recovery plans

The following threat abatement plan has been identified as being relevant to this species.

- Department of the Environment and Energy (2016). Threat abatement plan for competition and land degradation by rabbits. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.

The following recovery plan has been identified as being relevant for this species:

- Department of the Environment (2016). National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-regent-honeyeater-anthochaera-phrygia-2016. In effect under the EPBC Act from 04-May-2016 as Anthochaera phrygia.

5.12.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for competition and land degradation by rabbits includes:

- Competition with native wildlife for food and shelter
- Prevention of plant regeneration
- Increased grazing pressure and damage to native vegetation
- Altering the regular process of plant succession

- Altering ecological communities and impacting soil structure and nutrient cycling contributing to serious erosion
- Increasing predation and reducing reproduction for native arboreal mammals and birds through the removal of critical habitat.

Threat abatement actions for rabbits include:

- Supress rabbit populations at the landscape scale below thresholds in identified priority areas
- Gain a better understanding of the impacts rabbits have and their interactions with other species and ecological processes
- Increase the effectiveness of rabbit control programs
- Increase engagement within the local community to provide awareness of the environmental impact of rabbits and the need for integrated control.

Threats identified in the National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*) include:

- A reduction in population size
- The loss of habitat and further fragmentation
- Degradation of remaining habitat
- Competition with other nectivorous birds and the honeybee (*Apis mellifera*).

Recover plan actions for this species include:

- Improve Regent honeyeater habitat in extent and quality
- Utilise captive-bred birds to bolster wild populations until they become self-sustaining
- Better understand wild Regent honeyeater population parameters including size, structure and population trends
- Increase and maintain existing community awareness, understanding and involvement in the recovery program.

5.12.7 References

Atlas of Living Australia (2018). Anthochaera (Xanthomyza) phrygia. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:af9380ee-2f65-4213-bb6f-ea6baf92ad3e#overview [Accessed 17 August 2018].

Birdlife Australia (2018). Regent Honeyeater. Available from: http://www.birdlife.org.au/bird-profile/regent-honeyeater [Accessed 17 August 2018].

BirdLife International (2016). Anthochaera phrygia. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/full/22704415/0 [Accessed 17 August 2018].

Curtis, Lee K. Dennis, Andrew J. McDonald, Keith R. Kyne, Peter M. Debus, Stephen J.S (2012). Queensland's Threatened Animals. CSIRO.

Department of Environment and Science (2017). Regent Honeyeater. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/regent_honeyeater.html [Accessed 17 August 2018].

eBird Australia. (2015). Regent honeyeater (Anthochaera phrygia). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=ad1bf8a3-56b4-4f31-ab23-4e19388eeeac. [17 September 2019].

5.13 Squatter pigeon (*Geophaps scripta scripta*)

5.13.1 Status

EPBC Act – Vulnerable

5.13.2 Biology and ecology

5.13.2.1 Characteristics

The Squatter pigeon (*Geophaps scripta scripta)* (southern sub-species) is a heavily built, medium sized ground dwelling pigeon, measuring approximately 26 to 32 cm in total length with a wing span of 45 cm. Adults are generally grey-brown in colour, with black and white stripes on the face and throat, blue-grey skin around the eyes, dark brown (with some patches iridescent green or violet) wings, a blue-grey lower breast, and white flanks and lower belly (refer Photograph 5.11). Both sexes are of similar appearance, whilst juveniles are duller in colour, with patchy and less distinctive black and white facial stripes and paler facial skin (DotEE 2018; OEH 2017; NPWS 1999).



Photograph 5.11 Squatter pigeon southern sub-species (*Geophaps scripta scripta*)

Source: ALA (2016)

5.13.2.2 Known distribution

The Squatter pigeon (southern sub-species) was once found widespread nationally extending from southern NSW to the Burdekin River in northern Queensland (refer Figure 5.26). However, the species is now limited to an area from north Queensland to the northwest slopes of NSW, including southeast Queensland, the western slopes of the Great Diving Range, the Gwydir River region and the Liverpool Plains (Cooper et al. 2014; OEH 2017).



Figure 5.26 **Distribution range of the southern Squatter pigeon**

Source: DotEE (2018)

5.13.2.3 Distribution in relation to the project

Geophaps scripta scripta has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that a record of *Geophaps scripta scripta* exists within the ecology study area. The record is located near Helidon, approximately 500 m from the disturbance footprint and is dated 1989. The next closest record is located approximately 5 km north of the alignment in Murphys Creek and is dated 1937. A number of other records are located within a 50 km buffer of the disturbance footprint to the north, northeast, and east of the alignment. Most are located in the area between Crows Nest and Lowood (refer Figure 5.27).

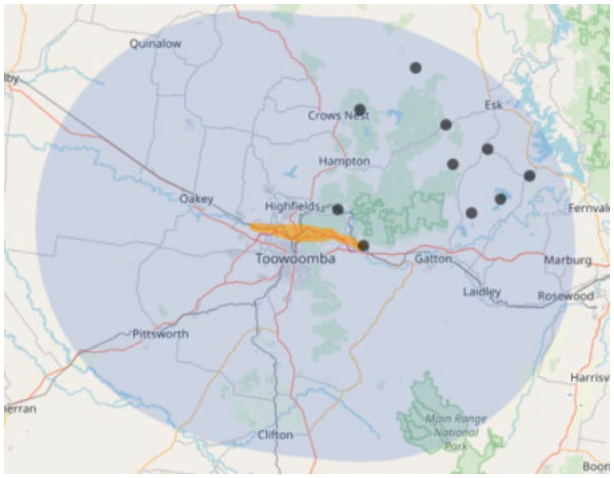


Figure 5.27 **Distribution range of the southern Squatter pigeon in relation to the Project**

Source: DotEE (2020)

5.13.2.4 Biology and reproduction

The Squatter pigeon (southern sub-species) forages on the ground for grass seeds, herbs, shrubs and insects. The Squatter pigeon is typically seen in pairs, or in small groups of up to 20 or more individuals and breed throughout the year. Breeding however is influenced by heavy rainfall which most commonly occurs during the dry season between May and June (DotEE 2018; OEH 2017; Pizzey and Knight 2007).

Squatter pigeon nests are depressions scraped into the ground beneath a tussock of grass, bush, fallen tree or log and sparsely lined with grass. The female lays two eggs which are smooth, lustrous, pale cream and oval with an incubation period of approximately 17 days by both parents. Southern Squatter pigeon chicks will remain in the nest for a further 2 to 3 weeks after hatching (Australian Bush Birds 2018; AWC 2017; DotEE 2018).

5.13.3 Habitat

The Squatter pigeon (southern sub-species) is known to inhabit grassy understorey of open eucalypt woodlands and plains featuring sandy areas within close proximity to water. Areas of semi-arid or arid landscape with sandy, open and short grass cover dissected by gravel ridges is the preferred habitat for the species. The ground cover in foraging and breeding habitat is typically patchy, consisting of native, perennial tussock grasses or a mix of perennial tussock grasses and low shrubs or forbs. This vegetated ground layer rarely exceeds 33% of the ground area. The remaining ground surface typically consists of bare patches of gravelly or dusty soil, and areas lightly covered in leaf litter and coarse, woody debris (e.g. fallen trees, logs and smaller debris). The species is also often found alongside tracks and roadsides (DotEE 2018; OEH 2017).

5.13.4 Threatening processes

The following have been identified as potentially threatening processes to the southern Squatter pigeon:

- Fragmentation and/or clearing of grassy woodland habitats for agriculture and development
- Overgrazing by domestic stock and feral rabbits of habitat
- Predation by feral cats and foxes
- Illegal shooting (OEH 2017).

5.13.5 Threat abatement/recovery plans

No recovery plan has been identified as being relevant to this species.

The following threat abatement plans has been identified as being relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.
- Department of the Environment and Energy (2016). Threat abatement plan for competition and land degradation by rabbits. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/competition-and-land-degradation-rabbits-2016. In effect under the EPBC Act from 07-Jan-2017.
- Department of the Environment, Water, Heritage and the Arts (2008). Threat abatement plan for predation by the European red fox. DEWHA, Canberra. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/predation-european-red-fox. In effect under the EPBC Act from 01-Oct-2008.

5.13.6 Summary of threat abatement/recovery plan

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

Threats identified in the threat abatement plan for competition and land degradation by rabbits includes:

- Competition with native wildlife for food and shelter
- Prevention of plant regeneration
- Increased grazing pressure and damage to native vegetation
- Altering the regular process of plant succession
- Altering ecological communities and impacting soil structure and nutrient cycling contributing to serious erosion
- Increasing predation and reducing reproduction for native arboreal mammals and birds through the removal of critical habitat.

Threat abatement actions for rabbits include:

- Supress rabbit populations at the landscape scale below thresholds in identified priority areas
- Gain a better understanding of the impacts rabbits have and their interactions with other species and ecological processes
- Increase the effectiveness of rabbit control programs
- Increase engagement within the local community to provide awareness of the environmental impact of rabbits and the need for integrated control.

Threats identified in the threat abatement plan for predation by the European red fox include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for the European red fox include:

- Baiting
- Biological control
- Barriers
- Habitat management
- Shooting and bounties.

5.13.7 References

Atlas of Living Australia (2016). *Geophaps (Geophaps) scripta scripta*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:d5c52cd0-6d21-4322-a5c5-bc11a94d8c3a#overview [Accessed 22 August 2018].

Australian Bush Birds (2018). Squatter Pigeon - *Geophaps scripta*. Available from: http://www.australianwildlife.org/wildlife/squatter-pigeon.aspx [Accessed 22 August 2018].

Australian Wildlife Conservancy (2017). Species profile - Squatter Pigeon. Available from: http://www.australianwildlife.org/wildlife/squatter-pigeon.aspx [Accessed 22 August 2018].

Cooper, R.M., I.A.W. McAllan and B.R. Curtis 2014, The Atlas of the Birds of NSW and the ACT. Mini-Publishing, Gordon, New South Wales.

Department of Environment and Energy (2018). *Geophaps scripta scripta* (Squatter Pigeon) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64440 [Accessed 22 August 2018].

National Parks and Wildlife Service (1999). Threatened Species Information – Squatter Pigeon. New South Wales Government. Available from: https://www.environment.nsw.gov.au/resources/nature/tsprofileSquatterPigeon.pdf [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Squatter Pigeon (southern) - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10350# [Accessed 22 August 2018].

Pizzey, G. and Knight, F. 2007, The Field Guide to the Birds of Australia (8th edition) Harper Collins Publishers, NSW, Australia

Squatter Pigeon Workshop (2011). Proceedings from the workshop for the Squatter Pigeon (southern). 14 to 15 December 2011. Toowoomba Office of the Queensland Parks and Wildlife Service.

5.14 Swift parrot (*Lathamus discolor*)

5.14.1 Status

EPBC Act – Critically Endangered, Marine

5.14.2 Biology and ecology

5.14.2.1 Characteristics

The Swift parrot (*Lathamus discolor*) is a small lorikeet-like parrot with a long slender tail measuring approximately 25 cm in body length and weighing 77 g. The Swift parrot is predominately bright green in colour, with dark-blue patches on the crown, a prominent red face, and the chin and throat are narrowly bordered with yellow. One of most distinctive features from a distance is its long 12 cm, thin tail, which is dark red (refer Photograph 5.12). The female Swift parrot is distinguishable from the male as it has slightly duller feathering with a creamy underwing bar (Birdlife 2018; DES 2017; OEH 2017).



Photograph 5.12 Swift parrot (*Lathamus discolor*)

Source: eBird Australia (2015)

5.14.2.2 Known distribution

The Swift parrot is endemic to southeastern Australia. This species breeds only in Tasmania and migrates during the autumn and winter months to southeast Queensland as well as both coastal and the southwest slopes of NSW (DotEE 2018; OEH 2017) (refer Figure 5.28).



Figure 5.28 **Distribution range of Swift parrot**

Source: ALA (2018)

5.14.2.3 Distribution in relation to the project

Lathamus discolor was not recorded during any Project-associated surveys or surveys for the adjacent TSRC Project. There are a number of records (AoLA) from the Toowoomba area. A single record for this species exists within the disturbance footprint near the western tunnel entrance to the north of Toowoomba. It is noted that this record does not have a date recorded and the location has been generalised to 0.1 degree due to the sensitivity of the species. A record from 1998 occurs approximately 2.5 km south of the disturbance footprint at the northern end of Toowoomba. There are several records from the area of Glen Lomond Park which is a 'priority habitat area' for the species (Saunders and Tzaros 2011) and is located approximately 10 km south of the disturbance footprint. There are records from this area dated from 2000 and 2010 whilst there are six occurrences in the same area without dates. Further east there are records south of Withcott (1998) and Flagstone Creek (undated) located 4 km and 6 km south of the Project respectively and there is a 2010 record north of Helidon (4.3 km north of the Project) (refer Figure 5.29).

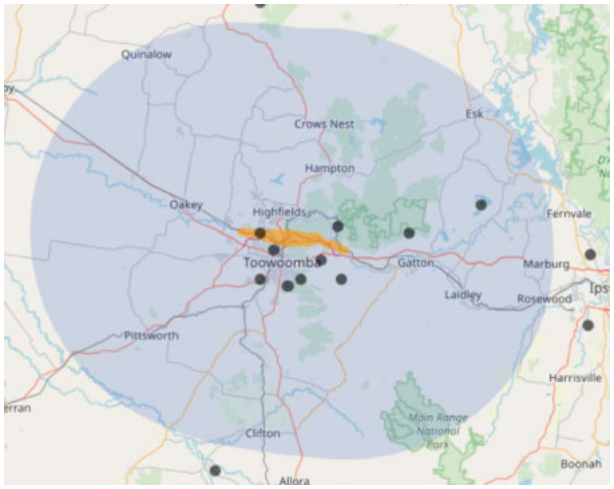


Figure 5.29 **Distribution range of Swift parrot in relation to the Project**

Source: ALA (2020)

5.14.2.4 Biology and reproduction

The Swift parrot feeds mostly on nectar, mainly from Eucalypts, but also eats psyllid insects and lerps (waxy secretion on Eucalypt leaves produced as a protection by young psyllid insects), seeds and fruit. Swift parrots are mostly arboreal foragers, foraging mainly in Eucalypts, but occasionally coming to the ground to feed on seeds, fallen flowers, fruit and lerp, and to drink (DotEE 2018; Higgins 1999; Mallick et al. 2004; Swift parrot Recovery Team 2011).

Swift parrot's breeding season occurs from mid-September to late-January in Tasmania. Nests are typically constructed in hollows of trunks, a branch or spout of a living or dead gum tree with nests known to be used each year. The typical nesting season begins in late September with females laying 3 to 5 eggs during October and November. The females incubate the eggs and fledging hatch from early December to late January (Birdlife 2018; DotEE 2018; Higgins 1999; Swift parrot Recovery Team 2011).

5.14.3 Habitat

The Swift parrot typically inhabits dry sclerophyll, Eucalypt forests, woodlands, suburban parks and even gardens with flowering fruit trees with records showing It occasionally inhabiting wet sclerophyll forests (Birdlife 2018; Swift parrot Recovery Team 2011).

In northern NSW and south-eastern Queensland, Narrow-leaved ironbark (*Eucalyptus crebra*), Forest red gum (*E. tereticornis*) forests and Yellow box (*E. melliodora*) forest are commonly utilised by Swift parrots (OEH 2017, Swift parrot Recovery Team 2011). While on the western slopes Mugga ironbark (*E. sideroxylon*) and Grey Box (*E. microcarpa*) woodlands are used (Saunders and Heinsohn 2008).

Habitats associated with the inland slopes of the Great Dividing Range, and along the eastern coastal plains, are considered the principal wintering grounds (Kennedy and Overs 2001; Kennedy and Tzaros 2005; Saunders 2002).

5.14.4 Threatening processes

The following have been identified as potentially threatening processes to the Swift parrot:

- Habitat loss associated with breeding sites as well as drought refugia habitat
- Habitat alteration through forestry operations, firewood collection and urbanisation in Tasmania
- Competition with noisy miner and aggressive honeyeaters
- Nest predation by gliders (DES 2017; OEH 2017).

5.14.5 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant to this species:

- Saunders, D.L. & C.L. Tzaros (2011). National Recovery Plan for the Swift Parrot (Lathamus discolor). Birds Australia, Melbourne. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/national-recovery-plan-swift-parrot-lathamus-discolor. In effect under the EPBC Act from 10-Feb-2012.

The following threat abatement plans has been identified as being relevant for this species:

- Department of the Environment (2015). Threat abatement plan for predation by feral cats. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/threat-abatement-plan-feral-cats. In effect under the EPBC Act from 23-Jul-2015.

5.14.6 Summary of threat abatement/recovery plan

Threats identified in the National Recovery Plan for the Swift parrot include:

- Habitat loss and alteration from forestry activities including fire wood harvesting
- Residential and industrial development
- Agricultural tree senescence and dieback
- Suppression of tree regeneration
- Frequent fires
- Climate change
- Mortality resulting in collision with wire netting or mesh fences
- Competition from large, aggressive honeyeaters
- Psittacine Beak and Feather Disease (PBFD), which can have devastating impacts depending on general conditions and parrot health
- Illegal poaching of wildlife
- The cumulative impact of all threats.

Threat abatement actions for this species include:

- The identification of the quality and extent of suitable habitat
- Managing and protecting suitable Swift parrot habitat at the landscape level
- Monitor and manage the impact of collisions, competition and disease
- Monitor population and habitat
- Increase community awareness and involvement in the recovery program
- Report on and review the recovery process.

Threats identified in the threat abatement plan for predation by feral cats include:

- Predation on native species causing a critical decline in many species across animal groups
- Competition for food with species they share dietary overlap and disease transmission
- Contributed to the extinction of many ground nesting bird species and the decline of small mammals.

Threat abatement actions for feral cats include:

- Effectively control cats in different landscapes
- Improve effectiveness of existing control measures for feral cats
- Develop and maintain alternative strategies for the recovery of threatened species
- Gain public support for feral cat management and promote responsible cat ownership.

5.14.7 References

Atlas of Living Australia (2018). Lathamus discolor. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:3f12e573-a7b7-45e7-a6e4-aeae9bc3a9ed [Accessed 22 Aug. 2018].

Birdlife Australia (2018). Swift Parrot. Available from: http://www.birdlife.org.au/bird-profile/swift-parrot [Accessed 22 August 2018].

Department of Environment and Energy (2018). Lathamus discolor (Swift Parrot) in Species Profile and Threats Database. Australian Government. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=744 [Accessed 22 August 2018].

Department of Environment and Science (2011). Swift parrot. Queensland Government. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/swift_parrot.html [Accessed 22 August 2018].

eBird Australia. (2015). Swift parrot (Lathamus discolor). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=5fdc44e4-6dcf-4a63-955c-c6ae76f938a1. [17 September 2019].

Higgins, P.J. (ed.) 1999, Handbook of Australian, New Zealand and Antarctic Birds. Volume Four - Parrots to Dollarbird. Melbourne: Oxford University Press.

Kennedy, S.J. and A. Overs 2001, Foraging ecology and habitat use of the Swift parrot on the western slopes of New South Wales. Corella. 25:68-74.

Kennedy, S.J. and C.L. Tzaros 2005, Foraging ecology of the Swift parrot *Lathamus discolor* in the box-ironbark forests and woodlands of Victoria. Pacific Conservation Biology. 11:158-173.

Mallick, S., D. James, R. Brereton and S. Plowright 2004, Blue-gums Eucalyptus globulus in north-west Tasmania: an important food resource for the endangered Swift parrot *Lathamus discolor*. *Victorian Naturalist*. 121:36-46.

Office of Environment and Heritage (2017). Swift Parrot - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10455 [Accessed 22 August 2018].

Saunders, D. and Heinsohn, R. 2008, Winter habitat use by the endangered, migratory Swift parrot (Lathamus discolor) in New South Wales. Emu. 108:81-89. CSIRO Publishing.

Saunders, D. 2002, Assessment of Swift parrot Sites near Cessnock, Lower Hunter Valley Region, NSW - including the Hunter Employment Zone. Report prepared in response to porposed developments in the Hunter Employment Zone.

Swift Parrot Recovery Team. (2011). Swift Parrot Lathamus discolor recovery plan 2011. Report to Environment Australia, Canberra. Queensland Parks and Wildlife Service, Brisbane.

5.15 White-throated needletail (*Hirundapus caudacutus*)

5.15.1 Status

EPBC Act – Vulnerable, Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

5.15.2 Biology and ecology

5.15.2.1 Characteristic

The White-throated needletail (*Hirundapus caudacutus*) is a large swift with a thickset, cigar-shaped body, a stubby tail and pointed wings (refer Photograph 5.13). This species typically measures 20 cm in length and approximately 115 to 120 g in weight. Adults exhibit a dark-olive head and neck, with an iridescent gloss on the crown, whilst the mantle and the back are paler and greyish. The upperwings are blackish (often with a greenish gloss), with a contrasting white patch at the base of the trailing edge. The face is dark-olive with a narrow, white band across the forehead, and lores and a white patch on the chin and throat. The underparts are generally dark-olive except for a U-shaped band across the rear flanks, the vent and the undertail coverts, and the undertail is black with a greenish gloss (DotEE 2018).



Photograph 5.13 White-throated needletail (*Hirundapus caudacutus*)

Source: Knight (2007)

5.15.2.2 Known distribution

White-throated needletails breed in Asia, from central and south-eastern Siberia and Mongolia, east to the Maritime Territories of Russia, Sakhalin and the Kuril Islands and south to northern Japan and north-eastern China. Most White-throated needletails spend the non-breeding season in Australia, and occasionally in New Guinea and New Zealand (DotEE 2018).

The White-throated needletail is considered widespread in eastern and south-eastern Australia. In eastern Australia, it is recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Divide and occasionally onto the adjacent inland plains (DotEE 2018) (refer Figure 5.30).



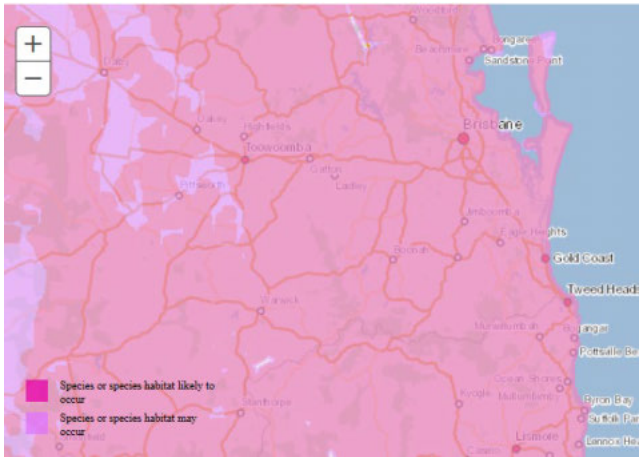


Figure 5.30 Distribution range of the White-throated needletail

Source: ALA (2018), DotEE (2018)

5.15.2.3 Distribution in relation to the project

Database records (i.e. ALA) indicate that records of *Hirundapus caudacutus* exist within the ecology study area at two locations. One record is located approximately 100 m south of the disturbance footprint near Cranley and is dated 2003. The second record is located approximately 1.5 km north of the alignment near Mount Kynoch and is not dated. A number of other records are located within a 50 km buffer of the disturbance footprint in all directions. Most are located in the area between Toowoomba and Lowood (refer Figure 5.31).

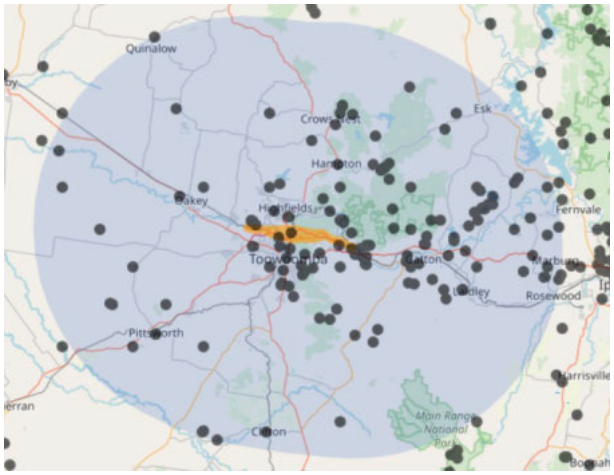


Figure 5.31 **Distribution range of the White-throated needletail in relation to the Project**

Source: ALA (2020)

5.15.2.4 Biology and reproduction

In Australia the White-throated needletail has been recorded eating a wide variety of insects, including beetles, cicadas, flying ants, bees, etc. (DotEE 2018).

White-throated needletails are non-breeding migrants in Australia. Breeding takes place in northern Asia from April to October (DotEE 2018).

5.15.3 Habitat

In Australia, the White-throated needletail is almost exclusively aerial, flying at heights of less than 1 m up to more than 1,000 m above the ground. White-throated needletails often forage along the edges of low pressure systems, which both lift their food sources, and assist with their flight. The species has been recorded roosting in trees in forests and woodlands, both among dense foliage in the canopy or in hollows (DotEE 2018).

This species is known to occur over most types of habitat, however, they are most often recorded above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy. In coastal areas, they are soften seen flying over sandy beaches or mudflats, and often around coastal cliffs and areas with prominent updraughts, such as ridges and sand-dunes (DotEE 2018).

5.15.4 Threatening processes

There appear to be few threats to the populations of White-throated Needletails in Australia, but there is always the potential threat of habitat destruction and predation by feral animals (DotEE 2018).

5.15.5 Threat abatement/recovery plans

No threat abatement/recovery plan has been identified as being relevant for this species.

5.15.6 References

Atlas of Living Australia (2018). *Hirundapus caudacutus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21205690-54fd-452a-9772-d3e1f8780dff# [Accessed 24 August 2018].

Burrows S. (2017). *Hirundapus caudacutus* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21205690-54fd-452a-9772-d3e1f8780dff# [Accessed 24 August 2018].

Department of the Environment and Energy (2018). *Hirundapus caudacutus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682 [Accessed 24 August 2018].

Knight, R. (2007). White-throated needletail (Hirundapus caudacutus). [image] [online] Available from: https://www.flickr.com/photos/sussexbirder/8077024804/in/photolist-dCzG2D-diJS5m-diJRGS-s1aH3F. [17 September 2019].

6 Threatened ecological communities

6.1 Coolibah – Black box woodlands of the Darling Riverine Plains and the Brigalow belt south bioregions

6.1.1 Status

EPBC Act – Endangered

6.1.2 Ecology

6.1.2.1 Characteristic and defining features

Coolibah TEC is a semi-arid to humid subtropical woodlands dominated by *Eucalyptus coolabah* subsp. *coolabah* and/or *Eucalyptus largiflorens* (Black Box) with a grassy understorey. The mid or shrub layer may or may not be present. When present it is typically sparse or clumped and is of variable composition. The ground layer is of variable composition and cover ranging from sparse to dense (refer Photograph 6.1). It typically occurs on grey, self-mulching clays of periodically waterlogged floodplains, swamp margins, ephemeral wetlands and stream levees (DSEWPC 2011).



Photograph 6.1 Coolibah TEC

Source: Elliot (2015)

In Queensland, Coolibah TEC occur within the following REs:

- 11.3.3 - *Eucalyptus coolabah* woodland on alluvial plains
- 11.3.16 - *Eucalyptus largiflorens, ± Acacia cambagei ± A. harpophylla* woodland to low open woodland on alluvial plains
- 11.3.28 - *Eucalyptus coolabah ± Casuarina cristata* open woodland on alluvial plains
- 11.3.37 - *Eucalyptus coolabah* fringing woodland on alluvial plains (DSEWPC 2011).

6.1.2.2 Known distribution

Coolibah TEC are situated within the upper reaches of the Murray-Darling Basin and southern part of the Fitzroy River system and are limited to the Darling Riverine Plains and Brigalow Belt South bioregions, situated in northern NSW and southern Queensland (DSEWPC 2011) (refer Figure 6.1).



Figure 6.1 **Distribution range of Coolibah TEC**

Source: DotEE (2018)

6.1.2.3 Distribution in relation to the Project

The Coolibah TEC was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping for Coolibah TEC indicates that potential habitat does not occur within or directly adjacent to the Ecology study area.

6.1.3 Threatening processes

The following have been identified as potentially threatening processes Coolibah TEC:

- Grazing, cropping and pasture improvement
- Weeds and pest animals
- Mining activities and construction of roads and other infrastructure
- Hydrological changes
- Changes in fire regime (DSEWPC 2011).

6.1.4 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this community.

The following threat abatement plan has been identified as being relevant for this community:

- Saving our species: Help save Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregions.

6.1.5 Summary of threat abatement/recovery plans

Threats specific to Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregions in the strategy include:

- Land clearing for infrastructure, rural and agricultural development and associated activities
- Lack of recruitment in some areas, particularly east of Walgett
- Herbicide and pesticide drift
- Overgrazing and trampling causing loss of flora species and structural diversity, particularly in the understorey and ground layer resulting in erosion and changes in soil structure
- Incursion by exotic flora including Lippia, African boxthorn and particularly Hudson's pear, which has the potential to severely degrade this TEC
- Changes to hydrological processes impacting flooding regimes as a result of drainage works resulting in less frequent flooding events which impacts recruitment.

Objectives and actions outlined in the threat abatement plan for Coolibah-Black Box Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain and Mulga Lands Bioregions include:

- Where this TEC occurs on private properties provide residents with information about how to identify TEC plant species and inform them of the impacts through stakeholder engagement forums, information packages and other community engagement means
- Consult with landholders about adopting a Volunteer Conservation Agreement or similar form of long-term in perpetuity conservation/stewardship agreement to protect the TEC on their property
- Retain hollow trees, plant native hollow producing species ensuring they are left to grow to maturity, as a last resort install artificial hollows in areas where natural hollows are currently lacking
- Encourage landholders to retain standing dead trees, fallen trees, coarse woody debris and logs in remnant patches
- Protect cultural heritage scar trees within the TEC consulting with the Aboriginal community and NSW government
- Install exclusion fencing to protect areas from grazing and foster natural regeneration
- Encourage land managers to regenerate or revegetate cleared areas of the TEC to improve connectivity and overall condition encouraging natural revegetation where possible if groundcover and over-storey is still present. Planting in a continues, stepping stone or buffering approach
- Provide appropriate stakeholders information regarding pesticide choice and application methods encouraging the retention of buffers around the TEC to protect from spray drift along with encouraging early weed identification, intervention and prevention in line with best practice management strategies
- Provide advice to Water NSW on the importance in providing natural flow regimes for the TEC and reinstate appropriate hydrological regimes by infilling drains installing smart gates.

6.1.6 References

Department of Sustainability, Environment, Water, Population and Communities (2011). Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions in Community and Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra [Accessed 31 August 2018].

Department of the Environment and Energy (2018). Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=66 [Accessed 31 August 2018].

Elliot, D. (2015). Coolibah – Black box woodlands of the Darling Riverine Plains and the Brigalow belt south bioregions [image] [online] Available from: https://www.flickr.com/photos/drelliott0net/20918518819/in/photolist-8Hc8kk-8Hfaqb-8Hfe4L-dhXpRE-8Hc4Dr-Nr4bvD-2KjDHt-8uYQhD-8v2SEu-8uYQca-NzJdL-xSuSRz/. [18 September 2019].

6.2 Lowland rainforest of subtropical Australia

6.2.1 Status

EPBC Act – Critically Endangered

6.2.2 Biology and Ecology

6.2.2.1 Characteristic and defining features

The ecological community occurs prominently on basalt and alluvial soils, including sand and old or elevated alluvial soils as well as floodplain alluvia. Lowland rainforest mostly occurs in areas less than 300 m above sea level, with high annual rainfall (>1,300 mm) and typically occurs more than 2 km from the coast, however, it can (and does) intergrade with littoral rainforest in some coastal areas (TSSC 2011).

The ecological community is generally a 20 to 30 m tall, closed forest (canopy cover 70%). Tree species with compound leaves are common and leaves are relatively large (notophyll to mesophyll). Plant species diversity and richness is very high (refer Photograph 6.2). The canopy comprises a range of tree species but in some areas a particular species may dominate e.g. Bangalow palm (*Archontophoenix cunninghamiana*) or Cabbage palm (*Livistona australis*). The canopy is often multilayered consisting of an upper, discontinuous layer of emergents, over the main canopy and subcanopy. Below the canopy is an understorey of sparse shrubs and seedlings. Canopy emergents such as Hoop pine (*Araucaria cunninghamii*) and *Ficus* spp. may be 40 to 50 m tall and have large spreading crowns. The understorey contains a sparse layer of species such as Narrow-leaved palm lily (*Cordyline stricta*), Walking stick palm (*Linospadix monostachya*), Lawyer vine (*Calamus muelleri*) and Rough maidenhair fern (*Adiantum hispidulum*) (TSSC 2011).



Photograph 6.2 Lowland rainforest TEC

Source: Royal (2019)

In Queensland, Lowland rainforest TEC occur within the following REs:

- 12.3.1 Complex to simple notophyll vine forest- Gallery rainforest (notophyll vine forest) on alluvial plains (endangered)
- 12.5.13 Microphyll to notophyll vine forest +/- *Araucaria cunninghamii* (endangered)
- 12.8.3 Complex notophyll vine forest – complex notophyll vine forest on Cainozoic igneous rocks (no concern)
- 12.8.4 Complex notophyll vine forest with *Araucaria* spp. on Cainozoic igneous rocks (no concern)
- 12.8.13 Araucarian complex microphyll vine forest on Cainozoic igneous rocks (of concern)
- 12.11.1 Simple notophyll vine forest often with abundant *Archontophoenix cunninghamiana* (“gully vine forest”) on metamorphics +/- interbedded volcanics (no concern)

- 12.11.10 Notophyll vine forest +/- *Araucaria cunninghamii* on metamorphics +/- interbedded volcanics (no concern)
- 12.12.1 Simple notophyll vine forest usually with abundant *Archontophoenix cunninghamiana* (“gully vine forest”) on Mesozoic to Proterozoic igneous rocks (of concern)
- 12.12.16 Notophyll vine forest on Mesozoic to Proterozoic igneous rocks (no concern) (TSSC 2011).

6.2.2.2 Known distribution

The ecological community primarily occurs from Maryborough in Queensland to the Clarence River (near Grafton) in NSW. The ecological community also includes isolated areas between the Clarence River and Hunter River such as the Bellinger and Hastings valleys (TSSC 2011) (refer Figure 6.2).



Figure 6.2 Distribution range of Lowland rainforest TEC

Source: DotEE (2018)

6.2.2.3 Distribution in relation to the Project

The Lowland rainforest of subtropical Australia TEC was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping indicates that approximately 0.09 ha of suitable habitat for Lowland rainforest TEC is predicted to occur within the Ecology study area although none has been predicted to occur within the EIS disturbance footprint.

6.2.3 Threatening processes

The following have been identified as potentially threatening processes to Lowland rainforest TEC:

- Land clearing
- Impacts associated with fragmentation of remnants
- Weeds
- Private native forestry (TSSC 2011).

6.2.4 Threat abatement/recovery plans

No recovery plan has been identified as being relevant for this community.

The following threat abatement plan has been identified as being relevant for this community:

- Department of the Environment and Energy (2018). Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*. Canberra: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018. In effect under the EPBC Act from 22-Feb-2019.

6.2.5 Summary of threat abatement/recovery plans

The consequences of potential infection outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:

- Inability of infected plants to develop new shoots, flowers, fruit and seed
- Complete loss of some flora populations
- Dramatic alteration to the structure and composition of native plant communities
- A severe reduction in primary productivity and functionality
- Irreversible habitat loss and degradation of dependent flora and fauna
- Loss of shelter and nesting sites and food sources resulting in major declines of fauna.
- Objectives and actions outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:
- Identifying and prioritising the protection of biodiversity assets that are, or may be, impacted by Phytophthora including listed threatened species, ecological communities and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act occur
- Reduce the spread and mitigate the impacts of Phytophthora to protect priority biodiversity assets and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act
- Inform the community through education on the impacts that Phytophthora has on biodiversity and actions to mitigate these impacts
- Encourage research on Phytophthora species and option to manage infestations and protect biodiversity assets.

6.2.6 References

Department of the Environment and Energy (2018). Lowland Rainforest of Subtropical Australia in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=101 [Accessed 31 August 2018].

Royal, S. Lowland rainforest of subtropical Queensland. [image] [online] Available from: https://www.instagram.com/p/B1vvAoZAf6J/. [17 September 2019].

Threatened Species Scientific Committee (2011). Lowland Rainforest of Subtropical Australia, advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee on an Amendment to the List of Threatened Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) [Accessed 31 August 2018].

6.3 Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland

6.3.1 Status

EPBC Act – Critically endangered

6.3.2 Ecology

6.3.2.1 Characteristic and defining features

The Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern Queensland TEC occurs on basalt and fine-textured alluvial plains of northern NSW and southern Queensland. Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern Queensland TEC change with seasonal conditions and are dominated by perennial tussock grasses such as Mitchell grasses (*Astrebla* spp.), Plains grass (*Austrostipa aristiglumis*), Queensland blue grass (*Dichanthium sericeum*), Kangaroo grass (*Themeda australis*), Yadbila (*Panicum queenslandicum*) or one of 13 other indicator grass species (refer Photograph 6.3). The composition of the grassland will change according to seasonal rainfall, temperature, fire and management. The TEC occurs on plains with a slope less than 5 degrees. The communities have very few trees or shrubs, but will have a diversity of herb species including legumes, orchids, daisies and lilies (OEH 2014).



Photograph 6.3 **Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland TEC**

Source: Aurecon (2019)

In Queensland, this TEC is considered to be analogous to the following regional ecosystems REs:

- 11.3.21 *Dichanthium sericeum* and/or *Astrebla* spp. grassland on alluvial plains (cracking clay soils)
- 11.3.24 *Themeda avenacea* grassland on alluvial plains (basalt derived soils) (TSSC 2010).

6.3.2.2 Known distribution

The Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern Queensland TEC can be found on the Liverpool Plains and the Moree Plains of NSW and the Darling Downs of Queensland (OEH 2014) (refer Figure 6.3).

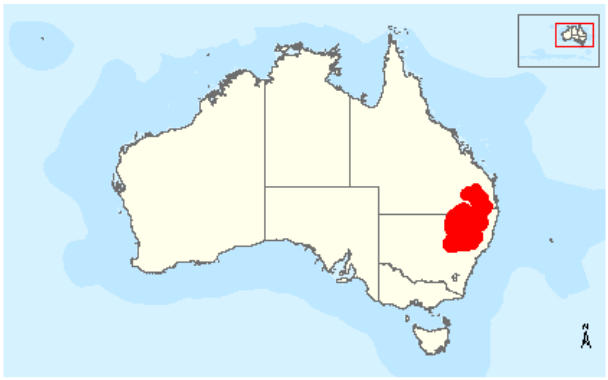


Figure 6.3 **Distribution range of Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland TEC**

Source: DotEE (2018)

6.3.2.3 Distribution in relation to the Project

The Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping indicates that approximately 4.5 ha of suitable habitat for Natural grasslands TEC is predicted to occur within the Ecology study area although none has been predicted to occur within the EIS disturbance footprint.

6.3.3 Threatening processes

The following have been identified as potentially threatening processes to Natural grasslands on basalt and fine-textured alluvial plains of northern NSW and southern Queensland TEC:

- Clearing for cropping and mining
- Grazing by introduced livestock
- Weed invasion
- Changed flood regimes
- Changed fire regimes
- Feral animals such as pigs (OEH 2014).

6.3.4 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this community.

6.3.5 References

Department of the Environment and Energy (2018). Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=88 [Accessed 3 September 2018].

Office of Environment and Heritage, NSW (2014). Natural Grasslands on Alluvial Plains. Available from: https://northerntablelands.lls.nsw.gov.au/__data/assets/pdf_file/0003/542559/TECfact-NaturalGrassland-LLS.pdf [Accessed 3 September 2018].

Threatened Species Scientific Committee (2010). Advice to the Minister for the Environment, Heritage and the Arts from the Threatened Species Scientific Committee (the Committee) on an Amendment to the list of Threatened Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* [Accessed 3 September 2018].

6.4 Poplar Box Grassy Woodland on Alluvial Plains

6.4.1 Status

EPBC Act – Endangered

6.4.2 Ecology

6.4.2.1 Characteristic and defining features

The Poplar Box Grassy Woodland on Alluvial Plains ecological community is typically a grassy woodland with a canopy dominated by Eucalyptus populnea and understorey mostly of grasses and other herbs. The ecological community mostly occurs in gently undulating to flat landscapes and occasionally in hilly terrain on a wide range of soil types of alluvial and depositional origin.



Photograph 6.4 Poplar Box Grassy Woodland

Source: Aurecon (2019)

In Queensland, Poplar Box Grassy Woodland TEC occur within the following REs:

- 11.3.2- Eucalyptus populnea woodland on alluvial plains
- 11.3.17- Eucalyptus populnea woodland with Acacia harpophylla and/or Casuarina cristata on alluvial plains
- 11.4.7- Eucalyptus populnea with Acacia harpophylla and/or Casuarina cristata open forest to woodland on Cainozoic clay plains
- 11.4.12 - Eucalyptus populnea woodland on Cainozoic clay plains
- 12.3.10- Eucalyptus populnea +/- E. tereticornis grassy woodland/tall woodland +/- patches of Acacia harpophylla and Melaleuca bracteate.

6.4.2.2 Known distribution

The Poplar Box Grassy Woodland is located west of the Great Dividing Range, typically at less than 300m above sea level (ASL) and between latitudes 20°S to 34°S. The ecological community is scattered across a broad distribution within an area that is roughly:

- South of Charters Towers in Queensland
- North of Cowra in New South Wales

- West of Ipswich in Queensland and Armidale in New South Wales
- East of Longreach in Queensland and Hillston in New South Wales.

The ecological community primarily occurs within the Brigalow Belt North, Brigalow Belt South, Cobar Peneplain, Darling Riverine Plains, NSW South Western Slopes and Riverina IBRA.

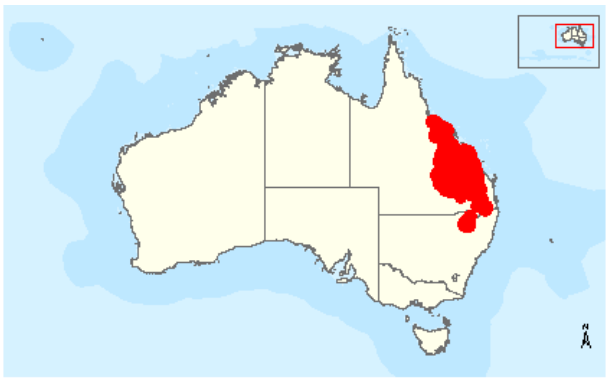


Figure 6.4 Distribution range of Poplar Box Grassy Woodland

Source: DotEE (2018)

6.4.2.3 Distribution in relation to the Project

The Poplar box TEC was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping for Poplar box TEC indicates that potential habitat does not occur within or directly adjacent to the Ecology study area.

6.4.3 Threatening processes

The following have been identified as potentially threatening processes to Semi-evergreen vine thicket TEC:

- Fragmentation
- Land clearing
- Inappropriate fire regimes
- Invasion by introduced pasture species and increased grazing
- Dieback
- Chemical impact and spraydrift
- Salinity
- Nutrient enrichment
- Hydrological changes
- Invasive fauna
- Climate change (TSSC 2019).

6.4.4 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this community.

The following threat abatement plan has been identified as being relevant for this community:

- Department of the Environment and Energy (2017). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (2017). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017. In effect under the EPBC Act from 18-Mar-2017.

6.4.5 Summary of threat abatement/recovery plans

The threats outlined in the threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) include:

- Impacts on plant species composition and succession
- Alterations to nutrient, water cycling and water quality
- Predation of native fauna and flora including small mammals, birds, reptiles, frogs, crayfish, eggs, invertebrates, fungi and all part of plants including fruit, seeds, roots, tubers, bulbs and foliage
- Digging and disturbance to substrate resulting in the destruction of plants threatening their survival and recruitment of new plants altering the floral composition and soil structure
- Disturbance caused by pigs can increase the incursion and recruitment of weeds and provide reservoirs for endemic animal diseases.

Threat abatement actions for feral pics (*Sus scrofa*) include:

- Implementation of control measures including trapping, aerial and ground shooting, poisoning and fencing
- Using tracking dogs to detect and flush out feral pigs by commercial harvesters
- Manipulating habitat by reducing watering points and crop waste
- Manage feral pigs within a policy, legislative and planning framework.

6.4.6 References

Back PV, Anderson ER, Burrows WH and Playford C (2009a) Research note: Poplar Box (Eucalyptus populnea) growth rates in thinned and intact woodlands in central Queensland. Tropical Grasslands 43, 188–190.

Batterham MC (2008) The resilience of Eucalyptus populnea woodlands in the production landscape of the Condamine catchment, southern Queensland. BSc Hons. Thesis, University of Southern Queensland.

Beeston GR, Walker PJ, Purdie R and Pickard John (1980) Plant communities of the Poplar Box (Eucalyptus populnea) lands of eastern Australia. Australian Rangelands Journal 2/1, 1–16.

DotE (Department of the Environment) (2016) Species Profile and Threats Database, Listed Key Threatening Processes. Available on the internet at: http://www.environment.gov.au/cgi-bin/sprat/public/publicgetkeythreats.pl

Department of the Environment (2019). Conservation Advice (including listing advice) for the Poplar Box Grassy Woodland on Alluvial Plains in Community and Species Profile and Threats Database. Department of the Environment. Canberra. Available from: http://www.environment.gov.au/sprat [Accessed 19 August 2019].

Tunstall BR, Torsell BWR, Moore RM, Robertson JA and Goodwin WF (1981) Vegetation Change in Poplar Box (Eucalyptus populnea) Woodlands. Effects of Tree Kill and Domestic Livestock. Australian Rangeland Journal 3/2, 123–32.

6.5 Semi-evergreen vine thickets of the Brigalow Belt (north and south) and Nandewar Bioregions

6.5.1 Status

EPBC Act – Endangered

6.5.2 Ecology

6.5.2.1 Characteristic and defining features

Semi-evergreen vine thicket TEC is considered an extreme form of dry seasonal subtropical rainforest. It is generally characterised by the prominence of trees with microphyll sized leaves and the presence of Bottle trees (*Brachychiton* spp.) as emergent. Semi-evergreen vine thicket TEC are generally less than 10 m high, made up of vines and rainforest trees as well as some shrubs (refer Photograph 6.5). The main canopy is dominated by rainforest species such as Red olive plum (*Cassine australis var. angustifolia*), Wilga (*Geijera parvifolia*), Native olive (*Notelaea microcarpa var. microcarpa*) and Peach bush (*Ehretia membranifolia*). Currant bush (*Carissa ovata*) is often present and typical vines include Gargaloo (*Parsonsia eucalytophylla*) and Wonga vine (*Pandorea pandorana*). The thickets occur in areas with a subtropical, seasonally dry climate on soils of high to medium fertility. It is common on undulating plains on fine grained sedimentary rocks (frequently shale) and on basalt hills and plains (DotEE 2018; OEH 2017; McDonald 1996).



Photograph 6.5 Semi-evergreen vine thicket TEC

Source: Aurecon (2019)

In Queensland, Semi-evergreen vine thicket TEC occur within the following REs:

- 11.2.3-Microphyll vine forest ("beach scrub") on sandy beach ridges
- 11.3.11-Semi-evergreen vine thicket on alluvial plains
- 11.4.1-Semi-evergreen vine thicket ± *Casuarina cristata* on Cainozoic clay plains
- 11.5.15-Semi-evergreen vine thicket on Cainozoic sand plains/remnant surfaces
- 11.8.3-Semi-evergreen vine thicket on Cainozoic igneous rocks
- 11.8.6-*Macropteranthes leichhardtii* thicket on Cainozoic igneous rocks
- 11.8.13-Semi-evergreen vine thicket and microphyll vine forest on Cainozoic igneous rocks
- 11.9.4-Semi-evergreen vine thicket on Cainozoic fine-grained sedimentary rocks
- 11.9.8-*Macropteranthes leichhardtii* thicket on Cainozoic fine-grained sedimentary rocks
- 11.11.18-Semi-evergreen vine thicket on old sedimentary rocks with varying degrees of metamorphism and folding (TSSC 2001).

6.5.2.2 Known distribution

Semi-evergreen vine thicket TEC extend from the Townsville area in Queensland to northern NSW. It is mostly located within the Brigalow Belt bioregion (refer Figure 6.5). In Queensland, the remnant patches are mostly scattered from coastal dunes and river deltas through the northern and central parts of the Brigalow Belt Bioregion to its south-eastern parts between Jandowae and Killarney on the Queensland/NSW border (Queensland Herbarium 2002).

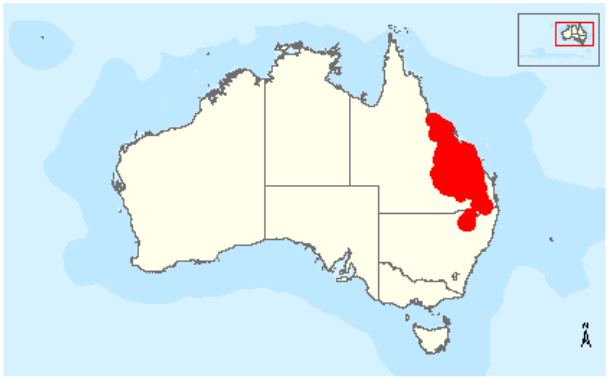


Figure 6.5 **Distribution range of Semi-evergreen vine thicket TEC**

Source: DotEE (2018)

6.5.2.3 Distribution in relation to the Project

The SEVT TEC was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping for SEVT TEC indicates that potential habitat does not occur within or directly adjacent to the Ecology study area.

6.5.3 Threatening processes

The following have been identified as potentially threatening processes to Semi-evergreen vine thicket TEC:

- Fragmentation
- Land clearing
- Inappropriate fire regimes
- Invasion by introduced pasture species and increased grazing (TSSC 2001).

6.5.4 Threat abatement/recovery plans

The following recovery plan has been identified as being relevant for this community:

- McDonald, W.J.F (2010). National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community. Report to Department of the Environment, Water, Heritage and the Arts, Canberra. Queensland Department of Environment and Resource Management, Brisbane. Available from: http://www.environment.gov.au/resource/national-recovery-plan-semi-evergreen-vine-thickets-brigalow-belt-north-and-south-and. In effect under the EPBC Act from 12-Mar-2010.

The following threat abatement plans have been identified as being relevant for this community:

- Department of Sustainability, Environment, Water, Population and Communities (2011). Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-biological-effects-including-lethal-toxic-ingestion-caused-cane-toads. In effect under the EPBC Act from 06-Jul-2011.

- Department of the Environment and Energy (2017). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) (2017). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017. In effect under the EPBC Act from 18-Mar-2017.

6.5.5 Summary of threat abatement/recovery plans

The threats outlined in the National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community include:

- Broad-scale land clearing of remnant vegetation
- Fire where SEVT is not protected by topography or substrate and where fuel characteristics have been altered by the introduction of introduced pasture grasses
- Incursion by exotic flora including Buffel grass *Pennisetum ciliare*, Green panic *Megathyrsus maximus var. pubiglumis*, Parthenium weed *Parthenium hysterophorus*, Velvet tree pear *Opuntia tomentosa*, Lantana *Lantana camara*, Rubber vine *Cryptostegia grandiflora* and Brazilian nightshade *Solanum seaforthianum*. Of these *L. camara* and *C. grandiflora* pose the most serious threat to this TEC.
- Trampling from cattle grazing opening up the understorey of SEVT habitat facilitating the incursion of invasive flora
- Invertebrate pest species including feral pigs, foxes, rabbits and cane toads impacting the vegetation structure and associated native fauna
- Coastal development where remnant vine thicket occurs on coastal beach ridges.

Threat abatement actions outlined in the National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions" ecological community include:

- Identify and evaluate the extent, biodiversity value and condition of remnant and regrowth areas of this TEC in the Brigalow Belt (North and South) and Nandewar Bioregions
- Complete mapping of this TEC in New South Wales and refine mapping of remnants in Queensland
- Establish a condition assessment methodology establishing benchmark sites for each component regional ecosystem
- Determine the extent and condition of SEVT areas that have been impacted by invasive flora, particularly weeds of national significance
- Survey data deficient species within SEVT communities
- Identify key ecosystem components and processes determining their response to management actions
- Monitor selected populations of EPBC-Act listed species that occur within SEVT communities including *Cadellia pentastylis, Cossinia australiana, Denhamia parvifolia, Macropus dorsalis, Paradelma orientalis, Turnix melanogaster* and *Zieria verrucose*
- Establish a comprehensive, adequate and representative system of SEVT ecological community across the Brigalow Belt (North and South) and Nandewar Bioregions, protected by either reservations or conservation agreements (including MOU's)
- Ensure best practice management to sites containing SEVT
- Involve landholders and community members in the conservation and management of SEVT ecological communities
- Enhance the ability of government and non-government organisations at the national, regional and local level (including consent authorities) to recognise and incorporate SEVT ecological community conservation issues into all planning processes.

The threats outlined in the threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads include:

- Predation by cane toads
- Larval competition with frog tadpoles or mosquitoes
- Parasite transfer
- Competition for terrestrial food
- Competition for shelter sites.

Threat abatement actions for cane toads (*Rhinella marina*) include:

- $11 million in funding from the Australian Government provided for the development of a broad-scale control method
- $9 million in funding from the Australian Government for research and management activities
- Identification of native species, ecological communities and off-shore islands that are known to have a high to moderate risk
- Identify the impacts that toads have on listed native species and ecological communities
- Where the impact is expected to be high on native species and ecological communities establish support research techniques in aiding the recovery of priority native species and ecological communities
- Develop a prioritisation tool to aid in the direction of resources for the protection of native species and ecological communities.

The threats outlined in the threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) include:

- Impacts on plant species composition and succession
- Alterations to nutrient, water cycling and water quality
- Predation of native fauna and flora including small mammals, birds, reptiles, frogs, crayfish, eggs, invertebrates, fungi and all part of plants including fruit, seeds, roots, tubers, bulbs and foliage
- Digging and disturbance to substrate resulting in the destruction of plants threatening their survival and recruitment of new plants altering the floral composition and soil structure
- Disturbance caused by pigs can increase the incursion and recruitment of weeds and provide reservoirs for endemic animal diseases.

Threat abatement actions for feral pics (*Sus scrofa*) include:

- Implementation of control measures including trapping, aerial and ground shooting, poisoning and fencing
- Using tracking dogs to detect and flush out feral pigs by commercial harvesters
- Manipulating habitat by reducing watering points and crop waste
- Manage feral pigs within a policy, legislative and planning framework.

6.5.6 References

Department of the Environment and Energy (2018). Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=24 [Accessed 31 August 2018].

Queensland Herbarium (2002). Environment Protection and Biodiversity Conservation Act Threatened ecological communities 1997 remnant. Unpublished map, Queensland Herbarium, Brisbane.

Threatened Species Scientific Committee (2001). Commonwealth Listing Advice on Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions. Available from: www.ea.gov.au/biodiversity/threatened/communities/sevt.html [Accessed 31 August 2018].

McDonald, W.J.F. (1996). *Spatial and temporal patterns in the dry season subtropcial rainforests of eastern Australia, with particular reference to the vine thickets of central and southern Queensland*. PhD thesis, Botany Department, University of New England.

6.6 Weeping Myall woodlands

6.6.1 Status

EPBC Act – Endangered

6.6.2 Ecology

6.6.2.1 Characteristic and defining features

Weeping Myall woodland TEC are predominantly underlain by red-brown earths and heavy textured grey and brown alluvial soils in areas receiving 375 mm to 500 mm of mean annual rainfall. Weeping Myall (*Acacia pendula*) is the dominant overstorey flora species due to its ability to undergo regular cycles of senescence and regeneration, making it often the only tree species in a Weeping Myall woodland TEC (OEH 2017b; DEWHA 2009) (refer Photograph 6.6).

The structure of the community varies between low to open woodland and open shrubland. Understorey structure and composition is affected by latitude with areas south of the Lachlan River district featuring a dominant open layer of chenopod shrubs including saltbushes, native cotton bushes and bluebushes. More woody species and summer grasses including Mitchell grass (*Astrebla* spp.), Queensland blue grass (*Dichanthium sericeum*) as well as Wallaby grass (*Austrodanthonia*) species feature in the northern part of the TEC (DEWHA 2009).



Photograph 6.6 Weeping Myall woodland TEC

Source: Aurecon (2019)

Weeping Myall Woodland TEC are typically restricted to small patches and occur within two REs in Queensland, which are:

- 11.3.2 *Eucalyptus populnea* woodland on alluvial plains
- 11.3.28 *Casuarina cristata* ± *Eucalyptus coolabah* open woodland on alluvial plains (DEWHA 2009).

6.6.2.2 Known distribution

The TEC is found inland along alluvial plains west of the Great Diving Range in NSW and Queensland. Weeping Myall Woodland is found in natural resource management and catchment management authority regions (refer Figure 6.6), including the:

- Border-Rivers-Gwydir catchment management authority region, NSW
- Border Rivers and Maranoa Balonne natural resource management region, QLD
- Condamine natural resource management region, QLD (DEWHA 2009).

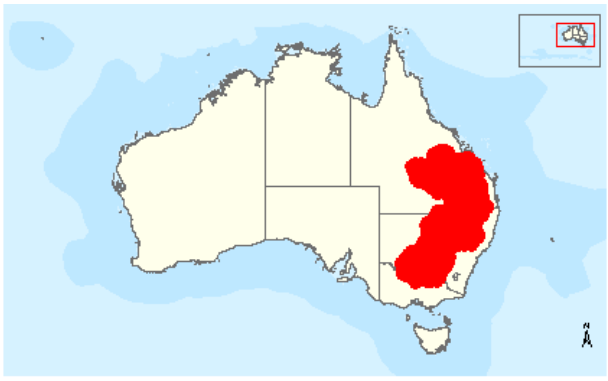


Figure 6.6 Distribution range of Weeping Myall woodland TEC

Source: DotEE (2018)

6.6.2.3 Distribution in relation to the Project

The Weeping myall woodland TEC was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping for Weeping Myall Woodland TEC indicates that potential habitat does not occur within or directly adjacent to the Ecology study area.

6.6.3 Threatening processes

The following have been identified as potentially threatening processes to Weeping Myall woodland TEC:

- Land clearing due to cropping or agriculture
- Land degradation
- Weed invasion and herbivory by caterpillars (DotEE 2018).

6.6.4 Threat abatement/recovery plans

The following threat abatement plan has been identified for this community:

- Office of Environment and Heritage, National Recovery Plan Weeping Myall – Coobah – Scrub Wilga Shrubland of the Hunter Valley. NSW: Department of Premier and Cabinet. Available from: https://www.environment.gov.au/system/files/resources/ac38dfdc-df4b-44ea-99b5-e99c016ca34d/files/weeping-myall-recovery-plan.pdf. This plan has been prepared by the Office of Environment and Heritage, Department of Premier and Cabinet NSW (OEH) in consultation with the Hunter Valley Threatened Flora Recovery Team.

The following threat abatement plan has been identified as being relevant for this community:

- Department of Sustainability, Environment, Water, Population and Communities (2011). *Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-biological-effects-including-lethal-toxic-ingestion-caused-cane-toads. In effect under the EPBC Act from 06-Jul-2011.

6.6.5 Summary of threat abatement/recovery plans

Threats identified in the National Recovery Plan Weeping Myall – Coobah – Scrub Wilga Shrubland of the Hunter Valley include:

- Habitat loss and fragmentation
- Habitat degradation from grazing, weeds, road maintenance and longwall mining
- Long-term consequences of small population size.

Threat abatement actions for Weeping Myall – Coobah – Scrub Wilga Shrubland of the Hunter Valley include:

- Establishment of a recovery team with various government, industry and research stateholders
- Development of a status report to assist the drafting of the recovery report
- In-situ protection and habitat management to improver long-term security
- Community education, awareness and involvement
- Conducting surveys and ongoing monitoring
- Identify and minimise threats
- Gain greater insight into the taxonomy of Weeping Myall.

The threats outlined in the threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads include:

- Predation by cane toads
- Larval competition with frog tadpoles or mosquitoes
- Parasite transfer
- Competition for terrestrial food
- Competition for shelter sites.

Threat abatement actions for cane toads (*Rhinella marina*) include:

- $11 million in funding from the Australian Government provided for the development of a broad-scale control method
- $9 million in funding from the Australian Government for research and management activities
- Identification of native species, ecological communities and off-shore islands that are known to have a high to moderate risk
- Identify the impacts that toads have on listed native species and ecological communities
- Where the impact is expected to be high on native species and ecological communities establish support research techniques in aiding the recovery of priority native species and ecological communities
- Develop a prioritisation tool to aid in the direction of resources for the protection of native species and ecological communities.

6.6.6 Reference

Department of the Environment, Water, Heritage and the Arts (2009). Weeping Myall Woodlands. Australian Government. Available from: http://www.environment.gov.au/system/files/resources/a887e6ec-f4db-4476-8e72-977085028dbd/files/weeping-myall-woodlands.pdf [Accessed 17 August 2018].

Office of Environment and Heritage (2017). Myall Woodland in the Darling Riverine Plains, Brigalow Belt South, Cobar Peneplain, Murray-Darling Depression, Riverina and NSW South Western Slopes bioregions - profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10973 [Accessed 17 August 2018].

6.7 White box-yellow box-Blakely's red gum grassy woodland and derived native grassland (also known as Box-gum grassy woodland and derived grassland)

6.7.1 Status

EPBC Act – Critically endangered

6.7.2 Ecology

6.7.2.1 Characteristic and defining features

White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC is a open woodland communities, which have a tussock grass layer, patchy shrub layer and tree layer predominantly made up of *Eucalyptus albens*, *E. melliodora* and *E. blakelyi*. Intact sites contain a high diversity of trees, shrubs, climbing plants, grasses and especially herbs. Tree cover is generally discontinuous and consists of widely-spaced trees of medium height (refer Photograph 6.7). This ecological community occurs on moderate to highly fertile soils at altitudes of 170 m to 1,200 m (NSWSC 2002; OEH 2017; Yates and Hobbs 1997).



Photograph 6.7 White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC

Source: Aurecon (2019)

In Queensland, White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC is considered to be analogous to the following regional ecosystems REs:

- 11.3.23 *Eucalyptus conica, E. tereticornis, Angophora floribunda* ± *E. melliodora* ± *E. nobilis grassy* woodland
- 11.8.2a *Eucalyptus tereticornis* and *E. melliodora* occurring on low hills
- 11.8.8 *Eucalyptus albens* ± *E. crebra* ± *E. tereticornis* ± *Callitris baileyi* grassy woodland
- 11.9.9a *Eucalyptus albens* ± *E. crebra* ± *E. tereticornis* ± *Callitris baileyi* woodland
- 12.8.16 *Eucalyptus crebra*, generally with *E. tereticornis* and *E. melliodora* ± *E. albens* grassy woodland (only at the far western edge of the bioregion)
- 13.3.4 *Eucalyptus conica, E. microcarpa or E. moluccana, E. melliodora* grassy woodland
- 13.3.1 *Eucalyptus blakelyi* grassy woodland or open forest +/- *E. bridgesiana* +/- *E. melliodora* on Cainozoic alluvial plains

- 13.11.3 *Eucalyptus crebra, E. dealbata, E. albens* grassy woodland
- 13.11.4 *Eucalyptus melanophloia, E. dealbata, E. albens* ± *Callitris glaucophylla* grassy woodland.
- 13.11.8 Woodland of *E. melliodora* and/or *E. microcarpa/moluccana* on rolling hills, depressions and lower slopes around drainage lines
- 13.12.8 Woodland of *E. melliodora* and/or *E. microcarpa/ moluccana +/- conica*, on undulating plains and lower slopes in granite basins
- 13.12.9 Woodland to open forest of *E. blakelyi* and/or *E. calignosa* or *E. mckieana* on plains and rolling hills in granite basins (TSSC 2006).

6.7.2.2 Known distribution

White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC occur in an arc along the western slopes and tablelands of the Great Dividing Range from southern Queensland through NSW to central Victoria (Beadle 1981) (refer Figure 6.7).

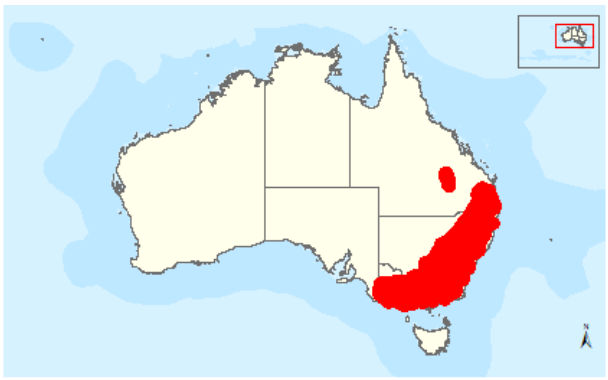


Figure 6.7 **Distribution range of White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC**

Source: DotEE (2018)

6.7.2.3 Distribution in relation to the Project

The White Box-Yellow box-Blakely's red gum grassy woodland and derived native grassland TEC was identified as having the potential to occur within the Ecology study area during desktop searches. Predictive habitat mapping indicates that approximately 100.3 ha of suitable habitat for Natural grasslands TEC is predicted to occur within the Ecology study area although none has been predicted to occur within the EIS disturbance footprint.

6.7.3 Threatening processes

The following have been identified as potentially threatening processes to White box-yellow box-Blakely's red gum grassy woodland and derived native grassland TEC:

- Habitat loss, degradation and fragmentation from agricultural, forestry, mining, infrastructure and residential development
- Degradation by over grazing and trampling
- Degradation of remnants by non-native plant species
- Increased nutrient status due to application of fertilisers to native groundcover
- Altered fire regimes.
- Lack of community knowledge
- Human disturbance by off road vehicles, camping, other recreational activities (OEH 2017).

6.7.4 Threat abatement/recovery plans

The following recovery plan has been identified for this community:

- Department of Environment, Climate Change and Water NSW (2010). *National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Department of Environment, Climate Change and Water NSW, Sydney. Available from: http://www.environment.gov.au/biodiversity/threatened/recovery-plans/white-box-yellow-box-blakelys-red-gum-grassy-woodland-and-derived-native-grassland-national. In effect under the EPBC Act from 22-Mar-2013.

The following threat abatement plans has been identified as being relevant for this community:

- Department of Sustainability, Environment, Water, Population and Communities (2011). Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/resource/threat-abatement-plan-biological-effects-including-lethal-toxic-ingestion-caused-cane-toads. In effect under the EPBC Act from 06-Jul-2011.
- Department of the Environment and Energy (2017). Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (Sus scrofa) (2017). Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/feral-pig-2017. In effect under the EPBC Act from 18-Mar-2017.
- Department of the Environment and Energy (2018). Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*. Canberra: Commonwealth of Australia. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/threat-abatement-plan-disease-natural-ecosystems-caused-phytophthora-cinnamomi-2018. In effect under the EPBC Act from 22-Feb-2019.

6.7.5 Summary of threat abatement/recovery plans

Threats identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Land use and management change
- Agricultural and horticultural development
- Public Infrastructure upgrades in travelling stock routes (TSRs)
- Firewood collection and ‘tidying up’
- Changed fire regimes
- Increase in soil nutrients and use of chemicals
- Mowing and slashing regimes
- Revegetation management
- Weed invasion
- Climate change
- Salinity
- Acid soils
- Declining tree health and regeneration
- Increased grazing pressure from invasive herbivores
- Disease – *Phytophthora cinnamomi*
- Collection and removal of native flora.

Recovery actions identified in the National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland include:

- Collect baseline data on the locations, quality and management regimes of remnant sites
- Extent and condition mapping
- Component species surveys
- Protection of existing habitat in priority areas including on private land
- Engagement with the community, particularly where remnants occur on private land to provide information on appropriate management and with Aboriginal communities.

Summary of baseline information actions undertaken to date:

- The establishment of databases comprising of information on CMN members (land managers with Box-Gum Grassy Woodland remnants), remnant locations, composition of flora and fauna species and remnant condition from surveys of CMN members' sites and other sites
- Minimum condition criteria and assessment method developed to assist land managers in identification of listed ecological communities
- Development of regional models using remote sensing
- Mapping of Box-Gum Grassy Woodland extent
- Surveys conducted during research programs through various organisations.

The threats outlined in the threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads include:

- Predation by cane toads
- Larval competition with frog tadpoles or mosquitoes
- Parasite transfer
- Competition for terrestrial food
- Competition for shelter sites.

Threat abatement actions for cane toads (*Rhinella marina*) include:

- $11 million in funding from the Australian Government provided for the development of a broad-scale control method
- $9 million in funding from the Australian Government for research and management activities
- Identification of native species, ecological communities and off-shore islands that are known to have a high to moderate risk
- Identify the impacts that toads have on listed native species and ecological communities
- Where the impact is expected to be high on native species and ecological communities establish support research techniques in aiding the recovery of priority native species and ecological communities
- Develop a prioritisation tool to aid in the direction of resources for the protection of native species and ecological communities.

The threats outlined in the threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*) include:

- Impacts on plant species composition and succession
- Alterations to nutrient, water cycling and water quality
- Predation of native fauna and flora including small mammals, birds, reptiles, frogs, crayfish, eggs, invertebrates, fungi and all part of plants including fruit, seeds, roots, tubers, bulbs and foliage
- Digging and disturbance to substrate resulting in the destruction of plants threatening their survival and recruitment of new plants altering the floral composition and soil structure

- Disturbance caused by pigs can increase the incursion and recruitment of weeds and provide reservoirs for endemic animal diseases.

Threat abatement actions for feral pics (*Sus scrofa*) include:

- Implementation of control measures including trapping, aerial and ground shooting, poisoning and fencing
- Using tracking dogs to detect and flush out feral pigs by commercial harvesters
- Manipulating habitat by reducing watering points and crop waste
- Manage feral pigs within a policy, legislative and planning framework.

The consequences of potential infection outlined in the threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi* include:

- Inability of infected plants to develop new shoots, flowers, fruit and seed
- Complete loss of some flora populations
- Dramatic alteration to the structure and composition of native plant communities
- A severe reduction in primary productivity and functionality
- Irreversible habitat loss and degradation of dependent flora and fauna
- Loss of shelter and nesting sites and food sources resulting in major declines of fauna.

Objectives and actions outlined in the threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi include:

- Identifying and prioritising the protection of biodiversity assets that are, or may be, impacted by Phytophthora including listed threatened species, ecological communities and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act occur
- Reduce the spread and mitigate the impacts of Phytophthora to protect priority biodiversity assets and areas where non-listed species or ecological communities that may become eligible for listing under the EPBC Act
- Inform the community through education on the impacts that Phytophthora has on biodiversity and actions to mitigate these impacts
- Encourage research on Phytophthora species and option to manage infestations and protect biodiversity assets.

6.7.6 References

Department of the Environment and Energy (2018). White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, Department of the Environment and Energy, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=43 [Accessed 4 September 2018].

Office of Environment and Heritage, NSW (2017). White Box Yellow Box Blakely's Red Gum Woodland. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10837 [Accessed 4 September 2018].

Threatened Species Scientific Committee (2006). Advice to the Minister for the Environment and Heritage from the Threatened Species Scientific Committee (TSSC) on Amendments to the List of Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* [Accessed 4 September 2018].

Beadle, N.C.W. (1981). The Vegetation of Australia. Cambridge University Press, Cambridge.

Yates, C.J. and R.J. Hobbs (1997). Temperate Eucalypt Woodlands: a review of their status, processes threatening their persistence and techniques for restoration in Australian Journal of Botany 45: 949-973.

NSW Scientific Committee (2002). White Box Yellow Box Blakely's Red Gum Woodland – endangered ecological community listing. Final Determination. Available from: http://www.nationalparks.nsw.gov.au/npws.nsf/content/boxgum+woodland+endangered+ecological+community+listing [Accessed 4 September 2018].

APPENDIX

J

INLAND RAIL

Matters of National Environmental Significance

Appendix C Herbarium confirmation letter

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

IR_1536

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Queensland Government

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha•Toowong 4066 Queensland•Australia
Telephone +61 7 3896 9326 • Facsimile +61 7 3896 9624
e-mail Queensland.Herbarium@qld.gov.au
www.qld.gov.au/herbarium

Department of
Science, Information Technology and Innovation

Enquiries Megan Thomas
Telephone 07 3896 9318
Your reference
Our reference MBT 784/17

6 November 2017

Chris Schell
Aurecon
Locked Bag 331
BRISBANE QLD 4001

Dear Chris

The botanical specimens received by the Queensland Herbarium on 17 October 2017, have been identified as:

Sample A	*Hymenosporum flavum*
Sample B	*Parsonsia* sp., probably *P. lanceolata*
Site 12	Poaceae, possibly *Ottochloa gracillima*
Site 28	*Jasminum dianthifolium*

There is a charge of $110.55 (minimum charge 1hr incl. GST) for these identifications.

Yours sincerely

G.P. Guymer
Director

Download a full version of Census of the Queensland Flora 2016
https://data.qld.gov.au/dataset/census-of-the-queensland-flora-2016

APPENDIX J

Matters of National Environmental Significance

Appendix D Database search results

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

IR_1536

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

EPBC Act Protected Matters Report

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

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

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

Report created: 25/03/20 14:18:11

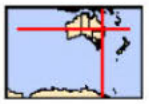
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



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

Coordinates
Buffer: 1.0Km



Summary

Matters of National Environmental Significance

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

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	5
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	7
Listed Threatened Species:	47
Listed Migratory Species:	16

Other Matters Protected by the EPBC Act

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

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

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

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	23
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

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

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	40
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar)	[Resource Information]
Name	Proximity
Banrock station wetland complex	1300 - 1400km
Moreton bay	50 - 100km upstream
Narran lake nature reserve	400 - 500km upstream
Riverland	1200 - 1300km
The coorong, and lakes alexandrina and albert wetland	1400 - 1500km

Listed Threatened Ecological Communities		[Resource Information]
For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.		
Name	Status	Type of Presence
Coolibah - Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions	Endangered	Community may occur within area
Lowland Rainforest of Subtropical Australia	Critically Endangered	Community may occur within area
Natural grasslands on basalt and fine-textured alluvial plains of northern New South Wales and southern Queensland	Critically Endangered	Community likely to occur within area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community may occur within area
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	Endangered	Community likely to occur within area
Weeping Myall Woodlands	Endangered	Community may occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community likely to occur within area

Listed Threatened Species		[Resource Information]
Name	Status	Type of Presence
Birds		
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour may occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Cyclopsitta diophthalma coxeni Coxen's Fig-Parrot [59714]	Endangered	Species or species habitat may occur within area
Erythrotriorchis radiatus Red Goshawk [942]	Vulnerable	Species or species habitat known to occur within area
Geophaps scripta scripta Squatter Pigeon (southern) [64440]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat known to occur within area
Turnix melanogaster Black-breasted Button-quail [923]	Vulnerable	Species or species habitat known to occur within area
Mammals		
Chalinolobus dwyeri Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat likely to occur within area
Dasyurus hallucatus Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat likely to occur within area
Dasyurus maculatus maculatus (SE mainland population) Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat likely to occur within area
Nyctophilus corbeni Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat may occur within area
Petauroides volans Greater Glider [254]	Vulnerable	Species or species habitat known to occur within area
Petrogale penicillata Brush-tailed Rock-wallaby [225]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT) Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Vulnerable	Species or species habitat known to occur within area
Potorous tridactylus tridactylus Long-nosed Potoroo (SE Mainland) [66645]	Vulnerable	Species or species habitat may occur within area
Pseudomys novaehollandiae New Holland Mouse, Pookila [96]	Vulnerable	Species or species habitat likely to occur within area
Pteropus poliocephalus Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Plants		
Arthraxon hispidus Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area

Name	Status	Type of Presence
Bothriochloa bunyensis Satin-top Grass [15961]	Vulnerable	Species or species habitat known to occur within area
Bulbophyllum globuliforme Miniature Moss-orchid, Hoop Pine Orchid [6649]	Vulnerable	Species or species habitat likely to occur within area
Cadellia pentastylis Ooline [9828]	Vulnerable	Species or species habitat likely to occur within area
Clematis fawcettii Stream Clematis [4311]	Vulnerable	Species or species habitat likely to occur within area
Dichanthium queenslandicum King Blue-grass [5481]	Endangered	Species or species habitat may occur within area
Dichanthium setosum bluegrass [14159]	Vulnerable	Species or species habitat likely to occur within area
Grevillea quadricauda [64651]	Vulnerable	Species or species habitat known to occur within area
Haloragis exalata subsp. velutina Tall Velvet Sea-berry [16839]	Vulnerable	Species or species habitat may occur within area
Lepidium peregrinum Wandering Pepper-cress [14035]	Endangered	Species or species habitat known to occur within area
Macadamia integrifolia Macadamia Nut, Queensland Nut Tree, Smooth-shelled Macadamia, Bush Nut, Nut Oak [7326]	Vulnerable	Species or species habitat may occur within area
Paspalidium grandispiculatum a grass [10838]	Vulnerable	Species or species habitat likely to occur within area
Phebalium distans Mt Berryman Phebalium [81869]	Critically Endangered	Species or species habitat likely to occur within area
Picris evae Hawkweed [10839]	Vulnerable	Species or species habitat likely to occur within area
Rhaponticum australe Austral Cornflower, Native Thistle [22647]	Vulnerable	Species or species habitat likely to occur within area
Samadera bidwillii Quassia [29708]	Vulnerable	Species or species habitat may occur within area
Sarcochilus hartmannii Waxy Sarcochilus, Blue Knob Orchid [4124]	Vulnerable	Species or species habitat likely to occur within area
Sarcochilus weinthalii Blotched Sarcochilus, Weinthals Sarcanth [12673]	Vulnerable	Species or species habitat likely to occur within area
Sophora fraseri [8836]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Thesium australe Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Reptiles		
Anomalopus mackayi Five-clawed Worm-skink, Long-legged Worm-skink [25934]	Vulnerable	Species or species habitat known to occur within area
Delma torquata Adorned Delma, Collared Delma [1656]	Vulnerable	Species or species habitat known to occur within area
Egernia rugosa Yakka Skink [1420]	Vulnerable	Species or species habitat may occur within area
Furina dunmalli Dunmall's Snake [59254]	Vulnerable	Species or species habitat may occur within area
Tympanocryptis condaminensis Condamine Earless Dragon [87888]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

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

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Defence - TOOWOOMBA RIFLE RANGE

Listed Marine Species [Resource Information]

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

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat known to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Monarcha melanopsis Black-faced Monarch [609]		Species or species habitat known to occur within area
Monarcha trivirgatus Spectacled Monarch [610]		Species or species habitat known to occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca Satin Flycatcher [612]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Rhipidura rufifrons Rufous Fantail [592]		Species or species habitat known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

Invasive Species [Resource Information]

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

Name	Status	Type of Presence
Birds		
Acridotheres tristis Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Lonchura punctulata Nutmeg Mannikin [399]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species habitat known to occur within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Lepus capensis Brown Hare [127]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus africanus Climbing Asparagus, Climbing Asparagus Fern [66907]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Cryptostegia grandiflora Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Nassella neesiana Chilean Needle grass [67699]		Species or species habitat likely to occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Parthenium hysterophorus Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Senecio madagascariensis Fireweed, Madagascar Ragwort, Madagascar Groundsel [2624]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

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

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

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

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

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

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

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

- migratory and
- marine

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

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

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

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

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

Coordinates

-27.50424 151.85356,-27.50328 151.84913,-27.50164 151.84626,-27.49936 151.84435,-27.49686 151.84333,-27.49288 151.84393,-27.49006 151.84542,-27.48789 151.84848,-27.48693 151.85201,-27.48699 151.85482,-27.48911 151.86392,-27.49028 151.87098,-27.48947 151.88524,-27.48979 151.89146,-27.49048 151.89529,-27.49106 151.89774,-27.48959 151.9673,-27.49853 152.01622,-27.49823 152.02481,-27.49678 152.03073,-27.49716 152.03682,-27.49937 152.04403,-27.50119 152.0473,-27.51178 152.06154,-27.51284 152.06455,-27.51315 152.0691,-27.51299 152.07588,-27.51497 152.08523,-27.51878 152.09244,-27.52417 152.09869,-27.52577 152.10195,-27.52706 152.10719,-27.52874 152.11388,-27.53102 152.11646,-27.53848 152.11809,-27.54312 152.11508,-27.54502 152.11079,-27.5454 152.10779,-27.54312 152.0956,-27.53863 152.08659,-27.53323 152.08015,-27.53148 152.07637,-27.53094 152.07277,-27.53117 152.06281,-27.52874 152.05363,-27.52128 152.04247,-27.52201 152.03895,-27.52863 152.01149,-27.52779 152.00179,-27.52779 151.99209,-27.5268 151.98471,-27.52886 151.97527,-27.52931 151.96548,-27.51645 151.90815,-27.51339 151.90162,-27.51339 151.89862,-27.51141 151.89828,-27.50943 151.89553,-27.50753 151.88841,-27.50742 151.8852,-27.50826 151.87112,-27.50719 151.86159,-27.50559 151.85885,-27.50415 151.85344,-27.50424 151.85356

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

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

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

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Queensland Government

Department of Environment and Science

Environmental Reports

Matters of State Environmental Significance

For the selected area of interest

Environmental Reports - General Information

The Environmental Reports portal provides for the assessment of selected matters of interest relevant to a user specified location, or area of interest (AOI). All area and derivative figures are relevant to the extent of matters of interest contained within the AOI unless otherwise stated. Please note, if a user selects an AOI via the "central coordinates" option, the resulting assessment area encompasses an area extending for a 2km radius from the point of interest.

All area and area derived figures included in this report have been calculated via reprojecting relevant spatial features to Albers equal-area conic projection (central meridian = 146, datum Geocentric Datum of Australia 1994). As a result, area figures may differ slightly if calculated for the same features using a different co-ordinate system.

Figures in tables may be affected by rounding.

The matters of interest reported on in this document are based upon available state mapped datasets. Where the report indicates that a matter of interest is not present within the AOI (e.g. where area related calculations are equal to zero, or no values are listed), this may be due either to the fact that state mapping has not been undertaken for the AOI, that state mapping is incomplete for the AOI, or that no values have been identified within the site.

The information presented in this report should be considered as a guide only and field survey may be required to validate values on the ground.

Please direct queries about these reports to: Planning.Support@des.qld.gov.au

Disclaimer

Whilst every care is taken to ensure the accuracy of the information provided in this report, the Queensland Government makes no representations or warranties about its accuracy, reliability, completeness, or suitability, for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or consequential damage) and costs which the user may incur as a consequence of the information being inaccurate or incomplete in any way and for any reason.



Table of Contents

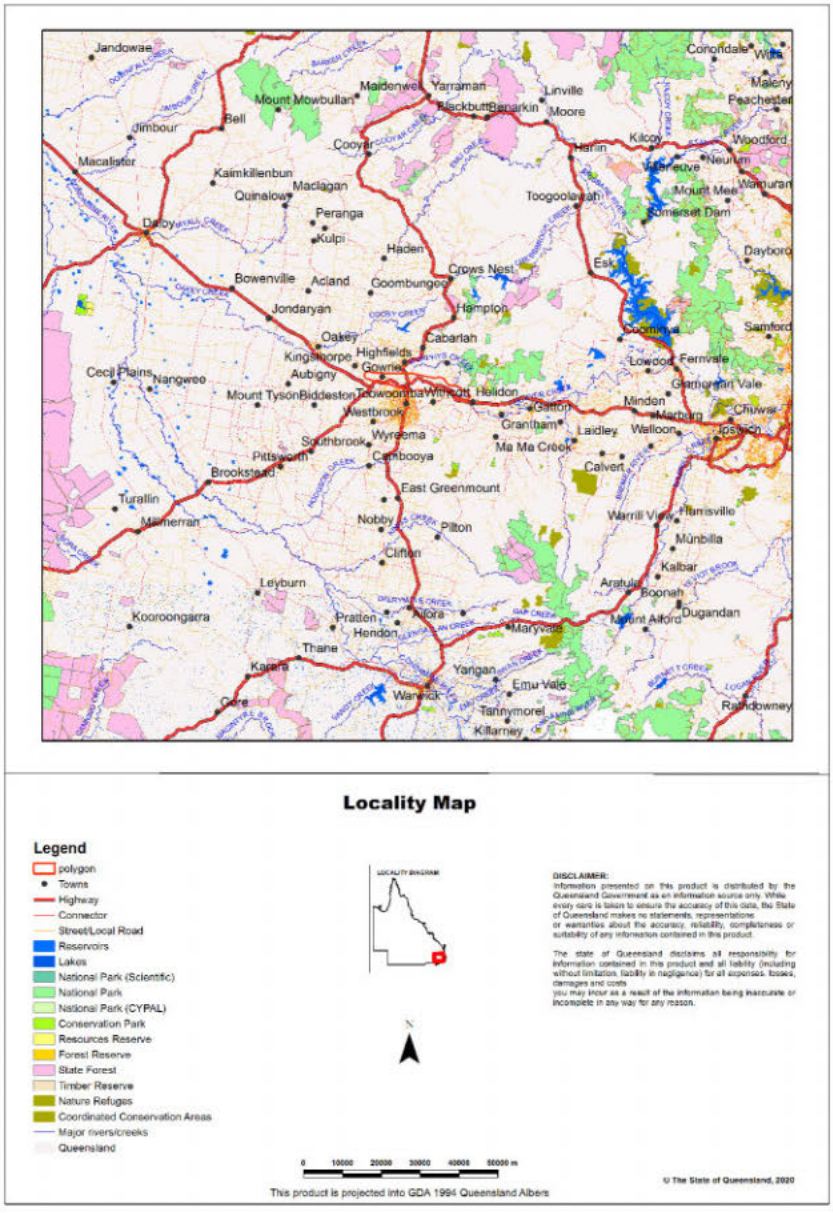
Assessment Area Details . . . 4
Matters of State Environmental Significance (MSES) . . . 5
MSES Categories . . . 5
MSES Values Present . . . 6
Additional Information with Respect to MSES Values Present . . . 7
MSES - State Conservation Areas . . . 7
MSES - Wetlands and Waterways . . . 7
MSES - Species . . . 7
MSES - Regulated Vegetation . . . 9
Map 1 - MSES - State Conservation Areas . . . 12
Map 2 - MSES - Wetlands and Waterways . . . 13
Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals . . . 14
Map 3b - MSES - Species - Koala habitat area (SEQ) . . . 15
Map 4 - MSES - Regulated Vegetation . . . 16
Map 5 - MSES - Offset Areas . . . 17
Appendices . . . 18
Appendix 1 - Matters of State Environmental Significance (MSES) methodology . . . 18
Appendix 2 - Source Data . . . 19
Appendix 3 - Acronyms and Abbreviations . . . 20

Assessment Area Details

The following table provides an overview of the area of interest (AOI) with respect to selected topographic and environmental values.

Table 1: Summary table, details for AOI

Size (ha)	7,965.7
Local Government(s)	Lockyer Valley Regional, Toowoomba Regional
Bioregion(s)	Brigalow Belt, Southeast Queensland
Subregion(s)	Moreton Basin, Eastern Darling Downs
Catchment(s)	Balonne-Condamine, Brisbane



Matters of State Environmental Significance (MSES)

MSES Categories

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states:

'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset.'

The MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The SPP defines matters of state environmental significance as:

- Protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992* ;

- Marine parks and land within a 'marine national park', 'conservation park', 'scientific research', 'preservation' or 'buffer' zone under the *Marine Parks Act 2004* ;

- Areas within declared fish habitat areas that are management A areas or management B areas under the Fisheries Regulation 2008;

- Threatened wildlife under the *Nature Conservation Act 1992* and special least concern animals under the Nature Conservation (Wildlife) Regulation 2006;

- Regulated vegetation under the *Vegetation Management Act 1999* that is:

    • Category B areas on the regulated vegetation management map, that are 'endangered' or 'of concern' regional ecosystems;

    • Category C areas on the regulated vegetation management map that are 'endangered' or 'of concern' regional ecosystems;

    • Category R areas on the regulated vegetation management map;

    • Regional ecosystems that intersect with watercourses identified on the vegetation management watercourse and drainage feature map;

    • Regional ecosystems that intersect with wetlands identified on the vegetation management wetlands map;

- Strategic Environmental Areas under the *Regional Planning Interests Act 2014* ;

- Wetlands in a wetland protection area of wetlands of high ecological significance shown on the Map of Queensland Wetland Environmental Values under the Environment Protection Regulation 2019;

- Wetlands and watercourses in high ecological value waters defined in the Environmental Protection (Water) Policy 2009, schedule 2;

- Legally secured offset areas.

MSES Values Present

The MSES values that are present in the area of interest are summarised in the table below:

Table 2: Summary of MSES present within the AOI

1a Protected Areas- estates	0.0 ha	0.0 %
1b Protected Areas- nature refuges	0.0 ha	0.0 %
2 State Marine Parks- highly protected zones	0.0 ha	0.0 %
3 Fish habitat areas (A and B areas)	0.0 ha	0.0 %
4 Strategic Environmental Areas (SEA)	0.0 ha	0.0 %
5 High Ecological Significance wetlands on the map of Referable Wetlands	0.0 ha	0.0 %
6a High Ecological Value (HEV) wetlands	5.57 ha	0.1%
6b High Ecological Value (HEV) waterways **	4.5 km	Not applicable
7a Threatened (endangered or vulnerable) wildlife	2069.83 ha	26.0%
7b Special least concern animals	623.72 ha	7.8%
7c i Koala habitat area - core (SEQ)	3017.94 ha	37.9%
7c ii Koala habitat area - locally refined (SEQ)	0.0 ha	0.0 %
8a Regulated Vegetation - Endangered/Of concern in Category B (remnant)	1348.98 ha	16.9%
8b Regulated Vegetation - Endangered/Of concern in Category C (regrowth)	913.32 ha	11.5%
8c Regulated Vegetation - Category R (GBR riverine regrowth)	0.0 ha	0.0 %
8d Regulated Vegetation - Essential habitat	3371.56 ha	42.3%
8e Regulated Vegetation - intersecting a watercourse **	182.9 km	Not applicable
8f Regulated Vegetation - within 100m of a Vegetation Management Wetland	0.0 ha	0.0 %
9a Legally secured offset areas- offset register areas	0.0 ha	0.0 %
9b Legally secured offset areas- vegetation offsets through a Property Map of Assessable Vegetation	0.0 ha	0.0 %

Additional Information with Respect to MSES Values Present

MSES - State Conservation Areas

1a. Protected Areas - estates

(no results)

1b. Protected Areas - nature refuges

(no results)

2. State Marine Parks - highly protected zones

(no results)

3. Fish habitat areas (A and B areas)

(no results)

Refer to **Map 1 - MSES - State Conservation Areas** for an overview of the relevant MSES.

MSES - Wetlands and Waterways

4. Strategic Environmental Areas (SEA)

(no results)

5. High Ecological Significance wetlands on the Map of Queensland Wetland Environmental Values

(no results)

6a. Wetlands in High Ecological Value (HEV) waters

Natural wetlands that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (water) Policy are present.

6b. Waterways in High Ecological Value (HEV) waters

Natural waterways that occur in HEV (maintain) freshwater and estuarine areas under the Environmental Protection (water) Policy are present.

Refer to **Map 2 - MSES - Wetlands and Waterways** for an overview of the relevant MSES.

MSES - Species

7a. Threatened (endangered or vulnerable) wildlife

Values are present

7b. Special least concern animals

Values are present

7c i. Koala habitat area - core (SEQ)

Values are present

7c ii. Koala habitat area - locally refined (SEQ)

Not applicable

Threatened (endangered or vulnerable) wildlife habitat suitability models

Species	Common name	NCA status	Presence
Boronia keysii		V	None
Calyptorhynchus lathami	Glossy black cockatoo	V	Core
Casuarius casuarius johnsonii	Sthn population cassowary	E	None
Crinia tinnula	Wallum froglet	V	None
Denisonia maculata	Ornamental snake	V	None
Litoria freycineti	Wallum rocketfrog	V	None
Litoria olongburensis	Wallum sedgefrog	V	None
Melaleuca irbyana		E	None
Petaurus gracilis	Mahogany Glider	E	None
Petrogale persephone	Proserpine rock-wallaby	E	None
Phascolarctos cinereus	Koala - outside SEQ*	V	None
Pezoporus wallicus wallicus	Eastern ground parrot	V	None
Taudactylus Pleione	Kroombit tinkerfrog	E	None
Xeromys myoides	Water Mouse	V	None

**For koala model, this includes areas outside SEQ. Check 7c SEQ koala habitat for presence/absence.*

Threatened (endangered or vulnerable) wildlife species records

Scientific name	Common name	NCA status	EPBC status	Migratory status
Adelotus brevis	tusked frog	V		
Delma torquata	collared delma	V	V	
Sophora fraseri	brush sophora	V	V	
Sarcochilus weinthalii	blotched sarcochilus	E	V	
Bothriochloa bunyensis	Bunya Mountains bluegrass	V	V	
Picris evae		V	V	
Cyperus clarus		V		
Rhaponticum australe		V	V	
Grantiella picta	painted honeyeater	V	V	PM
Rostratula australis	Australian painted snipe	E	E	
Geophaps scripta scripta	squatter pigeon (southern subspecies)	V	V	
Ninox strenua	powerful owl	V		
Petrogale penicillata	brush-tailed rock-wallaby	V	V	

Scientific name	Common name	NCA status	EPBC status	Migratory status
Jalmenus eubulus	pale imperial hairstreak	V		
Grevillea quadricauda		V	V	

Special least concern animal species records

Scientific name	Common name	Migratory status
Tachyglossus aculeatus	short-beaked echidna	
Ornithorhynchus anatinus	platypus	
Gallinago hardwickii	Latham's snipe	M-J/R/B/E
Actitis hypoleucos	common sandpiper	M-C/J/R/B/E
Tringa stagnatilis	marsh sandpiper	M-C/J/R/B/E
Calidris acuminata	sharp-tailed sandpiper	M-C/J/R/B/E
Calidris ruficollis	red-necked stint	M-C/J/R/B/E
Pluvialis fulva	Pacific golden plover	M-C/J/R/B/E
Numenius phaeopus	whimbrel	M-C/J/R/B/E
Limosa limosa	black-tailed godwit	M-C/J/R/B/E
Tringa nebularia	common greenshank	M-C/J/R/B/E

**Nature Conservation Act 1992 (NCA) Status- Endangered (E), Vulnerable (V) or Special Least Concern Animal (SL). Environment Protection and Biodiversity Conservation Act 1999 (EPBC) status: Critically Endangered (CE) Endangered (E), Vulnerable (V)*

Migratory status (M) - China and Australia Migratory Bird Agreement (C), Japan and Australia Migratory Bird Agreement (J), Republic of Korea and Australia Migratory Bird Agreement (R), Bonn Migratory Convention (B), Eastern Flyway (E)

To request a species list for an area, or search for a species profile, access Wildlife Online at:
https://www.qld.gov.au/environment/plants-animals/species-list/

Refer to **Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals** and **Map 3b - MSES - Species - Koala habitat area (SEQ)** for an overview of the relevant MSES.

MSES - Regulated Vegetation

For further information relating to regional ecosystems in general, go to:
https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/
For a more detailed description of a particular regional ecosystem, access the regional ecosystem search page at:
https://environment.ehp.qld.gov.au/regional-ecosystems/

8a. Regulated Vegetation - Endangered/Of concern in Category B (remnant)

Regional ecosystem	Vegetation management polygon	Vegetation management status
12.3.7/12.9-10.7	O-subdom	rem_oc
12.9-10.7/12.9-10.2	O-dom	rem_oc
12.9-10.7/12.9-10.3	O-dom	rem_oc
12.9-10.7	O-dom	rem_oc

Regional ecosystem	Vegetation management polygon	Vegetation management status
12.3.7/12.3.3	E-subdom	rem_end
12.9-10.2/12.9-10.3	O-subdom	rem_oc
12.8.21	E-dom	rem_end
12.9-10.15	E-dom	rem_end
12.8.21/12.8.9	E-dom	rem_end
11.3.21	E-dom	rem_end
12.9-10.7/12.9-10.15	E-subdom	rem_end
12.9-10.2/12.9-10.7	O-subdom	rem_oc
12.9-10.17a/12.9-10.7	O-subdom	rem_oc
12.9-10.15/12.9-10.7	E-dom	rem_end
12.9-10.2/12.3.3	E-subdom	rem_end
12.8.14a/12.8.24	E-subdom	rem_end
12.9-10.7/12.9-10.2/12.9-10.3	O-dom	rem_oc
12.8.9/12.8.21	E-subdom	rem_end
12.3.3/12.3.3d	E-dom	rem_end
12.9-10.15/12.3.7	E-dom	rem_end
11.8.11	O-dom	rem_oc
12.9-10.7/12.9-10.2/12.9-10.15	E-subdom	rem_end

8b. Regulated Vegetation - Endangered/Of concern in Category C (regrowth)

Regional ecosystem	Vegetation management polygon	Vegetation management status
12.9-10.7	O-dom	hvr_oc
12.3.3/12.3.7	E-dom	hvr_end
12.9-10.2/12.9-10.5a/12.9-10.7	O-subdom	hvr_oc
12.8.14a/12.8.24	E-subdom	hvr_end
12.3.3	E-dom	hvr_end
12.9-10.7/12.9-10.2	O-dom	hvr_oc
12.9-10.7/12.9-10.2/12.9-10.15	E-subdom	hvr_end
12.9-10.2/12.9-10.3	O-subdom	hvr_oc
12.8.21/12.8.9	E-dom	hvr_end
12.3.7/12.3.3	E-subdom	hvr_end
12.9-10.7/12.9-10.15	E-subdom	hvr_end
12.9-10.7/12.9-10.3	O-dom	hvr_oc
12.3.7/12.9-10.7	O-subdom	hvr_oc
12.9-10.7/12.9-10.2/12.9-10.3	O-dom	hvr_oc
12.9-10.15/12.9-10.7	E-dom	hvr_end
12.9-10.15/12.3.7	E-dom	hvr_end
12.9-10.2/12.9-10.3/12.9-10.7	O-subdom	hvr_oc
11.8.11	O-dom	hvr_oc

Regional ecosystem	Vegetation management polygon	Vegetation management status
12.5.6/12.5.6a	E-dom	hvr_end
12.9-10.2/12.9-10.7	O-subdom	hvr_oc

8c. Regulated Vegetation - Category R (GBR riverine regrowth)

Not applicable

8d. Regulated Vegetation - Essential habitat

Values are present

8e. Regulated Vegetation - intersecting a watercourse**

A vegetation management watercourse is mapped as present

8f. Regulated Vegetation - within 100m of a Vegetation Management wetland

Not applicable

Refer to **Map 4 - MSES - Regulated Vegetation** for an overview of the relevant MSES.

MSES - Offsets

9a. Legally secured offset areas - offset register areas

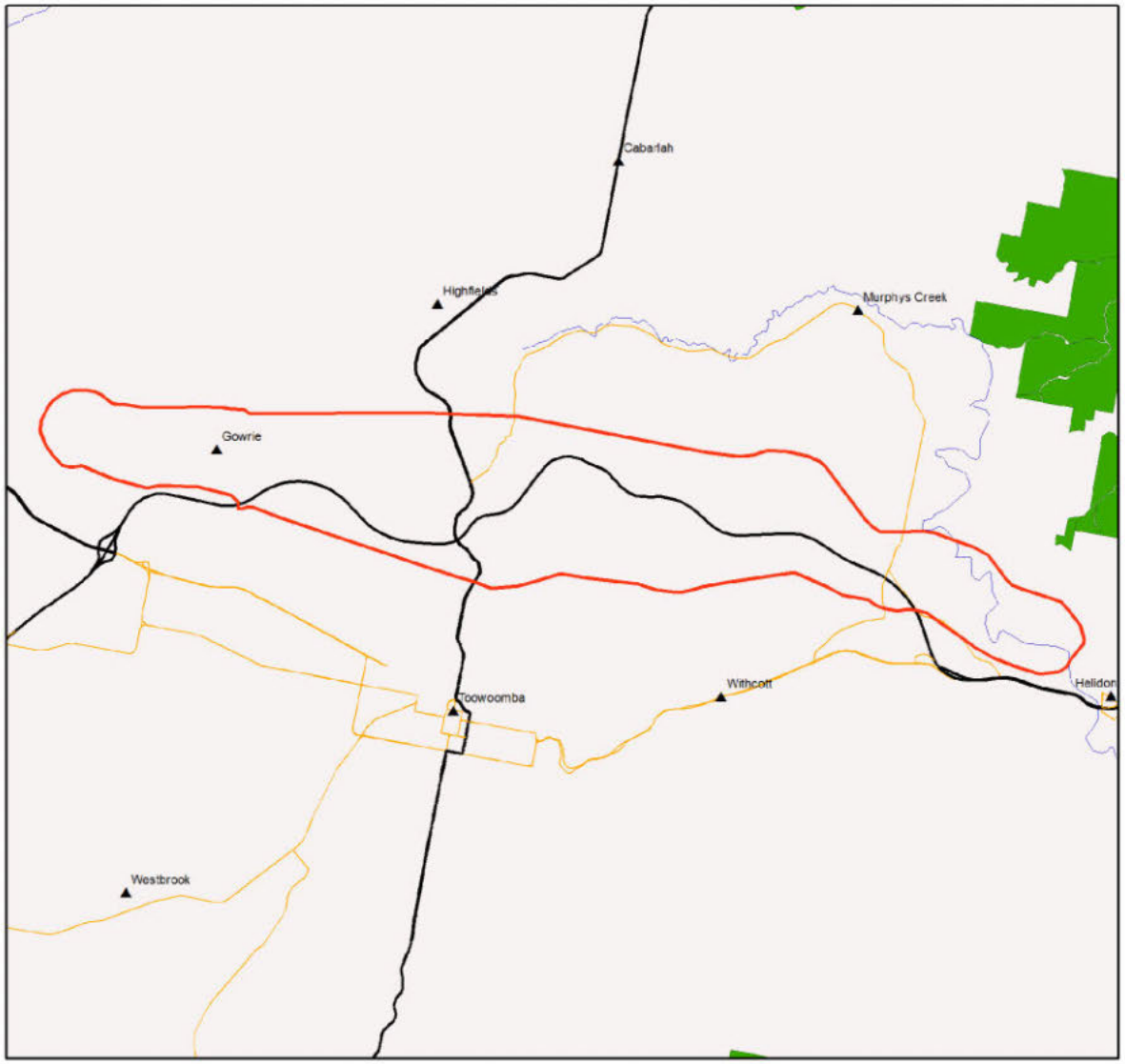
(no results)

9b. Legally secured offset areas - vegetation offsets through a Property Map of Assessable Vegetation

(no results)

Refer to **Map 5 - MSES - Offset Areas** for an overview of the relevant MSES.

Map 1 - MSES - State Conservation Areas

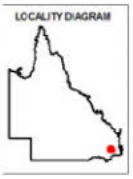


MSES - State Conservation Areas

Area of Interest

- polygon
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Protected area (estates)
- Declared fish habitat area (A and B areas)
- Marine park (highly protected)

LOCALITY DIAGRAM



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0 1500 3000 4500 6000 7500 m

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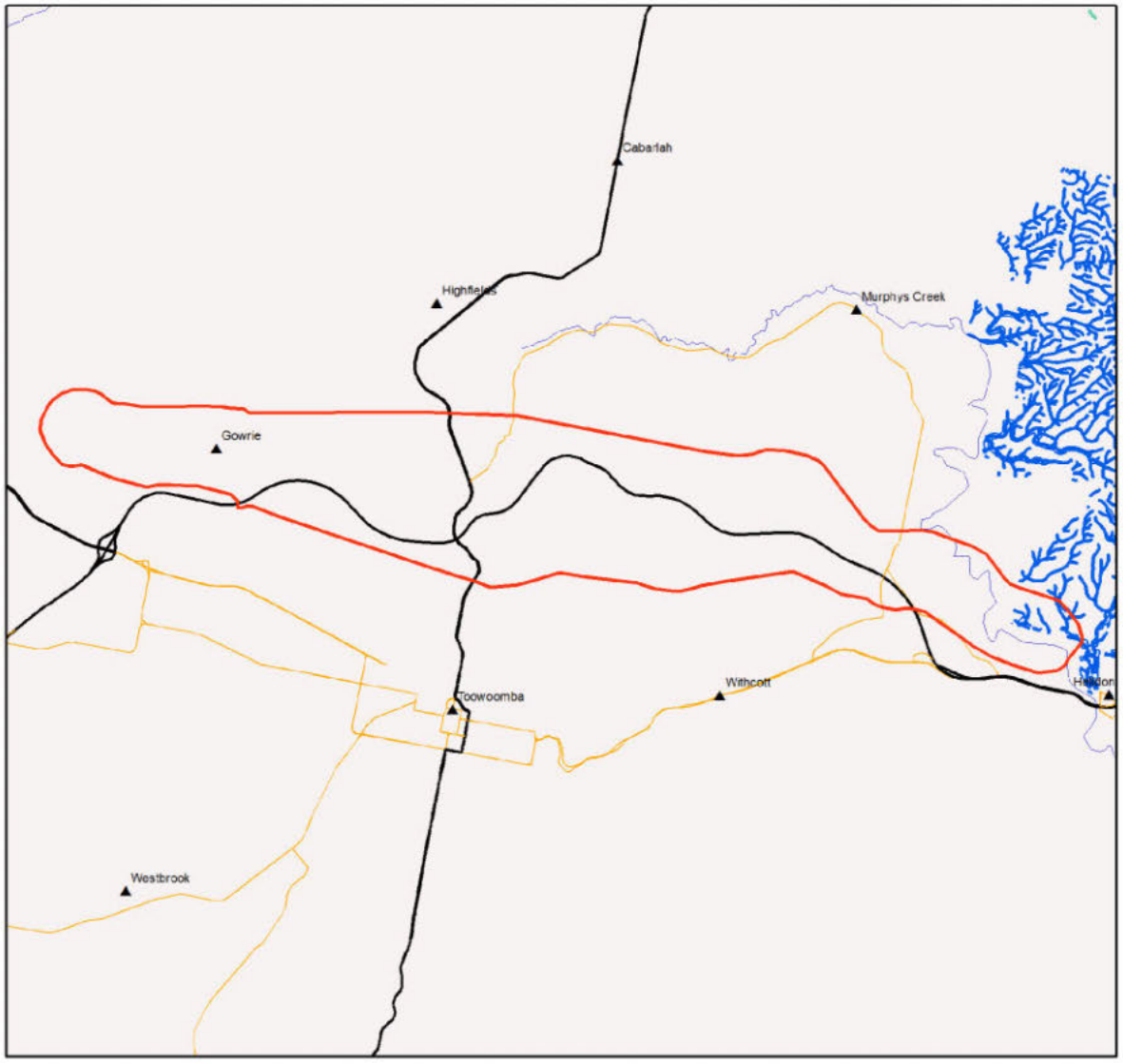
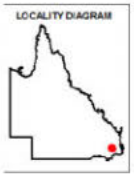
Map 2 - MSES - Wetlands and Waterways



MSES - Wetlands and Waterways

Area of Interest

- polygon
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Declared high ecological value waters (watercourse)
- Strategic environmental area (designated precinct)
- Declared high ecological value waters (wetland)
- High ecological significance wetlands



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0 1500 3000 4500 6000 7500 m

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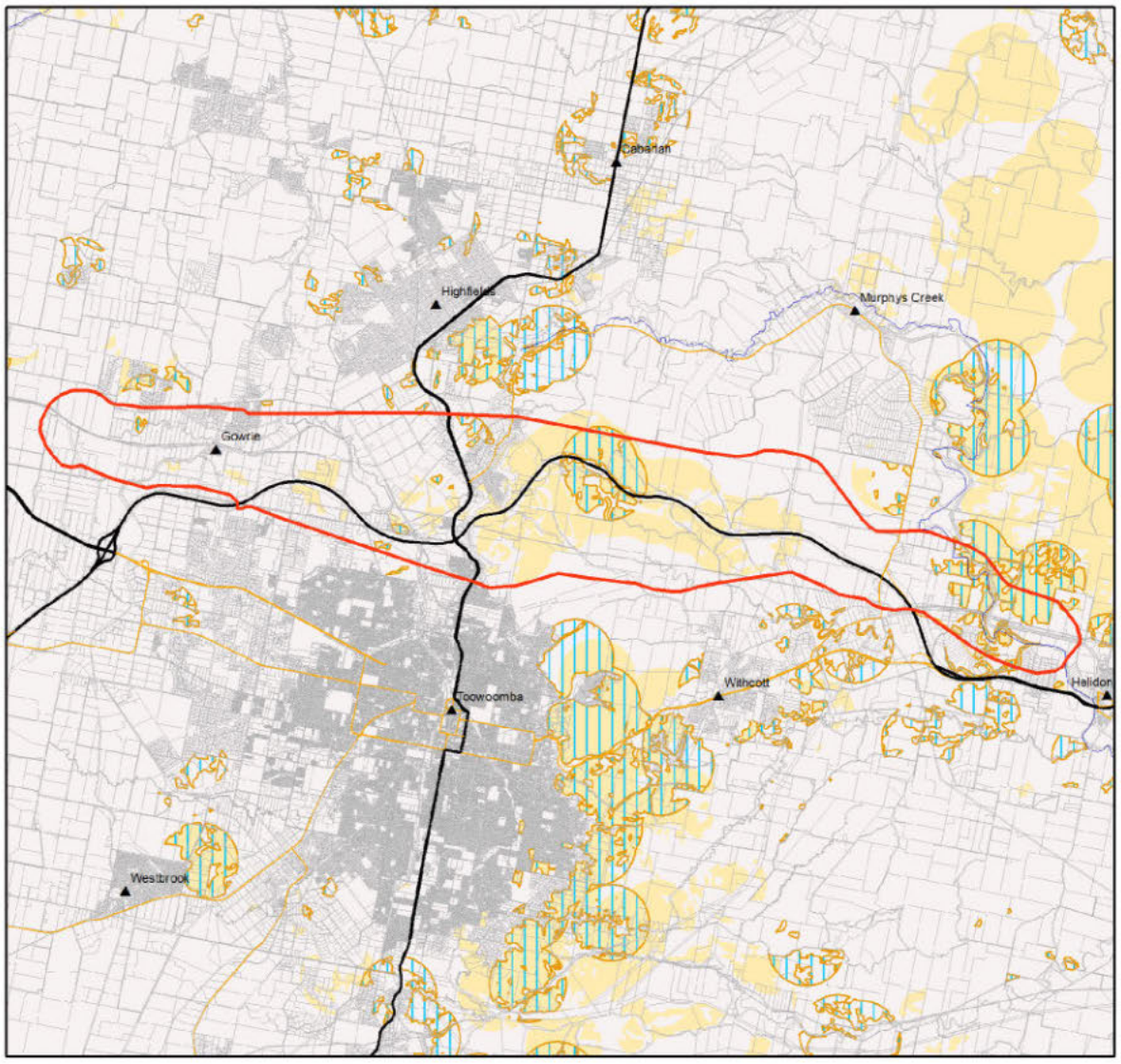
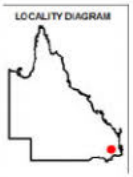
Map 3a - MSES - Species - Threatened (endangered or vulnerable) wildlife and special least concern animals



MSES - Species
Threatened (endangered or vulnerable) wildlife and special least concern animals

Area of Interest

- polygon
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Wildlife habitat (special least concern)
- Wildlife habitat (endangered or vulnerable)



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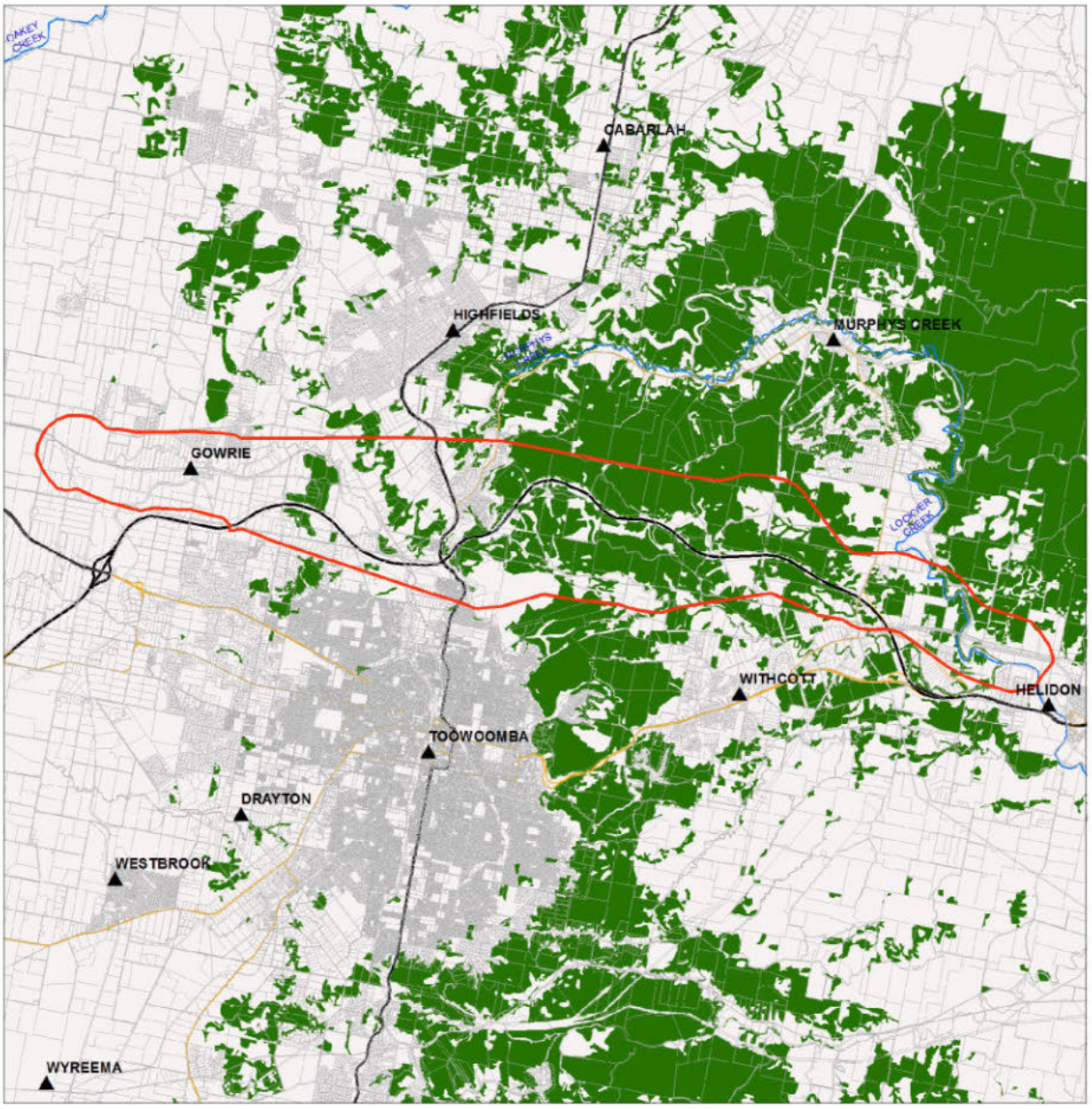
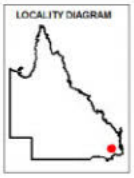
Map 3b - MSES - Species - Koala habitat area (SEQ)



MSES - Species
Koala habitat area (SEQ)

Area of Interest
- polygon
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Koala habitat area (core)
- Koala habitat area (locally refined)

LOCALITY DIAGRAM



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The represented layers for SEQ 'koala habitat area-core' and 'koala habitat area- locally refined' in MSES are sourced directly from the regulatory mapping under the Nature Conservation (Koala) Conservation Plan 2017. Whilst every effort is made to ensure the information remains current, there may be delays between updating versions. Please refer to the original mapping for the most recent version. See https://environment.des.qld.gov.au/wildlife/animals/living-with/koalas/mapping

The koala habitat mapping within South East Queensland uses regional ecosystem linework compiled at a scale varying from 1:25,000 to 1:100,000. Linework should be used as a guide only. The positional accuracy of regional ecosystem data mapped at a scale of 1:100,000 is +/- 100 metres.

0 1,500 3,000 4,500 6,000 7,500 m

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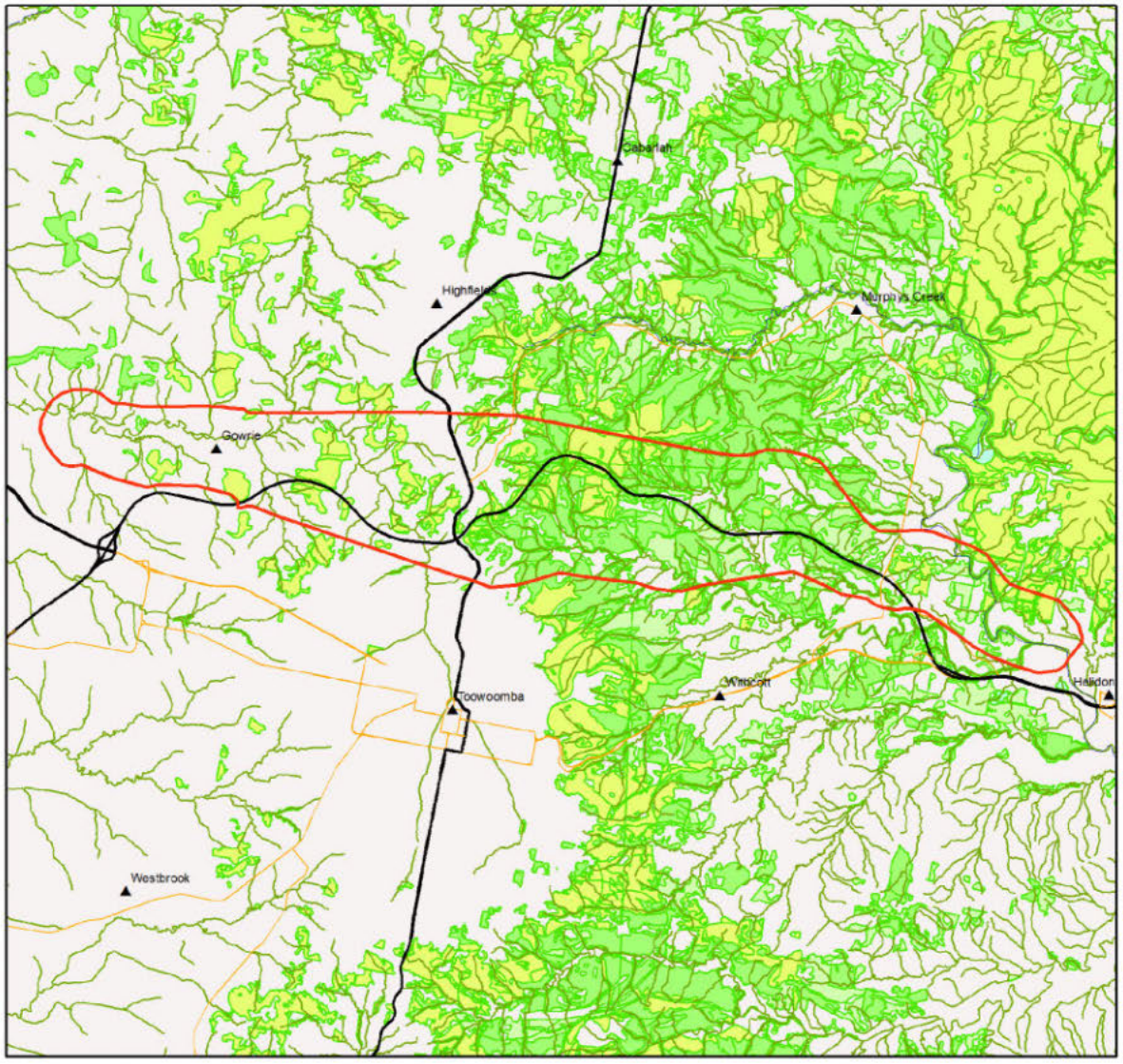
Map 4 - MSES - Regulated Vegetation



MSES - Regulated Vegetation

Area of Interest

- polygon
- Towns
- Freeways/Highways
- Secondary roads
- Major rivers/creeks
- Regulated vegetation (intersecting a watercourse)
- Regulated vegetation (100m from wetland)
- Regulated vegetation (category B - endangered or of concern)
- Regulated vegetation (category C - endangered or of concern)
- Regulated vegetation (category R - GBR riverine)
- Regulated vegetation (essential habitat)

LOCALITY DIAGRAM



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0 1500 3000 4500 6000 7500 m

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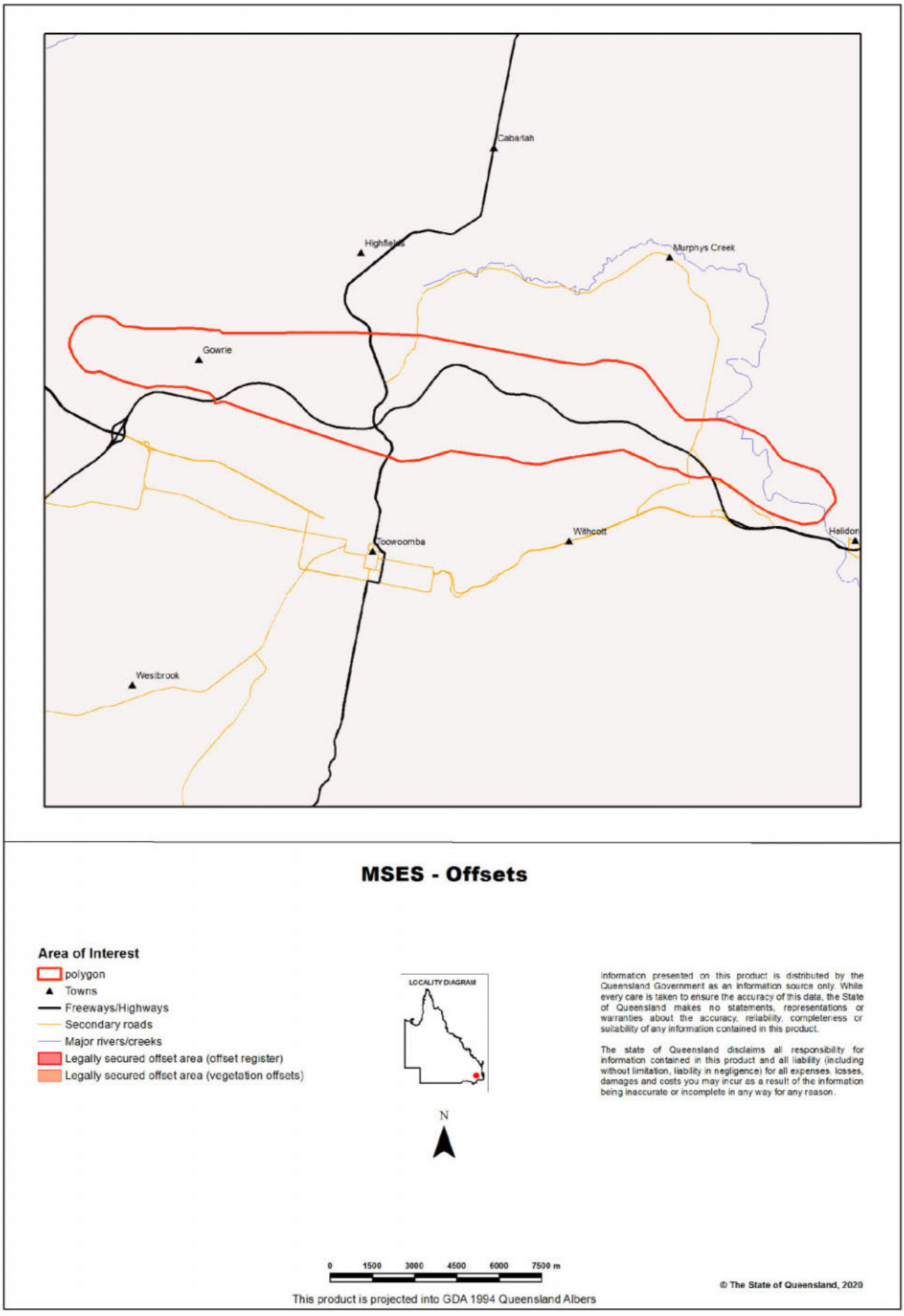
Map 5 - MSES - Offset Areas



Appendices

Appendix 1 - Matters of State Environmental Significance (MSES) methodology

MSES mapping is a regional-scale representation of the definition for MSES under the State Planning Policy (SPP). The compiled MSES mapping product is a guide to assist planning and development assessment decision-making. Its primary purpose is to support implementation of the SPP biodiversity policy. While it supports the SPP, the mapping does not replace the regulatory mapping or environmental values specifically called up under other laws or regulations. Similarly, the SPP biodiversity policy does not override or replace specific requirements of other Acts or regulations.

The Queensland Government's "Method for mapping - matters of state environmental significance for use in land use planning and development assessment" can be downloaded from:

http://www.ehp.qld.gov.au/land/natural-resource/method-mapping-mses.html .

Appendix 2 - Source Data

The datasets listed below are available on request from:

http://qldspatial.information.qld.gov.au/catalogue/custom/index.page

- Matters of State environmental significance

Note: MSES mapping is not based on new or unique data. The primary mapping product draws data from a number of underlying environment databases and geo-referenced information sources. MSES mapping is a versioned product that is updated generally on a twice-yearly basis to incorporate the changes to underlying data sources. Several components of MSES mapping made for the current version may differ from the current underlying data sources. To ensure accuracy, or proper representation of MSES values, it is strongly recommended that users refer to the underlying data sources and review the current definition of MSES in the State Planning Policy, before applying the MSES mapping.

Individual MSES layers can be attributed to the following source data available at QSpatial:

MSES layers	**current QSpatial data (http://qspatial.information.qld.gov.au)**
Protected Areas-Estates and Nature Refuges	- Protected areas of Queensland - Nature Refuges - Queensland
Marine Park-Highly Protected Zones	Moreton Bay marine park zoning 2008
Fish Habitat Areas	Queensland fish habitat areas
Strategic Environmental Areas-designated	Regional Planning Interests Act - Strategic Environmental Areas
HES wetlands	Map of Queensland Wetland Environmental Values
Wetlands in HEV waters	HEV waters: - EPP Water (multiple locations) intent for waters Source Wetlands: - Queensland Wetland Mapping (Current version 4, 2015) Source Watercourses: - Vegetation management watercourse and drainage feature map (1:100000 and 1:250000)
Wildlife habitat (threatened and special least concern)	-WildNet database species records - habitat suitability models (various) - SEQ koala habitat areas under the Koala Conservation Plan 2019
VMA regulated regional ecosystems	Vegetation management regional ecosystem and remnant map
VMA Essential Habitat	Vegetation management - essential habitat map
VMA Wetlands	Vegetation management wetlands map
Legally secured offsets	Vegetation Management Act property maps of assessable vegetation. For offset register data-contact DES
Regulated Vegetation Map	Vegetation management - regulated vegetation management map

Appendix 3 - Acronyms and Abbreviations

AOI	- Area of Interest
DES	- Department of Environment and Science
EP Act	- *Environmental Protection Act 1994*
EPP	- Environmental Protection Policy
GDA94	- Geocentric Datum of Australia 1994
GEM	- General Environmental Matters
GIS	- Geographic Information System
MSES	- Matters of State Environmental Significance
NCA	- *Nature Conservation Act 1992*
RE	- Regional Ecosystem
SPP	- State Planning Policy
VMA	- *Vegetation Management Act 1999*

APPENDIX J

INLAND RAIL

Matters of National Environmental Significance

Appendix E Flora species list

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

IR_1536

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Atlas of Living Australia flora and fauna species records within the Ecology Study area

Accessed: 13th March 2020, 09:29 AEDT

Kingdom	Family	Common Name	Vernacular Name	NCA status	EPBC status
Animalia	Acanthizidae	Gerygone fusca	Western Gerygone	C	
Animalia	Acanthizidae	Gerygone mouki	Brown Gerygone	C	
Animalia	Acanthizidae	Gerygone olivacea	White-Throated Gerygone	C	
Animalia	Acanthizidae	Smicrornis brevirostris	Weebill	C	
Animalia	Accipitridae	Circus approximans	Swamp Harrier	C	
Animalia	Accipitridae	Circus assimilis	Spotted Harrier	C	
Animalia	Accipitridae	Elanus axillaris	Black-Shouldered Kite	C	
Animalia	Accipitridae	Haliastur indus	Brahminy Kite	C	
Animalia	Accipitridae	Haliastur sphenurus	Whistling Kite	C	
Animalia	Accipitridae	Lophoictinia isura	Square-Tailed Kite	C	
Animalia	Accipitridae	Milvus migrans	Black Kite	C	
Animalia	Agamidae	Amphibolurus muricatus	Jacky Lizard	C	
Animalia	Agamidae	Intellagama lesueurii	Water Dragon	C	
Animalia	Agamidae	Pogona barbata	Bearded Dragon	C	
Animalia	Alcedinidae	Ceyx azureus	Azure Kingfisher	C	
Animalia	Anatidae	Biziura lobata	Musk Duck	C	
Animalia	Anatidae	Chenonetta jubata	Australian Wood Duck	C	
Animalia	Anatidae	Malacorhynchus membranaceus	Pink-Eared Duck	C	
Animalia	Anatidae	Stictonetta naevosa	Freckled Duck	C	
Animalia	Anhingidae	Anhinga novaehollandiae	Australasian Darter	C	
Animalia	Anseranatidae	Anseranas semipalmata	Magpie Goose	C	
Animalia	Ardeidae	Ardea alba modesta		C	
Animalia	Ardeidae	Egretta garzetta	Little Egret	C	
Animalia	Ardeidae	Egretta novaehollandiae	White-Faced Heron	C	
Animalia	Ardeidae	Ixobrychus dubius	Australian Little Bittern	C	
Animalia	Ardeidae	Nycticorax caledonicus	Nankeen Night-Heron	C	
Animalia	Artamidae	Cracticus nigrogularis	Pied Butcherbird	C	
Animalia	Artamidae	Cracticus torquatus	Grey Butcherbird	C	
Animalia	Artamidae	Gymnorhina tibicen	Australian Magpie	C	

Kingdom	Family	Common Name	Vernacular Name	NCA status	EPBC status
Animalia	Brachytronidae	Dendroaeschna conspersa			
Animalia	Bufonidae	Rhinella marina	Cane Toad		
Animalia	Cacatuidae	Eolophus roseicapilla	Galah	C	
Animalia	Cacatuidae	Nymphicus hollandicus	Cockatiel	C	
Animalia	Camaenidae	Pallidelix bennetti	Bennett's Woodland Snail		
Animalia	Canidae	Vulpes vulpes	Fox		
Animalia	Carphodactylidae	Underwoodisaurus milii	Thick-Tailed Gecko	C	
Animalia	Charadriidae	Elseyornis melanops	Black-Fronted Dotterel	C	
Animalia	Charadriidae	Erythrogonys cinctus	Red-Kneed Dotterel	C	
Animalia	Climacteridae	Cormobates leucophaea metastasis		C	
Animalia	Coenagrionidae	Xanthagrion erythroneurum			
Animalia	Colubridae	Dendrelaphis punctulatus	Common Tree Snake	C	
Animalia	Columbidae	Chalcophaps indica	Emerald Dove	C	
Animalia	Columbidae	Geopelia humeralis	Bar-Shouldered Dove	C	
Animalia	Columbidae	Geopelia striata	Peaceful Dove	C	
Animalia	Columbidae	Leucosarcia melanoleuca	Wonga Pigeon	C	
Animalia	Columbidae	Macropygia amboinensis		C	
Animalia	Columbidae	Ocyphaps lophotes	Crested Pigeon	C	
Animalia	Coraciidae	Eurystomus orientalis	Eastern Broad-Billed Roller	C	
Animalia	Corcoracidae	Corcorax melanorhamphos	White-Winged Chough	C	
Animalia	Corcoracidae	Struthidea cinerea	Apostlebird	C	
Animalia	Corduliidae	Hemicordulia australiae			
Animalia	Corduliidae	Hemicordulia tau			
Animalia	Corvidae	Corvus orru	Torresian Crow	C	
Animalia	Cuculidae	Chalcites basalis	Horsfield's Bronze-Cuckoo	C	
Animalia	Cuculidae	Chalcites lucidus	Shining Bronze-Cuckoo	C	
Animalia	Cuculidae	Eudynamys orientalis	Pacific Koel	C	
Animalia	Cuculidae	Scythrops novaehollandiae	Channel-Billed Cuckoo	C	
Animalia	Dasyuridae	Planigale maculata	Common Planigale	C	
Animalia	Diplodactylidae	Nebulifera robusta	Robust Velvet Gecko	C	
Animalia	Elapidae	Cacophis squamulosus	Golden-Crowned Snake	C	

Kingdom	Family	Common Name	Vernacular Name	NCA status	EPBC status
Animalia	Elapidae	Demansia psammophis	Yellow-Faced Whip Snake	C	
Animalia	Elapidae	Parasuta dwyeri	Dwyer's Snake	C	
Animalia	Elapidae	Pseudechis porphyriacus	Red-Bellied Black Snake	C	
Animalia	Eleotridae	Hypseleotris galii	Firetail Gudgeon		
Animalia	Estrildidae	Taeniopygia guttata	Zebra Finch	C	
Animalia	Felidae	Felis catus	Cat		
Animalia	Hesperiidae	Neohesperilla xanthomera	Xanthomera Skipper		
Animalia	Hirundinidae	Cheramoeca leucosterna	White-Backed Swallow	C	
Animalia	Hylidae	Litoria fallax	Eastern Dwarf Tree Frog	C	
Animalia	Hylidae	Litoria rubella	Little Red Tree Frog	C	
Animalia	Jacanidae	Irediparra gallinacea	Comb-Crested Jacana	C	
Animalia	Laridae	Hydroprogne caspia	Caspian Tern	SL	
Animalia	Leporidae	Lepus europaeus			
Animalia	Leporidae	Oryctolagus cuniculus	Rabbit		
Animalia	Lestidae	Austrolestes leda			
Animalia	Libellulidae	Orthetrum caledonicum			
Animalia	Limnodynastidae	Limnodynastes salmini	Salmon Striped Frog	C	
Animalia	Limnodynastidae	Platyplectrum ornatum	Ornate Burrowing Frog	C	
Animalia	Lycaenidae	Candalides erinus erinus	Small Dusky Blue		
Animalia	Lycaenidae	Hypochrysops ignitus ignitus	Fiery Jewel		
Animalia	Macropodidae	Macropus giganteus	Eastern Grey Kangaroo	C	
Animalia	Macropodidae	Macropus rufogriseus		C	
Animalia	Macropodidae	Petrogale penicillata	Brush-Tailed Rock-Wallaby	V	V
Animalia	Macropodidae	Wallabia bicolor	Swamp Wallaby	C	
Animalia	Megaluridae	Megalurus timoriensis	Tawny Grassbird	C	
Animalia	Megapodagrionidae	Austroargiolestes icteromelas nigrolabiatus			
Animalia	Megapodiidae	Alectura lathami	Australian Brush-Turkey	C	
Animalia	Meliphagidae	Acanthagenys rufogularis	Spiny-Cheeked Honeyeater	C	
Animalia	Meliphagidae	Acanthorhynchus tenuirostris	Eastern Spinebill	C	
Animalia	Meliphagidae	Caligavis chrysops	Yellow-Faced Honeyeater	C	
Animalia	Meliphagidae	Entomyzon cyanotis	Blue-Faced Honeyeater	C	

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Animalia	Meliphagidae	Gavicalis virescens	Singing Honeyeater	C	
Animalia	Meliphagidae	Grantiella picta	Painted Honeyeater	V	V
Animalia	Meliphagidae	Plectorhyncha lanceolata	Striped Honeyeater	C	
Animalia	Meliphagidae	Ptilotula fusca	Fuscous Honeyeater	C	
Animalia	Meliphagidae	Ptilotula penicillata	White-Plumed Honeyeater	C	
Animalia	Monarchidae	Grallina cyanoleuca	Magpie-Lark	C	
Animalia	Muridae	Mus musculus	House Mouse		
Animalia	Muridae	Pseudomys gracilicaudatus	Eastern Chestnut Mouse	C	
Animalia	Muridae	Rattus rattus	Black Rat		
Animalia	Muridae	Rattus tunneyi	Pale Field-Rat	C	
Animalia	Myobatrachidae	Crinia signifera	Common Froglet	C	
Animalia	Myobatrachidae	Mixophyes fasciolatus	Great Barred Frog	C	
Animalia	Nymphalidae	Danaus plexippus	Monarch		
Animalia	Nymphalidae	Phaedyma shepherdi shepherdi	Common Aeroplane		
Animalia	Oriolidae	Sphecotheres vieilloti	Australasian Figbird	C	
Animalia	Ornithorhynchidae	Ornithorhynchus anatinus	Platypus	SL	
Animalia	Pachycephalidae	Falcunculus frontatus	Crested Shrike-Tit	C	
Animalia	Papilionidae	Graphium choredon	Blue Fanny		
Animalia	Parastacidae	Cherax destructor	Yabby		
Animalia	Peramelidae	Isoodon macrourus	Northern Brown Bandicoot	C	
Animalia	Peramelidae	Perameles nasuta		C	
Animalia	Petauridae	Petaurus breviceps	Sugar Glider	C	
Animalia	Petauridae	Petaurus norfolcensis	Squirrel Glider	C	
Animalia	Phalacrocoracidae	Microcarbo melanoleucos	Little Pied Cormorant	C	
Animalia	Phalangeridae	Trichosurus vulpecula	Common Brushtail Possum	C	
Animalia	Phascolarctidae	Phascolarctos cinereus	Koala	V	V
Animalia	Pieridae	Belenois java teutonia	Caper White		
Animalia	Pieridae	Eurema hecabe	Large Grass-Yellow		
Animalia	Pieridae	Pieris rapae	Cabbage White Butterfly		
Animalia	Podargidae	Podargus strigoides	Tawny Frogmouth	C	
Animalia	Podicipedidae	Podiceps cristatus	Great Crested Grebe	C	
Animalia	Podicipedidae	Poliocephalus poliocephalus	Hoary-Headed Grebe	C	
Animalia	Poeciliidae	Gambusia holbrooki	Eastern Gambusia		

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Animalia	Potoroidae	Aepyprymnus rufescens	Rufous Bettong	C	
Animalia	Pseudocheiridae	Pseudocheirus peregrinus	Common Ringtail Possum	C	
Animalia	Psittacidae	Alisterus scapularis	Australian King-Parrot	C	
Animalia	Psittacidae	Glossopsitta concinna	Musk Lorikeet	C	
Animalia	Psittacidae	Lathamus discolor	Swift Parrot	E	CE
Animalia	Psittacidae	Melopsittacus undulatus	Budgerigar	C	
Animalia	Psittacidae	Parvipsitta pusilla	Little Lorikeet	C	
Animalia	Psittacidae	Trichoglossus chlorolepidotus	Scaly-Breasted Lorikeet	C	
Animalia	Psittacidae	Trichoglossus haematodus moluccanus		C	
Animalia	Pteropodidae	Pteropus alecto	Black Flying-Fox	C	
Animalia	Pteropodidae	Pteropus poliocephalus	Grey-Headed Flying-Fox	C	V
Animalia	Ptilonorhynchidae	Ptilonorhynchus violaceus	Satin Bowerbird	C	
Animalia	Pygopodidae	Delma torquata	Adorned Delma	V	V
Animalia	Pygopodidae	Lialis burtonis	Burton's Snake-Lizard	C	
Animalia	Pythonidae	Morelia spilota	Carpet Python	C	
Animalia	Rallidae	Fulica atra	Eurasian Coot	C	
Animalia	Rallidae	Gallirallus philippensis		C	
Animalia	Recurvirostridae	Himantopus himantopus	Pied Stilt	C	
Animalia	Recurvirostridae	Recurvirostra novaehollandiae	Red-Necked Avocet	C	
Animalia	Rostratulidae	Rostratula australis	Australian Painted Snipe	E	E
Animalia	Scincidae	Anomalopus mackayi	Five-Clawed Worm-Skink	E	V
Animalia	Scincidae	Anomalopus verreauxii	Three-Clawed Worm-Skink	C	
Animalia	Scincidae	Calyptotis scutirostrum	Scute-Snouted Calyptotis	C	
Animalia	Scincidae	Carlia tetradactyla	Southern Rainbow-Skink	C	
Animalia	Scincidae	Concinnia tenuis	Barred-Sided Skink	C	
Animalia	Scincidae	Ctenotus spaldingi	Straight-Browed Ctenotus	C	
Animalia	Scincidae	Eulamprus quoyii	Eastern Water-Skink	C	
Animalia	Scincidae	Lampropholis amicula	Friendly Sunskink	C	
Animalia	Scincidae	Pygmaeascincus timlowi	Dwarf Litter-Skink	C	
Animalia	Scolopacidae	Phalaropus lobatus	Red-Necked Phalarope	SL	
Animalia	Sturnidae	Acridotheres tristis	Common Myna		

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Animalia	Synlestidae	Episynlestes albicauda			
Animalia	Synthemistidae	Eusynthemis nigra xanthosticta			
Animalia	Tachyglossidae	Tachyglossus aculeatus	Short-Beaked Echidna	SL	
Animalia	Theraphosidae	Selenocosmia crassipes		C	
Animalia	Threskiornithidae	Plegadis falcinellus	Glossy Ibis	SL	
Animalia	Threskiornithidae	Threskiornis spinicollis	Straw-Necked Ibis	C	
Animalia	Turdidae	Turdus merula	Blackbird	P	
Animalia	Turnicidae	Turnix pyrrhothorax	Red-Chested Button-Quail	C	
Animalia	Tytonidae	Tyto delicatula		C	
Animalia	Vespertilionidae	Nyctophilus geoffroyi	Lesser Long-Eared Bat	C	
Animalia	Vespertilionidae	Nyctophilus gouldi	Gould's Long-Eared Bat	C	
Animalia	Vespertilionidae	Scoteanax rueppellii	Greater Broad-Nosed Bat	C	
Fungi		Usnea dasaea		C	
Fungi		Usnea scabrida subsp. elegans		C	
Fungi	Agaricaceae	Coprinus comatus		C	
Fungi	Parmeliaceae	Xanthoparmelia pulla		C	
Fungi	Polyporaceae	Pycnoporus coccineus		C	
Fungi	Ramalinaceae	Ramalina celastri subsp. celastri		C	
Fungi	Ramalinaceae	Ramalina inflata subsp. perpusilla		C	
Fungi	Ramalinaceae	Ramalina peruviana		C	
Plantae	Acanthaceae	Brunoniella australis		C	
Plantae	Acanthaceae	Pseuderanthemum variabile		C	
Plantae	Acanthaceae	Ruellia simplex			
Plantae	Adoxaceae	Viburnum odoratissimum var. awabuki			
Plantae	Alliaceae	Nothoscordum borbonicum			
Plantae	Amaranthaceae	Guilleminea densa			
Plantae	Amaranthaceae	Ptilotus macrocephalus		C	
Plantae	Amaryllidaceae	Proiphys cunninghamii		C	
Plantae	Anacardiaceae	Euroschinus falcatus var. falcatus		C	
Plantae	Anacardiaceae	Rhodosphaera rhodanthema		C	

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Plantae	Aphanopetalaceae	Aphanopetalum resinosum		C	
Plantae	Apiaceae	Centella asiatica	Arthritis Herb	C	
Plantae	Apiaceae	Cyclospermum leptophyllum			
Plantae	Apiaceae	Daucus carota	Wild Carrot		
Plantae	Apiaceae	Foeniculum vulgare			
Plantae	Apocynaceae	Alyxia ruscifolia		C	
Plantae	Apocynaceae	Gomphocarpus physocarpus			
Plantae	Apocynaceae	Parsonsia straminea		C	
Plantae	Apocynaceae	Tylophora grandiflora		C	
Plantae	Araceae	Gymnostachys anceps		C	
Plantae	Araceae	Typhonium brownii		C	
Plantae	Araliaceae	Hydrocotyle acutiloba		C	
Plantae	Araliaceae	Polyscias elegans		C	
Plantae	Asparagaceae	Arthropodium milleflorum		C	
Plantae	Asparagaceae	Asparagus plumosus			
Plantae	Asparagaceae	Cordyline petiolaris		C	
Plantae	Asparagaceae	Lomandra longifolia		C	
Plantae	Asparagaceae	Thysanotus tuberosus subsp. tuberosus		C	
Plantae	Asphodelaceae	Bulbine bulbosa	Mountain Swamp Lily	C	
Plantae	Aspleniaceae	Asplenium australasicum		C	
Plantae	Aspleniaceae	Asplenium subglandulosum subsp. subglandulosum		C	
Plantae	Asteraceae	Apowollastonia spilanthoides		C	
Plantae	Asteraceae	Arctotheca calendula			
Plantae	Asteraceae	Baccharis halimifolia	Cotton-Seed Tree		
Plantae	Asteraceae	Brachyscome dentata		C	
Plantae	Asteraceae	Calotis lappulacea		C	
Plantae	Asteraceae	Carthamus lanatus			
Plantae	Asteraceae	Cassinia laevis		C	
Plantae	Asteraceae	Centaurea melitensis			
Plantae	Asteraceae	Centratherum riparium		C	
Plantae	Asteraceae	Cirsium vulgare	Boar Thistle		

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Plantae	Asteraceae	Cyanthillium cinereum		C	
Plantae	Asteraceae	Euchiton japonicus		C	
Plantae	Asteraceae	Glossocardia bidens		C	
Plantae	Asteraceae	Lagenophora gracilis		C	
Plantae	Asteraceae	Lagenophora stipitata		C	
Plantae	Asteraceae	Leiocarpa brevicompta		C	
Plantae	Asteraceae	Olearia elliptica subsp. elliptica		C	
Plantae	Asteraceae	Ozothamnus bidwillii		C	
Plantae	Asteraceae	Picris evae		V	V
Plantae	Asteraceae	Rhaponticum australe		V	V
Plantae	Asteraceae	Rhaponticum australe		V	V
Plantae	Asteraceae	Senecio minimus		C	
Plantae	Asteraceae	Tagetes minuta			
Plantae	Asteraceae	Tanacetum vulgare	Golden Buttons		
Plantae	Asteraceae	Tragopogon porrifolius			
Plantae	Bignoniaceae	Pandorea pandorana		C	
Plantae	Brassicaceae	Capsella bursa-pastoris			
Plantae	Brassicaceae	Hirschfeldia incana			
Plantae	Brassicaceae	Rapistrum rugosum			
Plantae	Cactaceae	Opuntia tomentosa			
Plantae	Campanulaceae	Lobelia purpurascens		C	
Plantae	Campanulaceae	Wahlenbergia gracilis		C	
Plantae	Cannabaceae	Aphananthe philippinensis		C	
Plantae	Capparaceae	Capparis arborea		C	
Plantae	Caryophyllaceae	Petrorhagia nanteuilii			
Plantae	Caryophyllaceae	Stellaria media	Kohukohu		
Plantae	Casuarinaceae	Allocasuarina luehmannii		C	
Plantae	Casuarinaceae	Allocasuarina torulosa		C	
Plantae	Celastraceae	Denhamia bilocularis		C	
Plantae	Celastraceae	Denhamia celastroides		C	
Plantae	Celastraceae	Denhamia pittosporoides subsp. pittosporoides		C	
Plantae	Celastraceae	Stackhousia viminea		C	
Plantae	Chenopodiaceae	Chenopodium album	Fat-Hen		
Plantae	Chenopodiaceae	Dysphania pumilio		C	

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Plantae	Colchicaceae	Iphigenia indica		C	
Plantae	Commelinaceae	Aneilema acuminatum		C	
Plantae	Convolvulaceae	Calystegia marginata		C	
Plantae	Convolvulaceae	Dichondra repens	Creeping Dichondra	C	
Plantae	Crassulaceae	Bryophyllum proliferum			
Plantae	Crassulaceae	Crassula sieberiana		C	
Plantae	Cupressaceae	Callitris glaucophylla	Gurraay	C	
Plantae	Cyatheaceae	Cyathea cooperi	Cicatrice Tree Fern	C	
Plantae	Cyperaceae	Carex declinata		C	
Plantae	Cyperaceae	Cyperus clarus		V	
Plantae	Cyperaceae	Cyperus eragrostis	Puketangata		
Plantae	Cyperaceae	Cyperus flavidus		C	
Plantae	Cyperaceae	Cyperus fulvus		C	
Plantae	Cyperaceae	Cyperus gracilis		C	
Plantae	Cyperaceae	Cyperus mirus		C	
Plantae	Cyperaceae	Cyperus rigidellus		C	
Plantae	Cyperaceae	Fimbristylis dichotoma		C	
Plantae	Cyperaceae	Gahnia aspera		C	
Plantae	Dennstaedtiaceae	Pteridium esculentum	Manehu	C	
Plantae	Ebenaceae	Diospyros geminata		C	
Plantae	Ebenaceae	Diospyros humilis		C	
Plantae	Elaeocarpaceae	Elaeocarpus obovatus		C	
Plantae	Ericaceae	Leucopogon biflorus		C	
Plantae	Ericaceae	Melichrus urceolatus		C	
Plantae	Euphorbiaceae	Bridelia exaltata		C	
Plantae	Euphorbiaceae	Bridelia leichhardtii		C	
Plantae	Euphorbiaceae	Croton phebalioides		C	
Plantae	Euphorbiaceae	Excoecaria dallachyana		C	
Plantae	Euphorbiaceae	Homalanthus populifolius	Bleeding Heart Tree	C	
Plantae	Euphorbiaceae	Mallotus philippensis		C	
Plantae	Euphorbiaceae	Manihot grahamii			
Plantae	Fabaceae	Acacia concurrens		C	
Plantae	Fabaceae	Acacia decora	Dhaniyaa	C	
Plantae	Fabaceae	Acacia falcata		C	
Plantae	Fabaceae	Acacia fasciculifera		C	
Plantae	Fabaceae	Acacia glaucocarpa		C	
Plantae	Fabaceae	Acacia implexa		C	

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Plantae	Fabaceae	Acacia melanoxylon		C	
Plantae	Fabaceae	Acacia podalyriifolia	Mount Morgan Wattle	C	
Plantae	Fabaceae	Acacia salicina	Dhulan	C	
Plantae	Fabaceae	Aotus subglauca var. filiformis		C	
Plantae	Fabaceae	Aotus subglauca var. subglauca		C	
Plantae	Fabaceae	Chorizema parviflorum		C	
Plantae	Fabaceae	Daviesia villifera		C	
Plantae	Fabaceae	Desmodium rhytidophyllum		C	
Plantae	Fabaceae	Desmodium varians		C	
Plantae	Fabaceae	Erythrostemon gilliesii			
Plantae	Fabaceae	Genista monspessulana			
Plantae	Fabaceae	Gleditsia triacanthos			
Plantae	Fabaceae	Glycine microphylla		C	
Plantae	Fabaceae	Glycine tabacina		C	
Plantae	Fabaceae	Glycine tomentella		C	
Plantae	Fabaceae	Gompholobium foliolosum		C	
Plantae	Fabaceae	Hardenbergia violacea	Purple Coral-Pea	C	
Plantae	Fabaceae	Hovea lorata		C	
Plantae	Fabaceae	Hovea planifolia		C	
Plantae	Fabaceae	Hovea planifolia x Hovea ramulosa		C	
Plantae	Fabaceae	Indigofera hirsuta		C	
Plantae	Fabaceae	Lespedeza juncea subsp. sericea		C	
Plantae	Fabaceae	Melilotus albus			
Plantae	Fabaceae	Melilotus indicus			
Plantae	Fabaceae	Sophora fraseri		V	V
Plantae	Fabaceae	Swainsona queenslandica		C	
Plantae	Fabaceae	Swainsona reticulata		C	
Plantae	Fabaceae	Tephrosia rufula		C	
Plantae	Fabaceae	Trifolium campestre var. campestre			
Plantae	Fabaceae	Trifolium repens var. repens			
Plantae	Geraniaceae	Geranium homeanum	Pinakitere	C	

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Plantae	Goodeniaceae	Velleia paradoxa		C	
Plantae	Gyrostemonaceae	Codonocarpus attenuatus		C	
Plantae	Haloragaceae	Haloragis heterophylla		C	
Plantae	Hemerocallidaceae	Dianella brevipedunculata		C	
Plantae	Hypericaceae	Hypericum gramineum		C	
Plantae	Lamiaceae	Ajuga australis		C	
Plantae	Lamiaceae	Clerodendrum floribundum		C	
Plantae	Lamiaceae	Mentha australis		C	
Plantae	Lamiaceae	Mentha satureioides	Buuybuuy	C	
Plantae	Lamiaceae	Salvia verbenaca			
Plantae	Lamiaceae	Teucrium argutum		C	
Plantae	Loranthaceae	Dendrophthoe glabrescens		C	
Plantae	Malvaceae	Brachychiton discolor		C	
Plantae	Malvaceae	Hibiscus tridactylites		C	
Plantae	Malvaceae	Modiola caroliniana			
Plantae	Malvaceae	Pavonia hastata			
Plantae	Malvaceae	Sida rhombifolia			
Plantae	Meliaceae	Melia azedarach	Umbrella Tree	C	
Plantae	Meliaceae	Toona ciliata		C	
Plantae	Meliaceae	Turraea pubescens		C	
Plantae	Menispermaceae	Legnephora moorei		C	
Plantae	Menispermaceae	Tinospora smilacina		C	
Plantae	Moraceae	Ficus henneana		C	
Plantae	Moraceae	Ficus rubiginosa forma glabrescens		C	
Plantae	Moraceae	Ficus superba			
Plantae	Moraceae	Maclura cochinchinensis		C	
Plantae	Moraceae	Streblus brunonianus		C	
Plantae	Myrtaceae	Angophora floribunda		C	
Plantae	Myrtaceae	Angophora leiocarpa		C	
Plantae	Myrtaceae	Corymbia clarksoniana	Gawuwildhaa	C	
Plantae	Myrtaceae	Corymbia intermedia		C	
Plantae	Myrtaceae	Corymbia tessellaris	Gaabiin	C	
Plantae	Myrtaceae	Eucalyptus carnea		C	
Plantae	Myrtaceae	Eucalyptus conica		C	

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Plantae	Myrtaceae	Eucalyptus crebra		C	
Plantae	Myrtaceae	Eucalyptus melliodora	Bibil	C	
Plantae	Myrtaceae	Eucalyptus nobilis		C	
Plantae	Myrtaceae	Eucalyptus tereticornis subsp. basaltica		C	
Plantae	Myrtaceae	Lophostemon confertus		C	
Plantae	Myrtaceae	Lysicarpus angustifolius		C	
Plantae	Myrtaceae	Melaleuca bracteata		C	
Plantae	Myrtaceae	Triplarina bancroftii		C	
Plantae	Oleaceae	Jasminum simplicifolium subsp. australiense		C	
Plantae	Oleaceae	Notelaea microcarpa		C	
Plantae	Onagraceae	Ludwigia peploides subsp. montevidensis		C	
Plantae	Onagraceae	Oenothera affinis			
Plantae	Onagraceae	Oenothera curtiflora			
Plantae	Onagraceae	Oenothera stricta subsp. stricta			
Plantae	Ophioglossaceae	Ophioglossum lusitanicum		C	
Plantae	Orchidaceae	Acianthus fornicatus	Pixie Caps	C	
Plantae	Orchidaceae	Cymbidium canaliculatum	Garrii	C	
Plantae	Orchidaceae	Dendrobium monophyllum		C	
Plantae	Orchidaceae	Dendrobium x delicatum		C	
Plantae	Orchidaceae	Diuris abbreviata		C	
Plantae	Orchidaceae	Diuris sulphurea		C	
Plantae	Orchidaceae	Dockrillia bowmanii		C	
Plantae	Orchidaceae	Dockrillia linguiformis		C	
Plantae	Orchidaceae	Dockrillia teretifolia		C	
Plantae	Orchidaceae	Prasophyllum brevilabre		C	
Plantae	Orchidaceae	Pterostylis acuminata		C	
Plantae	Orchidaceae	Pterostylis curta		C	
Plantae	Orchidaceae	Rhinerrhiza divitiflora		C	
Plantae	Orchidaceae	Sarcochilus ceciliae		C	
Plantae	Orchidaceae	Sarcochilus falcatus		C	

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Plantae	Orchidaceae	Sarcochilus weinthalii		E	V
Plantae	Papaveraceae	Fumaria bastardii			
Plantae	Papaveraceae	Papaver somniferum subsp. setigerum			
Plantae	Papaveraceae	Papaver somniferum subsp. setigerum			
Plantae	Passifloraceae	Passiflora herbertiana subsp. herbertiana		C	
Plantae	Passifloraceae	Passiflora subpeltata			
Plantae	Phyllanthaceae	Breynia oblongifolia		C	
Plantae	Phyllanthaceae	Phyllanthus gunnii		C	
Plantae	Pittosporaceae	Auranticarpa rhombifolia		C	
Plantae	Pittosporaceae	Bursaria incana		C	
Plantae	Pittosporaceae	Bursaria spinosa subsp. spinosa		C	
Plantae	Pittosporaceae	Pittosporum undulatum		C	
Plantae	Plantaginaceae	Plantago debilis		C	
Plantae	Plantaginaceae	Plantago lanceolata	English Plantain		
Plantae	Plantaginaceae	Veronica plebeia		C	
Plantae	Poaceae	Aristida caput-medusae		C	
Plantae	Poaceae	Aristida gracilipes		C	
Plantae	Poaceae	Austrostipa ramosissima		C	
Plantae	Poaceae	Bothriochloa bunyensis		V	V