APPENDIX

I

Terrestrial and Aquatic Ecology

Part 1 of 4

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 I – Terrestrial and Aquatic Technical Report

Australian Rail Track Corporation

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Abbreviations

Abbreviation	Explanation
AoLA	Atlas of Living Australia
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Method
ARTC	Australian Rail Track Corporation Limited
AUSRIVAS	Australian River Assessment System
BAMM	Biodiversity Assessment and Mapping Methodology
BD	biodiversity
Biosecurity Act	*Biosecurity Act 2014* (Qld)
BPA	Biodiversity Planning Assessment
C2K	Calvert to Kagaru
CE	Critically Endangered
CEMP	Construction Environmental Management Plan
Ch	Chainage
cm	centimetres
DAF	Department of Agriculture and Fisheries
DAWE	Department of Agriculture, Water and the Environment
DEHP	Department of Environment and Heritage Protection (former)
DERM	Department of Environment and Resources Management (former)
DES	Department of Environment and Science
DotE	Department of the Environment (former)
DotEE	Department of the Environment and Energy (former)
DNRME	Department of Natural Resources, Mines and Energy
DPI	Department of Primary Industries
DRDMW	Department of Regional Development, Manufacturing and Water
E	Endangered
EIS	Environmental Impact Statement
EP Act	*Environmental Protection Act 1994* (Qld)
EP Reg	*Environmental Protection Regulation 2008* (Qld)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
ERA	Environmentally Relevant Activity
Es	Emergent stratum
ESD	environmentally sustainable development
EVNT	Endangered, Vulnerable and Near-threatened
EX	Extinct
FFJV	Future Freight Joint Venture
FHA	Fish Habitat Area
Fisheries Act	*Fisheries Act 1994* (Qld)
G2H	Gowrie to Helidon
GDE	groundwater dependent ecosystem
GIS	geographic information system
H2C	Helidon to Calvert

Abbreviation	Explanation
ha	hectare
HES	High Ecological Significance
HVR	High Value Regrowth
ID	identification
Inland Rail	Melbourne to Brisbane Inland Rail
kg/m	kilogram/metre
km	kilometre
LC	Least concern
m	metre
M	migratory
MLES	matters of local environmental significance
mm	millimetre
MNES	matters of national environmental significance
MSES	matters of state environmental significance
NC Act	*Nature Conservation Act 1992* (Qld)
NC Reg	*Nature Conservation Regulation*
NRM	Natural Resource Management
NSW	New South Wales
NT	Near-threated
OC	Of concern
Offsets Act	*Environmental Offsets Act 2014 (Qld)*
PAH	polycyclic aromatic hydrocarbons
Planning Act	*Planning Act 2016 (Qld)*
PMST	Protected Matters Search Tool
QLD	Queensland
Qld	Queensland
QR	Queensland Rail
RE	Regional Ecosystem
S	Shrub Stratum
SLC	Special least concern
SPP	State Planning Policy 2017
SRI Guideline (DEHP)	QLD Environmental Offsets Policy Significant Residual Impact Guideline (Nature Conservation Act 1992, Environmental Protection Act 1994, Marine Parks Act 2004) (Department of Environment and Heritage Protection 2014a)
SRI Guideline (DSDIP)	Significant Residual Impact Guideline for matters of State environmental significance and prescribed activities assessable under the Sustainable Planning Act 2009, Queensland Environmental Offsets Policy (Department of State Development, Infrastructure and Planning 2014)
T	Tree (canopy) stratum
TEC	Threatened Ecological Community
The Project	Gowrie to Helidon Project
ToR	Terms of Reference
V	Vulnerable
VM Act	*Vegetation Management Act 1999* (Qld)

Abbreviation	Explanation
Water Act	*Water Act 2000* (Qld)
WIM	Watercourse Identification Mapping
WQO	Water quality objective

Glossary

Term	Explanation
Adverse impact	Adverse impacts are defined as those impacts that result in an unwanted and 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.
Back on Track species prioritisation framework (Qld)	An initiative of the Department of Environment and Science (DES), the Back on Track species prioritisation program ranks species as Critical, High, Medium or Low priority for the State and for the Natural Resource Management (NRM) region (irrespective of their *Nature Conservation Act 1992* (Qld) (NC Act) or *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) classification). There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery. While not legislated, Back on Track provides a useful framework for biodiversity assessment and species prioritisation when determining ecological values. Priority Back on Track species have been identified for each of the 14 NRM regions across QLD. The Gowrie to Helidon Environmental Impact Statement (EIS) disturbance footprint is located in SEQ and Condamine NRMs.
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 QLD's bioregions based on the methodology outlined in the Biodiversity Assessment and Mapping Methodology (BAMM) (QLD Government 2014). The BPAs draw upon the Department of Environment and Heritage protection (DEHP)-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 status	For biodiversity planning purposes the DES classifies a RE as 'Endangered' if: ■ Less than 10% of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss, or ■ 10 to 30% of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss and the remnant vegetation is less than 10,000 ha; or it is a rare Regional Ecosystem subject to a threatening process For biodiversity planning purposes DES classifies a RE as 'Of concern' if: ■ 10 to 30% of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss For biodiversity planning purposes a RE is listed as 'Least concern' at present if: ■ The degradation criteria listed above for 'Endangered' or 'Of concern' REs are not met
Bioregion	A bioregion as defined in An Interim Biographic Regionalisation of Australia (Thackway and Cresswell 1995). The bioregions subject to this report are the SEQ and Brigalow Belt 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.

Term	Explanation
	▪ Categories 3, 4, 5, 6 and 7 relate to restricted matter that is in a person's possession, under their control and is 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.
Conservation significant	A collective term used with reference to species that are listed as 'Critically Endangered', 'Endangered', 'Vulnerable' or 'Near threatened' under the provisions of the NC Act and/or EPBC Act (refer NC Act conservation significance and EPBC Act conservation significance for more details).
Critical habitat	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 listed under the EPBC Act and the NC Act.
Critical priority	Rating associated with the Back on Track species prioritisation framework. Constitutes the highest total score/priority.
Critically Endangered	Designated as 'Critically Endangered' under the EPBC Act or NC 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 that may have insignificant effects but when taken together have a significant effect.
Cumulative impact study area	Extent of the G2H Project as well as all other projects considered as part of the Cumulative impact assessment, up to 50 km beyond the Project disturbance footprint boundary
Direct impacts	Impacts that result from a direct interaction between integral Project activities and the receptor (e.g. land clearing resulting in vegetation and habitat loss)
Ecological community	An assemblage of species occupying a particular area
Ecology study area	The ecology study area adopts the EIS investigation corridor, being an approximate 2 km wide study area, 1 km either side of the proposed rail alignment. It includes the Project disturbance footprint, which encompasses all areas where works are proposed, including both permanent disturbance and temporary construction disturbance works, and land within a 1 km radius either side of the proposed rail alignment. The ecology study area is slightly wider between Project Chainage (Ch) 3.0 km to Ch 20.0 km to accommodate for the options analysis that was undertaken for the 6.24 km tunnel under the Toowoomba Range and the steep terrain east of Toowoomba Range. Refer Figure 1.1. (Ecology study area = 7,827.39 ha)
Environmental impact statement (EIS) Investigation Corridor	This is based on the preferred alignment and approximately 2 km wide study area, 1 km either side of the proposed rail alignment proposed in the EPBC Act referral. It includes the Project disturbance footprint, which encompasses all areas where works are proposed, including both permanent disturbance and temporary construction disturbance works, and land within a 1 km radius either side of the proposed rail alignment. The ecology study area is slightly wider between Project Chainage (Ch) 3.0 km to Ch 20.0 km to accommodate for the options analysis that was undertaken for the 6.24 km tunnel under the Toowoomba Range and the steep terrain east of Toowoomba Range.
Endangered	Designated as 'Endangered' under the EPBC Act, NC Act, *Vegetation Management Act 1999 (Qld)* (VM Act). Refer to definitions of EPBC Act conservation status, NC Act conservation status, VM Act and *Environmental Protection Act 1994 (Qld)* (EP Act) conservation status for meaning of 'Endangered' under each Act
Environmentally Sensitive Area (ESA)	▪ As defined under the Environment Protection and Biodiversity Conservation Regulations 2000, a Category A ESA is any of the following: – National Parks – Conservation Parks – Forest Reserves – Wet Tropics World Heritage Area – Great Barrier Reef Marine Park Area – Marine Parks other than General Use Zones ▪ A Category B ESA includes the following: – World Heritage Areas – QLD Heritage Register Places

Term	Explanation
	– Ramsar Sites – Cultural Heritage Registered Areas and DLAs – Special Forestry Areas – Fish Habitat Areas – Coordinated Conservation Areas – 'Endangered' Regional Ecosystems (remnant and mature regrowth (biodiversity status)) – Marine Parks other than General Use Zones – Marine Plants ■ A Category C ESA includes any of the following: – Essential Habitat – Referable Wetlands – Declared Catchment Areas – Nature Refuges – Resources Reserves – State Forests – Timber Reserves 'Of concern' REs (remnant and mature regrowth (biodiversity status))
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 or, ■ 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', and ■ 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', and ■ It is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria **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 are species of birds (e.g. albatrosses and petrels), mammals (e.g. whales) or reptiles. Listed migratory species are those listed 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) Noting that species listed under the EPBC Act as Critically Endangered, Endangered or Vulnerable have been assessed in EIS Appendix J: Matters of National Environmental Significance
Essential habitat	As defined by DES, Essential habitat, for protected wildlife, is a category A area, a category B area or category C area shown on the regulated vegetation management map— (a) that has at least 3 essential habitat factors for the protected wildlife that must include any essential habitat factors that are stated as mandatory for the protected wildlife in the essential habitat database; or (b) in which the protected wildlife, at any stage of its life cycle, is located.

Term	Explanation
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	According to the Department of Natural Resource Management and Energy (2018), regulated regrowth vegetation includes vegetation that falls into one of the following categories: ■ Vegetation identified on a regulated vegetation map as High Value Regrowth vegetation (Category C; light blue) ■ Vegetation located within 50 m of watercourses in priority reef catchment areas (Category R; yellow) ■ Vegetation that is a 'Least concern', 'Of concern' or 'Endangered' RE High Value Regrowth vegetation is mature native vegetation that has not been cleared in the last 15 years.
Important habitat	Consists of habitat that is: ■ Utilised by a species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or ■ Of critical importance to the species at particular life-cycle stages, and/or ■ Utilised by a species which is at the limit of the species range, and/or ■ Within an area where the species is declining.
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.
Least concern	Designated as 'Least concern' under the VM Act. Refer to definition of VM Act conservation status for meaning of 'Least concern' under the Act
Matters of local environmental significance (MLES)	A Matter of local environmental significance is a matter that is prescribed under a local planning instrument as a prescribed environmental matter. This includes MSES that are not prescribed environmental matters in urban areas (for example, remnant 'Of concern' regional ecosystems) or "Least concern" remnant vegetation.
Matters of national environmental significance (MNES)	The nine matters of national environmental significance 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.
Matters of state environmental significance (MSES)	Matters of state environmental significance includes environmental values protected under various State legislative Acts. These are identified as prescribed environmental matters and are defined under the State Planning Policy (SPP) and Schedule 2 of the QLD Environmental Offsets Regulation 2014.
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	Species listed as Migratory under the EPBC Act and are not listed under the EPBC Act as Critically Endangered, Endangered or Vulnerable. Refer to definitions of EPBC Act conservation status, for meaning of these terms under the EPBC Act

Term	Explanation
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.
NC Act conservation status	Under the NC Act, protected species are assigned a conservation status of Extinct in the wild, 'Critically Endangered', 'Endangered', 'Vulnerable', 'Near threatened', or 'Least concern'. Definitions of these terms under the NC Act are as follows: **Extinct in the wild** ■ There have been thorough searches conducted for the wildlife, and ■ It has not been seen in the wild over a period that is appropriate for the lifecycle or form of the wildlife **'Critically Endangered'** ■ The wildlife has undergone or is suspected to have undergone a very large reduction in numbers; or ■ It is likely that a very large reduction in the wildlife's numbers is imminent; or ■ The wildlife's geographic distribution is precarious for the survival of the wildlife and very restricted; or ■ The estimated total number of mature individuals is very low and it is likely the number will continue to decline at a very high rate, or continue to decline, and its geographic distribution is precarious for the survival of the wildlife; or ■ The estimated total number of mature individuals is extremely low; or ■ The probability of the wildlife's extinction in the wild is at least 50% in the immediate future. **'Endangered'** ■ There have not been thorough searches conducted for the wildlife and the wildlife has not been seen in the wild over a period that is appropriate for the lifecycle or form of the wildlife, or ■ The habitat or distribution of the wildlife has been reduced to an extent that the wildlife may be in danger of extinction, or ■ The population size of the wildlife has declined, or is likely to decline, to an extent that the wildlife may be in danger of extinction, or ■ The survival of the wildlife in the wild is unlikely if a threatening process continues **'Vulnerable'** ■ Its population is decreasing because of threatening processes, or ■ Its population has been seriously depleted, and its protection is not secured, or ■ Its population, while abundant, is at risk because of threatening processes, or ■ Its population is low or localised or depends on limited habitat that is at risk because of threatening processes **'Near threatened'** ■ The population size or distribution of the wildlife is small and may become smaller, or ■ The population size of the wildlife has declined, or is likely to decline, at a rate higher than the usual rate for population changes for the wildlife, or ■ The survival of the wildlife in the wild is affected to an extent that the wildlife is in danger of becoming 'Vulnerable' **'Least concern'** ■ The wildlife is common or abundant and is likely to survive in the wild Native wildlife may be prescribed as 'Least concern' wildlife even if: ■ The wildlife is the subject of a threatening process, or ■ The population size or distribution of the wildlife has declined, or ■ There is insufficient information about the wildlife to conclude whether the wildlife is common or abundant or likely to survive in the wild

Term	Explanation
Near threatened	Designated as 'Near threatened' under the NC Act. Refer to definition of NC Act conservation status for meaning of 'Near threatened' under the NC Act. Capitalisation of the term 'Near threatened' in this report refers to those species listed as such under the NC Act
Negative impact	An impact that is considered to result in an unfavourable or adverse change to the sensitive environmental receptor.
No concern at present	A RE is listed as 'Least concern' under the VM Act if: ■ remnant vegetation is over 30% of its pre-clearing extent across the bioregion, and the remnant area is greater than 10,000ha. In addition to the criteria listed for 'Least concern' regional ecosystems under the VM Act, for biodiversity planning purposes (under the EP Act) a regional ecosystem is listed with a biodiversity status of 'no concern at present' if: the degradation criteria listed above for 'Endangered' or 'Of concern' regional ecosystems are not met.
No habitat present	The presence of habitat to support self-sustaining populations of a species is absent.
Non-remnant vegetation	Vegetation that is not mapped as remnant vegetation by the Department of Resources or DES and/or which fails to meet DESs criteria for remnant vegetation (see 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. Non-remnant vegetation may retain significant biodiversity values (Neldner et al. 2019)
Of concern	Designated as 'Of concern' under the VM Act or '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.
Project disturbance footprint	The Project disturbance footprint (both temporary and permanent) associated with the Project. The Project disturbance footprint is the area subject to direct disturbance.
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 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, 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. 2019)
Sensitive environmental receptor	A sensitive environmental receptor is a feature, area, structure or grouping that may be affected by direct or indirect changes to the environment. For the purposes of this assessment, sensitive environmental receptors are those that constitute MNES or MSES. Note that only MNES that have not been identified as a controlling provision of the project (e.g. migratory species) have been included within this technical document. MNES associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) are addressed in a separate stand-alone MNES technical report.
Significant impact	In accordance with the EPBC Act, a significant impact is 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

Term	Explanation
Special least concern	**Fauna**: Means the following - ■ The Short-beaked echidna (Tachyglossus aculeatus) and Platypus (Ornithorhynchus anatinus) ■ Non-threatened migratory bird species listed under the EPBC Act **Flora**: A category for flora and as prescribed by Schedule 3A of the Nature Conservation (Wildlife Management) Regulations 2006
VM Act conservation status	Under the VM Act, REs may be classified as either 'Endangered', 'Of concern' or 'Least concern'. Definitions of these terms under the Act are provided below **'Endangered'** ■ Less than 10% of pre-clearing extent of remnant vegetation (see following definition) exists in the bioregion, or 10% to 30% of pre-clearing extent remains and the remnant vegetation is less than 10,000 ha **'Of concern'** ■ 10% to 30% of pre-clearing extent of remnant vegetation exists in the bioregion, or more than 30% of pre-clearing extent remains and the remnant vegetation is less than 10,000 ha **'Least concern'** ■ More than 30% of pre-clearing extent of remnant vegetation exists in the bioregion, and it is greater than 10,000 ha In addition, for biodiversity planning purposes DEHP also classifies a RE as No concern at present if the degradation criteria listed above for 'Endangered' or 'Of concern' REs are not met
Vulnerable	Designated as 'Vulnerable' under the EPBC Act and/or NC Act. Refer to definitions of EPBC Act conservation status and NC Act conservation status for meaning of 'Vulnerable' under these Acts
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 QLD 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 QLD 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*

Executive summary

This Terrestrial and aquatic ecology technical report has been prepared to address Sections 11.91 to 11.103 of the *Terms of Reference for an environmental impact statement: Inland Rail – Gowrie to Helidon Project*. Note that a separate "stand-alone" document pertaining to matters of national environmental significance (MNES) that have been identified as controlling provisions (i.e. *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) threatened species and communities), has been provided as EIS Appendix J: Matters of National Environmental Significance to address Sections 11.1 to 11.35 of the Terms of Reference (ToR). Therefore, in order to avoid repetition, the EPBC Act controlling provisions of the Project have been excluded from this document. This technical report has been prepared for the purpose of supporting the Primary approval process for the Project.

The Australian Rail Track Corporation Limited (ARTC) proposes to construct and operate the Gowrie to Helidon (G2H) (the Project) section of the Inland Rail Program, which consists of a single 28 kilometre (km) long dual gauge railway with three crossing loops to accommodate double stack freight trains up to 1,800 metres (m) in length. The Project will also involve the construction of a 6.24 km tunnel through the Toowoomba Range and several bridge and viaduct structures on the eastern side of the range to achieve 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 3,600 m in length.

The Project disturbance footprint is contained within the overall ecology study area (1 km buffer either side of the Project disturbance footprint; encompassing a total area of 7,827.39 ha) and is situated within the South East Queensland (SEQ) and Brigalow Belt 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.

For the purposes of the impact assessment sensitive environmental receptors are those that constitute:

- Non-threatened migratory species under the EPBC Act
- Matters of state environmental significance (MSES) which included environmental values protected under various state legislative Act (e.g. regulated vegetation, threatened species as listed under the provisions of the NC Act only).

The following *Nature Conservation Act 1992* (NC Act) conservation significant and 'Special least concern' flora and fauna species, as well as non-threatened EPBC Act migratory species were observed in the ecology study area during field investigations undertaken for the Project:

- Flora:
  - Finger panic (*Digitaria porrecta*) – 'Near threatened' (NC Act)
  - *Cyperus clarus* – 'Vulnerable' (NC Act)
  - Slender milkvine (*Marsdenia coronata)* – 'Vulnerable' (NC Act)
- Fauna:
  - Satin flycatcher (*Myiagra cyanoleuca*) – 'Special least concern' (NC Act), Migratory (EPBC Act)
  - Spectacled monarch (*Symposiachrus trivirgatus*) – 'Special least concern' (NC Act), Migratory (EPBC Act)
  - Platypus (*Ornithorhynchus anatinus*) – 'Special least concern' (NC Act)
  - Short-beaked echidna (*Tachyglossus aculeatus*) – 'Special least concern' (NC Act).

Based on predictive habitat modelling undertaken for the Project, the ecology study area is considered to provide potential habitat for:

- Nine (non-MNES) NC Act listed conservation significant species (including five flora species, three bird species and one reptile species)
- Two NC Act listed 'Special least concern' mammal species
- Eighteen non-threatened, migratory species listed under the EPBC Act.

In addition, a number of 'Endangered', 'Of concern' and 'Least concern' REs are also present within the ecology study area that are protected under the VM Act, as well as other sensitive environmental receptors, including protected areas, HVR vegetation and bioregional corridors (of local, regional and state significant).

Sensitive environmental receptors (i.e. Matters of National, State and Local environmental significance) 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. An assessment of the significance of impact from the Project for each sensitive environmental receptor was undertaken based on information gathered in the desktop analysis and field assessment.

The construction, commissioning and reinstatement, and operation of the Project has the potential to impact on environmental sensitive environmental receptors via the following mechanisms (predominantly associated with the construction phase):

- 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 by invasion of weed and pest species
- Reduction in the connectivity of biodiversity corridors
- Edge effects
- Habitat fragmentation
- Barrier effects
- Noise, dust, and light impacts
- Increase in litter (waste)
- Aquatic habitat degradation
- Erosion and sedimentation
- Tunnelling activities.

The nature of each unmitigated potential impact was considered in relation to the identified sensitive environmental receptors to derive an initial assessment of impact significance for the Project. This was determined by assigning sensitivity and magnitude ratings which were then allocated a significance rating through the significance assessment matrix. The potential impacts upon the sensitive environmental receptors were then assigned a major, high, moderate, low or negligible rating.

The proposed avoidance and mitigation measures for the Project were identified in order to reduce the significance of the potential impacts upon the sensitive environmental receptors. Following the application of the mitigation hierarchy (i.e. avoid, minimise, mitigate), which included a range of mitigation measures and management plans, the impacts to the identified sensitive environmental receptors were generally reduced.

Following initial impact assessment and the application of mitigation measures, each sensitive environmental receptor was then analysed to determine if the Project would result in significant residual impact in accordance with the relevant Commonwealth or State significant impact guidelines. This process allowed an assessment of the potential offsets required by the Project.

In accordance with the outcomes of the MNES significant impact guideline, there are **no significant impacts expected** for the following non-threatened EPBC Act listed migratory species:

- Common sandpiper (*Actitis hypoleucos*)
- Fork-tailed swift (*Apus pacificus*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Pectoral sandpiper (*Calidris melanotos*)
- Red-necked stint (*Calidris ruficollis*)
- Oriental cuckoo (*Cuculus optatus*)
- Latham's snipe (*Gallinago hardwickii*)
- Caspian tern (*Hydroprogne caspia*)
- Black-faced monarch (*Monarcha melanopsis*)
- Yellow wagtail (*Motacilla flava*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Eastern osprey (*Pandion haliaetus*)
- Glossy ibis (*Plegadis falcinellus*)
- Pacific golden plover (*Pluvialis fulva*)
- Rufous fantail (*Rhipidura rufifrons*)
- Spectacled monarch (*Symposiachrus trivirgatus*)
- Common greenshank (*Tringa nebularia*)
- Marsh sandpiper (*Tringa stagnatilis*).

Assessment of MSES prescribed matters against the significant residual guidelines has been undertaken. Analysis indicates that the **Project is likely/has the potential to result in significant residual impacts to the following sensitive environmental receptors**:

- 'Endangered' REs: 9.8 ha
- 'Of Concern' REs: 89.62 ha
- Remnant vegetation within the defined distance of a watercourse: 4.30 ha
- MSES Wildlife habitat: 105.66 ha
- Essential Habitat (EH): 112.36 ha
- Connectivity areas:
  - Landscape fragmentation and connectivity – 122.87 ha
- Protected wildlife habitat for the following NC Act listed conservation significant flora and fauna species:
  - Glossy Black-cockatoo (*Calyptorhynchus lathami lathami*): 21.58 ha
  - Powerful owl (*Ninox strenua*): 101.10 ha
  - Caustis (*Caustis blakei subsp. macrantha*): 10.41 ha
  - Bailey's Cypress (*Callitris baileyi*): 108.47 ha
  - Slender milk-vine (*Marsdenia coronata*): 51.02 ha
  - Finger Panic grass (*Digitaria porrecta*): 49.47 ha, though this species is near threatened and is not considered to be an MSES.

- Nature Conservation (Koala) Conservation Plan 2017 areas:
  - Koala Habitat Areas (core): 213.73 ha

Potential predicted cumulative impacts within 50 km of the Project were assessed incorporating the Project disturbance footprint. Impacts 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 added to the other similar projects that occur within 50 km of the Project boundary are likely to be higher on the following Sensitive environmental receptors:

- EPBC Act listed, non-threatened migratory species:
  - Black-faced Monarch (*Monarcha melanopsis*): Project impact makes a 14.33 per cent contribution to the clearing of approximately 471.83 ha (sum of cumulative impact) which constitutes 1.77 per cent of the available habitat within the cumulative impact assessment area
- NC Act listed species habitat:
  - Slender milkvine (*Marsdenia coronata*): Project impact makes a 99.88 per cent contribution to the clearing of 51.08 ha (sum of cumulative impact) which constitutes 1.77 per cent of the available habitat within the cumulative impact assessment area
  - Finger panic grass (*Digitaria porrecta*): Project impact makes a 2.76 per cent contribution to the clearing of 1,757.18 ha (sum of cumulative impact) which constitutes 6.48 per cent of the available habitat within the cumulative impact assessment area
  - Platypus (*Ornithorhynchus anatinus*): Project impact makes a 4.81 per cent contribution to the clearing of 972.81ha (sum of cumulative impact) which constitutes 1.52 per cent of the available habitat within the cumulative impact assessment area

Mitigation measures identified as part of the Project commitments are likely to reduce the Project's contribution to cumulative project impacts within the broader region.

The sensitive environmental receptors identified through the EIS will be subject to further investigation and survey during the detailed design phase to more accurately determine the magnitude of the significant residual impacts upon the identified MNES and MSES. 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.

In order to mitigate the residual impacts to the sensitive environmental receptors identified above, environmental offsets will be required. ARTC proposes to provide its offset obligation post EIS, following the detailed design phase. The ARTC Environmental Offset Delivery Strategy – QLD has been provided as Appendix J and documents the approach to be taken in relation to the delivery of Project related offsets.

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 a significant piece of national transport infrastructure which will enhance Australia's existing rail network and serve the interstate freight market. The Inland Rail Program consists of 13 separate sections.

The Australian Rail Track Corporation Limited (ARTC) proposes to construct and operate the Gowrie to Helidon (G2H) (the Project) section of the Inland Rail Program, which consists of a single 28 kilometre (km) long dual gauge railway with three crossing loops to accommodate double stack freight trains up to 1,800 metres (m) in length. The Project will also involve the construction of a 6.24 km undrained tunnel through the Toowoomba Range and several bridge and viaduct structures on the eastern side of the 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 3,600 m in length.

1.2 Scope and purpose

On the 10 February 2017, the Project was referred to the Commonwealth Minister for the Environment and Energy (EPBC 2017/7882). On the 17 March 2017, the Commonwealth Minister for the Environment and Energy declared the Project a 'controlled action' requiring the preparation of an Environmental Impact Statement (EIS), with the controlled action being assessed under the bilateral agreement with the QLD Government. The relevant controlling provision for the Project under the 'controlled action' is: Listed threatened species and communities[1].

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 *State Development and Public Works Organisation Act 1971* (Qld) (SDPWO Act) and *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act) respectively, and for recommendations to be made regarding approvals required by the Project under other legislation.

This report has been prepared in consideration of Sections 11.91 to 11.103 of the *Terms of Reference for an environmental impact statement: Inland Rail - Gowrie to Helidon Project* (ToR) (Department of State Development 2017) issued on the 9 August 2017 by the Coordinator-General (refer Section 1.3).

Matters of national environmental significance (MNES) associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) as identified by the ToR (i.e. Items 11.1 to 11.35) are addressed as a stand-alone document in EIS Appendix J: Matters of National Environmental Significance and as such, are not included within the scope of this technical report in order to avoid duplication. This includes flora and fauna species which are listed under the provisions of the NC Act.

However, MNES that have not been identified as a controlling provision of the Project have been included within this technical document in accordance with item 11.91 of the ToR.

- Migratory species[2] under the EPBC Act which are not listed as Critically endangered, Endangered or Vulnerable under the EPBC Act. Given the location of the Project, marine species are also excluded. All relevant migratory species are also recognised as Special least concern under the NC Act.

[1] The species or community is listed as Critically endangered, Endangered or Vulnerable under the EPBC Act

[2] Migratory species, include birds, reptiles and mammal which are listed under the following
- 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)

For the purposes of the Project and this technical report, the investigations and assessment were focussed on the Project disturbance footprint and the ecology study area presented in Figure 1.1 and Section 1.5.

This technical report outlines the legislative framework and methodology for undertaking the environmental assessment and subsequent assessment of environmental impacts related to the Project. This report describes the terrestrial and aquatic ecological values of the ecology study area, providing a summary of matters of national, state and local significance that have not been identified as controlling provisions of the Project (i.e. EPBC Act listed threatened species and communities), vegetation communities, habitats as well as weed and pest presence.

This information was used to undertake impact assessment in accordance with the:

- Significant Residual Impact Guidelines for matters of state environmental and prescribed activities assessable under the Sustainable Planning Act 2009 (henceforth referred to as SRI Guidelines (DSDIP) Department of State Development, Infrastructure and Planning (DSDIP 2014)
- Significant Residual Impact Guideline (*Nature Conservation Act 1992 Environmental Protection Act 1994 Marine Parks Act 2004*) (DEHP 2014a) (henceforth referred to as SRI Guidelines (DEHP)
- Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (henceforth referred to as the MNES Guidelines) (Department of the Environment (DotE) 2013) for EPBC Act listed migratory species.

Potential impacts to sensitive environmental receptors resulting from construction and operation of the Project were identified, with mitigation measures developed to avoid, minimise and manage environmental impacts resulting from the Project. An assessment of the impacts of the Project following the application of mitigation measures is provided, along with the significance of the anticipated impacts to each sensitive environmental receptor. This impact assessment determined which MNES/MSES (henceforth referred to as sensitive environmental receptors) were likely to be subject to significant residual impacts as a result of the Project.

1.3 Terms of reference

This report addresses the ToR for the Project, as summarised in Table 1.1. Compliance of the EIS against the full ToR is documented in EIS Appendix B: Terms of Reference compliance table.

Matters associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) as identified by the ToR (i.e. Items 11.1 to 11.35) are addressed in EIS Appendix J: Matters of National Environmental Significance and as such are not included in Table 1.1. However, MNES that have not been identified as a controlling provision of the Project (e.g. migratory species) have been included within this technical document in accordance with item 11.91 of the ToR.

Table 1.1 Terms of Reference compliance table relevant to flora and fauna

Flora and fauna/biosecurity Terms of Reference requirement		Report section
Flora and fauna		
Existing environment		
11.91	Identify and describe matters of State environmental significance (MSES), State and regionally significant biodiversity and natural environmental values of the terrestrial and aquatic ecology likely to be impacted by the project which have not been addressed in the section on MNES.	Chapter 11: Flora and Fauna, Sections 11.6, 11.7 and 11.11 Description of environmental values - Section 4

Flora and fauna/biosecurity Terms of Reference requirement		Report section
Impact assessment		
11.92	Describe the likely impacts on the biodiversity and natural environmental values of affected areas arising from the construction and operation of the project. The assessment should include, but not be limited to, the following key elements: a) MSES, matters of local environmental significance (MLES), and designated a State and regional biodiversity values and conservation corridors of conservation significance. Reference should be made to the Biodiversity Planning Assessment and BioCondition assessment tools where appropriate. b) terrestrial and aquatic ecosystems (including groundwater-dependent ecosystems) and their interaction and areas surrounding watercourses and wetlands c) biological diversity including listed flora and fauna species and regional ecosystems, connectivity and essential habitat d) the existing integrity of ecological processes, and habitats of threatened, near-threatened or special least-concern species e) the integrity of landscapes and places, including wilderness and similar natural places f) actions of the project that may require an authority under the Nature Conservation Act 1992 and Water Act (for example, riverine protection permits) and/or could be assessable development for the purposes of the VMA, Fisheries Act 1994 and PA g) any exposure to contaminants or the bio-accumulation of contaminants h) impacts on native fauna due to proximity to the site and site impacts (e.g. lighting, noise, waste and fencing) i) impacts to movement of native fauna due to the barrier effect of linear infrastructure j) impacts on vegetation category areas identified on the regulated vegetation management maps under Queensland's vegetation management framework.	Chapter 11: Flora and fauna, Sections 11.7, 11.9 and 11.11 Description of potential impacts - Section 5.1 Significant impact assessment - Section 5.3
Mitigation measures		
11.93	Describe any proposed measures to avoid, minimise or mitigate potential impacts on natural values, and enhance these values. Assess how the nominated quantitative indicators and standards may be achieved for nature conservation management. In particular, address measures to protect or preserve any threatened or near-threatened species.	Chapter 11: Flora and fauna, Sections 11.8.1 and 11.8.2 Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2
11.94	Assess the need for buffer zones and the retention, rehabilitation planting or construction of movement corridors across the railway and propose measures that would avoid the need for waterway barriers or propose measures to mitigate the impacts of their construction and operation.	Chapter 11: Flora and fauna, Section 11.8.2 Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2
11.95	Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.	Chapter 11: Flora and fauna, Section 11.8.3 Proposed mitigation measures - Section 5.2.3
11.96	Where a significant residual impact will occur on a prescribed environmental matter as outlined in the Environmental Offsets Regulation 2014, the offset proposal(s) must be consistent with the requirements of Queensland's *Environmental Offsets Act 2014* and the latest version of the Queensland Environmental Offsets Policy.	Chapter 11: Flora and fauna, Section 11.12 Biodiversity offsets - Section 5.4 Appendix J
11.97	Assess the need and suitability and provide objective commitments to the provision of fauna passage between habitat fragmented by the rail corridor, of suitable design and location for affected species and their habitat.	Chapter 11: Flora and fauna, Sections 11.8 Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2

Flora and fauna/biosecurity Terms of Reference requirement		Report section
11.98	Demonstrate that actions of the project avoid and minimise impacts of clearing of vegetation regulated through the VMA/PA and how any clearing maintains connectivity of the remaining mapped category B area in the landscape. Provide details on the exemptions/assessment pathway for any clearing of vegetation regulated through the VMA/PA.	Chapter 11: Flora and fauna, Sections 11.4, 11.8.1 and 11.8.2 Legislative, policy standards and guidelines - Section 2 Design considerations - Section 5.2.1 Proposed mitigation measures - Section 5.2.2
Biosecurity		
Existing environment		
11.99	Provide information on the current distribution of animal pests and weeds on the preferred alignment.	Chapter 11: Flora and fauna, Section 11.6.2.5, 11.6.3.2 and 11.6.6 Weed species - Section 4.3.1.4 Invasive animals - Section 4.3.2.3
11.100	Surveys of animal pests and weeds should be undertaken in those areas identified during the desktop assessment as containing listed flora, fauna or ecological communities of national or state environmental significance (MNES or MSES as defined by the EPBC and NC Acts respectively).	
Impact assessment		
11.101	Describe the impact the project's construction and operation will have on the spread of pest animals and weed species along the preferred alignment and into adjoining properties.	Chapter 11: Flora and fauna, Section 11.7.4 Displacement of flora and fauna species by invasion of weed and pest species - Section 5.1.2.4
Mitigation measures		
11.102	Propose detailed measures to control and limit the spread of pests and weeds on the preferred alignment and adjacent areas and any relevant local government area Biosecurity Plans. This includes restricted matters listed in the *Biosecurity Act 2014* and Biosecurity Regulation 2016 and designated pests under the Public Health Act 2005.	Chapter 11: Flora and fauna, Section 11.8.2 Proposed mitigation measures - Section 5.2.2
11.103	All proposed measures must be in accordance with any relevant biosecurity surveillance or prevention program authorised under the *Biosecurity Act 2014* and any requirements of the VMA/PA. Mitigation measures should be developed in consultation with relevant agencies and local government (e.g. baiting programs).	

1.4 Project location

The Project is located within the Toowoomba and Lockyer Valley Local Government Areas (LGAs) in South East Queensland (SEQ). The location of the Project and its regional context is shown in Figure 1.1.

The Project alignment is generally consistent with that of the Gowrie to Grandchester future State transport corridor protected under the *Transport Planning and Coordination Act 1994* (Qld) (TPC Act). The Project connects the adjacent Inland Rail projects of New South Wales (NSW)/QLD Border to Gowrie (B2G) to the west and Helidon to Calvert (H2C) to the east. B2G and H2C are coordinated projects, currently being assessed by the Coordinator-General under the SDPWO Act.

The Project will be co-located with existing rail infrastructure within the rail corridor of the QR West Moreton System for approximately 5.6 km and providing new railway infrastructure within approximately 22.4 km of new (greenfield) rail corridor.

The Project alignment begins at Charlton and follows the existing West Moreton System rail corridor (southern side) for approximately 4.8 km eastwards through Gowrie. The Project deviates from the existing rail corridor to the south-east, before passing into the proposed western tunnel portal within the vicinity of the Boundary Street and the Toowoomba Bypass interchange at Gowrie Junction.

The alignment then continues with a 6.24 km tunnel under the Toowoomba Range, passing under the localities of Cranley, Mount Kynoch and Ballard (including under the Toowoomba Bypass) and emerging on the eastern side of the Great Dividing Range at the eastern tunnel portal, within the vicinity of Mt Kynoch. The eastern tunnel portal is in a rural area predominantly consisting of undisturbed natural vegetation. At each of the tunnel portals, ventilation and other tunnel infrastructure are proposed, along with an intermediate ventilation shaft and supporting infrastructure at Cranley.

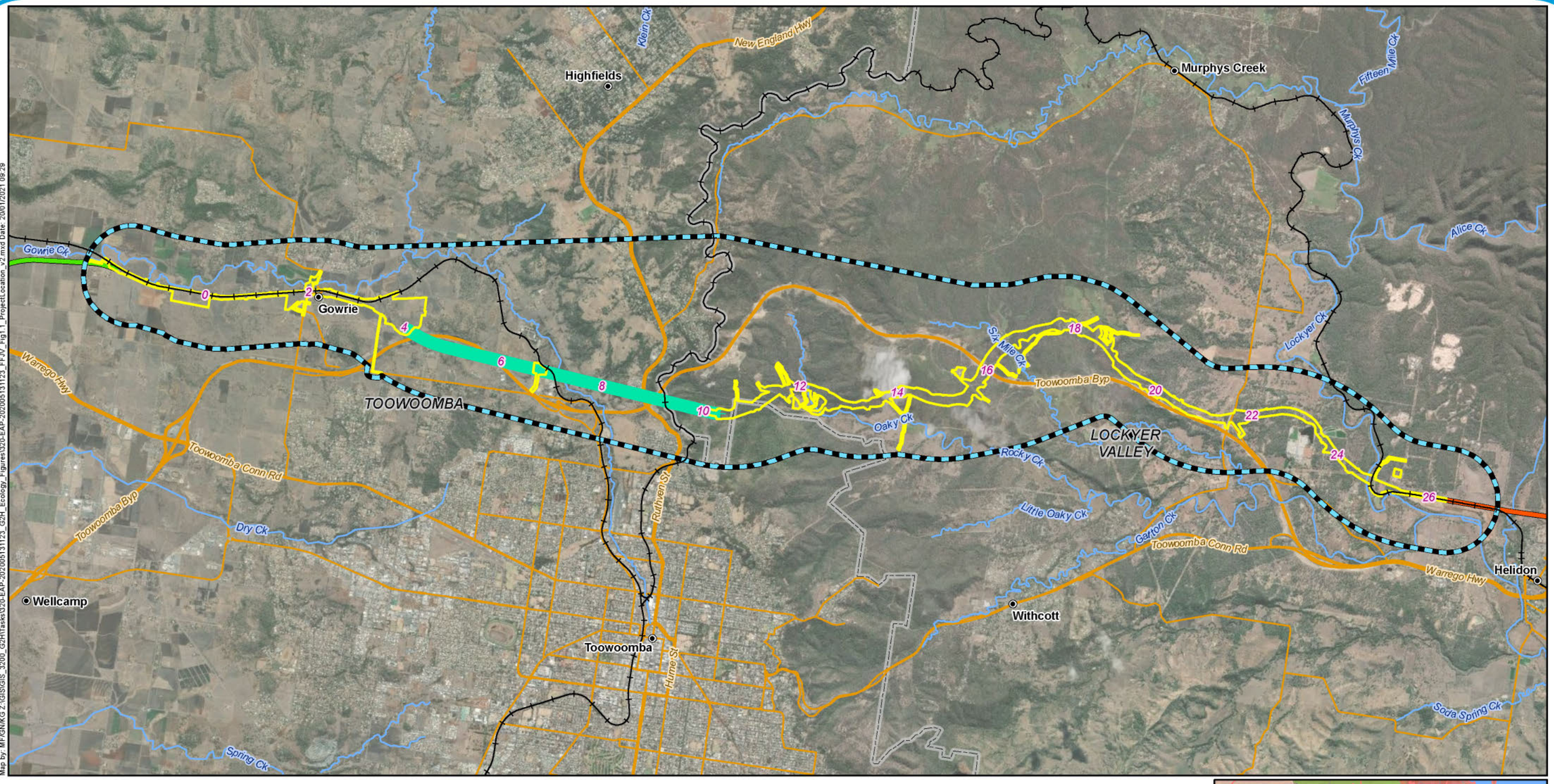
The Project then crosses through the northern edge of an area of Commonwealth land, previously utilised by the Department of Defence. Continuing east, the alignment passes on the northern side of Withcott and traverses areas of native vegetation and grazing properties, with proposed crossings over the valleys of Rocky Creek, Six Mile Creek and over the Toowoomba Bypass.

The Project alignment loops around Wards Hill in Postmans Ridge, and continues southeast parallel to the Toowoomba Bypass across Murphys Creek Road and south of Squires Road, Lockyer.

The alignment then intersects the two water storage dams associated with Withcott Seedlings, passing through rural land to the north of Ashlands Drive, Helidon Spa prior to crossing Lockyer Creek, and the existing West Moreton System rail corridor (Main Line) before tying into the northern side of the existing rail corridor for 800 m to north-west of Helidon.

The intended land use for the Project is rail and associated infrastructure, including road realignments, grade separations and ancillary infrastructure.

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



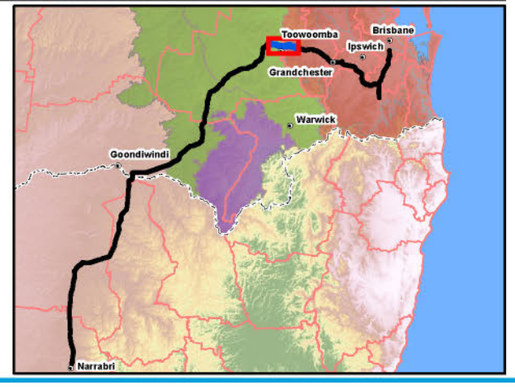
Map by: MFGN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513112\3_G2H_Ecology_Figures\320-EAP-20200513112\3_FFJV_Fig1.1_ProjectLocation_v2.mxd Date: 20/01/2021 09:29

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)
- Ecology 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: 20/01/2021 Version: 2
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 1.1: Location of Project and regional extent and ecology study area

1.5 Ecology study area

The ecology study area is an approximately 1 km buffer around the proposed rail alignment, extending further out where additional alignment options may have been considered. That is the ecology study area is slightly wider between Chainage (Ch) 3.0 km to Chainage 20.0 km to accommodate for the options analysis that was undertaken for the 6.24 km tunnel under the Toowoomba Range and the steep terrain east of Toowoomba Range.

It includes the Project disturbance footprint, which encompasses all areas where works are proposed, including both permanent disturbance and temporary construction disturbance works.

The ecology study area was used to identify sensitive environmental receptors (excluding the MNES controlling provisions) that are located in proximity to the Project and therefore relevant to the assessment of potential impacts.

For the estimation of direct impacts, it has been assumed that the entire Project disturbance footprint will be cleared. Noting that the Project disturbance footprint does not include the surface area associated with the Toowoomba Range tunnel (i.e. approx. Ch 4.0 km to Ch 10.0 km), with the exception of surfaces works at Cranley as no surface disturbance is predicted (refer Figure 1.1). However, indirect impacts on ecological values above the tunnel have been considered where relevant.

The identified Project disturbance footprint is defined as the area subject to direct disturbance (both temporary during construction and permanent during operations) associated with the Project, including the proposed rail alignment, laydown areas and stockpile locations. This area has been used to calculate the clearing extents for the various sensitive environmental receptors relevant to the Project.

1.6 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.

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

Aspect	Description
Crossing loops and turnouts	■ Crossing loops are places 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
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 level crossings
Environmental treatments	■ Potential noise barriers, fauna crossing structures, instream structures and fish passage design, fauna exclusion fencing, and rehabilitation and landscape treatments

Aspect	Description
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 2026, with operations commencing int 2027.

1.6.1 Tunnel infrastructure

The Project includes a 6.24 km undrained tunnel through the Toowoomba Range section of the GDR to facilitate the required gradients for the Project. The tunnel will enter the western aspect of Toowoomba Range via a portal at Chainage (Ch) 4.10 km and exit the eastern aspect of the Toowoomba Range via a portal at approximately Ch 10.30 km.

The Project proposes a 6.24 km tunnel through the Toowoomba Range. The tunnel services facilities are primarily at the western portal and include the tunnel control centre, intake substation, fire water tanks, fire pumps and emergency services staging area. Each tunnel portal will require a substation building for power supply and distribution to electrical equipment. Due to the length of the tunnel and limitations of cable voltage drop, it is envisaged that there would also be two in-tunnel substations to supply lighting, power and communications equipment.

The water collected inside the tunnel during operational Project activities (groundwater, storm water carry-in, wash-down, firefighting etc.) will be collected through a common tunnel drain and stored in a sump at the eastern tunnel portal (Ch 10.34 km). This water will likely (depending on quality of groundwater inflow and relevant WQO) be processed through a water treatment plant (WTP) including hydrocarbon and first flush separation. The water will be discharged, in accordance with relevant approval conditions and WQO, to the surrounding receiving environment (tributaries of Oaky Creek).

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.

1.6.2 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, and to maintain the constant 22 km sustained grade of 1.55 per cent from Helidon to the east of the tunnel a series, totally approximately 6.7 km in length and u to 50 m high are proposed.

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 permanent footprint.

New rail bridges are proposed to cross watercourses or roads, or a combination of both, and are summarised in Table 1.3.

Table 1.3 Summary of rail bridges and viaducts

Chainage (Ch)	Bridge name	Type	Crossing type	Length (m)
Ch 3.40 km	UT1 Gowrie Creek Rail Bridge	Rail bridge	Watercourse	56
Ch 11.63 km	Oaky Creek Viaduct	Rail viaduct	Terrain, road and watercourse	736
Ch 12.83 km	Withcott Viaduct 1	Rail viaduct	Waterway	261
Ch 13.64 km	Withcott Viaduct 2	Rail viaduct	Terrain and waterway	322
Ch 14.12 km	Withcott Viaduct 3	Rail viaduct	Terrain and waterway	174
Ch 15.15 km	Withcott Viaduct 4	Rail viaduct	Waterway	145
Ch 15.89 km	Toowoomba Bypass and Six Mile Creek Viaduct	Rail viaduct	Terrain, road and watercourse	966
Ch 18.44 km	Postmans Ridge Viaduct	Rail viaduct	Terrain, road and watercourse	644
Ch 20.98 km	Murphys Creek Road Viaduct	Rail viaduct	Terrain, road and watercourse	690
Ch 21.84 km	Withcott Seedlings Viaduct	Rail viaduct	Terrain and watercourse	1,794
Ch 24.45 km	Lockyer Creek Viaduct	Rail viaduct	Road, rail and watercourse	506
Total				6,294

1.6.3 Drainage infrastructure

Existing drainage paths will be maintained where possible; however, diversion of existing drainage paths is typically required where a rail cutting intersects an existing drainage path as the rail level is lower than the existing ground level and a cross-drainage structure cannot be installed. In these locations, the existing drainage path will be intersected upstream of the cutting and diverted to the nearest cross drainage structure location.

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. Bridges are proposed at all major waterway crossings to avoid disturbance to the existing riverine system.

Currently, 23 new reinforced pipe culverts (RCP) and 11 reinforced concrete box culverts (RCBC) (associated with the rail alignment) are proposed to be built along the Project alignment. (refer EIS Appendix C: Design Drawings and EIS Chapter 13: Surface water and hydrology). Where the Project is co-located within 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 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 location of the new culverts has been selected to maintain the existing flow paths and minimise the potential impacts to the local hydrology (e.g. depth, velocity and period of inundation) upstream and downstream of the culverts (refer Appendix M: Hydrology and Flooding). The cross-drainage structures have been designed to meet the design criteria of a 1% Annual Exceedance Probability (AEP) event.

Trapezoidal drains are the preferred shape and are adopted for the longitudinal drainage. The water quality study area is undulating for most areas along the alignment. The proposed drains are to be rock lined in steep areas and grass lined with velocity stops as necessary in the flat areas. The drainage features at cuttings have been designed in accordance with relevant industry standards. Existing drainage paths above cuttings have been diverted to the nearest cross drainage structure through a catch drain where possible to minimise flow into cutting and subsequent size of cutting drainage. Drainage channels are to be constructed along the cutting benches, which connect to batter chutes, which flow to the base of the cutting. A larger cutting (cess) drain is provided in the base of each cut adjacent to the rail embankment.

Culverts associated with the proposal will be a mix of reinforced concrete pipe culverts and reinforced concrete box culverts. Scour protection measures will generally be installed around culvert entrances and exits, on disturbed stream banks, and around waterfront land 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.

1.6.4 Watercourse diversions

To facilitate the Project the current design includes the following six alterations to existing unmapped watercourses. The works are illustrated in the EIS Appendix C: Design Drawings.

The western tunnel portal area (Ch 4.10 km) overlays two unmapped watercourses which travel from the west to the east, draining to Gowrie Creek (refer Section 4.2.5). One waterway is identified as an orange waterway under the Queensland Waterways for Waterway Barrier Works spatial data layer (refer Section 4.2.7).

Two trapezoidal diversion drains are proposed, one on the south (125 m long) and one on the north (600 m long). Based on aerial imagery these features are likely to be drainage features under the Water Act, and as such the works are unlikely to constitute a diversion under the Water Act. It should be noted that these watercourses have been impacted by the Toowoomba Bypass directly upstream of the western tunnel portal.

From Ch 17.25 km to Ch 17.44 km, the rail embankment will be placed over an existing flow path and a diversion of the flow path will be required. This flow path is a drainage feature under the Water Act (refer Section 4.2.5). The waterway is not mapped under the Queensland Waterways for Waterway Barrier Works spatial data layer.

The diversions are currently mapped within the design and will require further consultation with the Department of Regional Development, Manufacturing and Water (DRDMW), noting that ARTC has sought advice from the Department in October 2020 on the status of the watercourses intersected by the Project under the Water Act. The watercourse mapping in part has been changed in response to this request (refer Section 4.2.5).

Where the watercourse is deemed to be a defined watercourse under the Water Act, a development permit for operational works under the *Planning Act 2016* (Qld) (Planning Act) is required to authorise the diversion work, together with a Water Licence under the Water Act as evidence of entitlement to the resource may be required. If the watercourses are determined to be drainage features under the Water Act, approval to interfere with overland flow may be required.

An on ground assessment will be undertaken for waterways under the Fisheries Act but are not displayed on the spatial data layer Queensland waterways for waterway barrier works. The on-ground assessment will be required to determine if they are waterways. Once the assessment is completed consultation with DAF is required to determine the classification of the unmapped waterway(s) and to determine if the proposed works constitute waterway barrier works.

1.6.5 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.

1.6.6 Fauna fencing

Fauna fencing is constructed in association with fauna crossings to facilitate safe and effective movement of fauna to maintain existing movement corridors and animal behaviours within the vicinity of infrastructure where it is deemed that there is a risk of population fragmentation. Fencing and tie-ins with fauna crossings are designed to deter or effectively prevent animals entering the operating rail environment, and is an important aspect aimed at guiding animals towards the preferred fauna-crossing structure or passage. The elevation of fencing to fauna exclusion fencing is proposed where the alignment is considered likely to represent a moderate to high risk of fauna entering the rail alignment and become trapped within the active track area. A 3 m buffer clear of vegetation on the habitat side of the fauna exclusion fence is required to ensure that species cannot use vegetation to climb onto the exclusion fencing. Vegetation within the alignment will also be removed in these areas identified as moderate to high risk to ensure that fauna is not encouraged into the active track area.

The fauna corridor fencing strategy seeks to focus on areas of greenfield development where existing fauna movement may be impacted by the Project. All proposed fauna crossings are within areas of greenfield development for the Project. Three options for fauna fencing are:

- General fauna exclusion fencing where relevant
- Koala fencing only where koalas are considered likely to occur following completion of fauna surveys
- Barbed-wire fencing where relevant and consistent with existing landscape features of alignment.

1.6.7 Fish passage

Fish passage is an essential requirement for the survival and productivity of many species of QLD fish. Due to the construction of instream structures (such as dams and culverts) on waterways, the loss of access to habitat has caused the decline in distribution of native fish populations.

Schedule 1 of the *Fisheries Act 1994* (Qld) (Fisheries Act) defines waterway barrier works as a dam, weir, or other barrier across a waterway if the barrier limits fish stock access and movement along the waterway. Operational work that is the construction constructing or raising of waterway barrier works can either be accepted development or assessable development under the Planning Act.

Accepted development must comply with all of the relevant requirements within the Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018). If the development does not comply, it is assessable development and a development permit for operational work that is the construction constructing or raising of waterway barrier works must be obtained before development commences.

Waterways providing for fish passage are a prescribed environmental matter under Queensland Environmental Offsets legislation, unless the area waterway is within an urban area as defined under the Planning Regulation.

The early design phase was undertaken in accordance with the Guide for the determination of waterways using the spatial data layer Queensland waterways for waterway barrier works (Department of Agriculture, Fisheries and Forestry 2013) where watercourses that are not coloured on the Queensland Waterways for Waterway Barrier Works spatial data layer were not considered waterways. Under this guide waterway barrier works on these streams do not require approvals or assessment under the Fisheries Act.

Based on the *Queensland Waterways for Waterway Barrier Works* spatial data only 24 waterways for waterway barrier works intersect the Project disturbance footprint. Where the Project intersected a mapped waterway the design was undertaken in accordance with accepted development requirements for operational work that is constructing or raising waterway barrier works and/or a viaduct was proposed which is not considered to be a waterway barrier works.Fish passageway culverts have been upsized by 300 mm height for box culverts and 300 mm diameter for pipes from the calculated hydraulic sizes in order to submerge the culverts beneath the existing bed level by 300 mm at the upstream and downstream ends to comply with the fish passage requirements.

There are likely to be waterways present on ground that are not mapped on the *Queensland Waterways for Waterway Barrier Works* spatial data layer. An on ground assessment will be undertaken to confirm the status of the waterways under the Fisheries Act and whether the design conforms with Accepted development requirements for operational work that is constructing or raising waterway barrier works. The status classification of these watercourses waterways under the Fisheries Act is to be confirmed in consultation with DAF

Confirmation of the design of culverts, bridges (under both rail and road) and any other cross drainage structures and how they meet fish passage requirements is to be undertaken for the detailed design.

2 Legislative, policy, standards and guidelines

2.1 Commonwealth and State legislation

This section describes the legislative, policy and management framework for the Project, including:

- Legislative framework which applies to the assessment of terrestrial and aquatic ecology applicable to the Project at the Commonwealth and State levels, and provides the statutory context for which the terrestrial and aquatic environmental assessment has been undertaken
- Statutory approvals required as a result of potential impacts to terrestrial and aquatic ecology
- The approach to environmental offsets for significant residual impacts.

An overview of the Commonwealth and State legislation that is relevant to environmental aspects of the Project, is presented in Table 2.1.

Table 2.1 Legislative approvals, licences, permits and authorities relevant to the environmental aspects of 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 matters of national environmental significance (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 a bilateral agreement relating to environmental assessment. This agreement allows the Commonwealth Minister for the Environment and Department of Agriculture, Water and the Environment (DAWE) to rely on specified environmental impact assessment processes of QLD in assessing actions under the EPBC Act.	ARTC submitted an EPBC Act referral to the Department of the Environment and Energy (DotEE now DAWE) in February 2017 (EPBC 2017/7882) The Minster for the Environment determined that the Project is a 'controlled action" on 17 March 2017 requiring the preparation of an EIS. The controlling provisions for the controlled action are: ■ Listed threatened species and communities. The EPBC Act controlled action will be assessed under the bilateral agreement with the QLD Government. Note that EPBC Act controlling provisions have been assessed within EIS Appendix J: Matters of National Environmental Significance To avoid repetition between technical reports, this document does not discuss in detail flora and fauna species which are listed under the EPBC Act and the provisions of the NC Act (e.g. Koala (*Phascolarctos cinereus*)). The report however does consider migratory species which are considered to be MNES but are not controlling provisions for the Project.
EPBC Act Environmental Offsets Policy (2012) (EPBC Act Offsets Policy)	Areas subject to the EPBC Act	The EPBC Act Offset Policy was 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	The Project will implement a range of mitigation measures to avoid and minimise significant residual adverse impacts on the MNES. 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 residual impacts on MNES identified in EIS Appendix J: Matters of National Environmental Significance. The ARTC Environmental Offset Delivery Strategy – QLD, is provided in Appendix J.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		■ 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 ■ 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 (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC 2012). The Australian Government defines offsets as measures that compensate for the residual adverse impacts of an action on the environment (DSEWPaC 2012).	
Matters of National Environmental Significance: *Significant impact guidelines 1.1 – Environmental Protection and Biodiversity Conservation Act 1999* (Department of the Environment (DotE) 2013)	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 Australian Government Department of the Environment (the Department) 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 these guidelines will facilitate the determination of a Significant residual impact. Matters associated with the EPBC Act controlling provisions (i.e. EPBC Act listed threatened species and communities) are addressed as a stand-alone document in EIS Appendix J: Matters of National Environmental Significance and as such are not included within the scope of this technical report in order to avoid duplication. However, an assessment of relevant migratory species under the EPBC Act, which are considered to be MNES has been included in Section 5.3.3).

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Draft *Referral guidelines for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a)	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 14 migratory birds. 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 (migratory species) against the guidelines will facilitate the determination of a significant residual impact to migratory birds relevant to this guideline. Assessment has been undertaken in Section 5.3.3 for the following migratory species that are listed in this referral guideline: ■ Fork-tailed swift (*Apus pacificus*) ■ Oriental cuckoo (*Cuculus optatus*) ■ Black-faced monarch (*Monarcha melanopsis*) ■ Satin flycatcher (*Myiagra cyanoleuca*) ■ Spectacled monarch (*Symposiarchus trivirgatus*) ■ Rufous fantail (*Rhipidura rufifrons*) ■ Yellow wagtail (*Motacilla flava*) ■ Osprey (*Pandion cristatus*).
State			
Planning Act 2016 (Qld) (Planning Act)	Queensland	The purpose of the Planning Act is to provide an efficient, effective, transparent, integrated, coordinated and accountable system of land use planning, development assessment and dispute resolution to facilitate the achievement of ecological sustainability. Together with a development assessment system, Chapter 1 of the Planning Act establishes a hierarchy of planning instruments which comprises: ■ State planning policies (including temporary policies) ■ Regional plans ■ Planning schemes ■ Temporary local planning instruments ■ Planning scheme policies.	The Project will trigger the requirement to obtain approval for aspects of development that are assessable under Schedule 10 of the Planning Regulation 2017 (and integrated through other legislation as part of the Development Assessment Rules process) following completion of the EIS process. The Project is considered to be Government Supported Infrastructure as per requirements of the Planning Regulation 2017. Also the Project is considered an exempted development (i.e. coordinated project) under the Planning Regulation 2017.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
State Planning Policy 2017 (SPP) (Department of Infrastructure, Local Government and Planning (DILGP) 2017)	Queensland	The SPP is a key component of the QLD land use planning system which articulates the QLD Government's 17 State interests in land use planning and development. The SPP is a statutory instrument and requires that the State interests be integrated into local government planning schemes. Some State interests in the SPP include assessment benchmarks that apply to certain types of development where a local government planning scheme does not appropriately integrate the relevant State interest. A number of the State interests set out in the SPP apply to the Project and to the Project impact areas.	The SPP is applicable to the Project across various aspects, including terrestrial and aquatic ecology which is represented by the State interest of biodiversity (DSDIP 2014). The biodiversity State interest requires development to be located in areas to avoid significant impacts to MNES, avoid and minimise impacts to MSES and matters of local environmental significance (MLES), maintaining or enhancing ecological processes and connectivity by avoiding fragmentation and conserve and enhance koala habitat extent and condition. MLES are identified in relevant LGA planning schemes. The Project area is located within the Ipswich City Council and Lockyer Valley Regional Council areas. No MLES are identified within any current Planning Scheme applicable to the Project disturbance footprint.
Environmental Protection Act 1994	Queensland	The EP Act is the key legislative framework for environmental management and protection in Queensland. It regulates activities that will, or have the potential to, release contaminants into the environment which may cause environmental harm. These activities are defined as Environmentally Relevant Activities (ERAs). ERAs include both prescribed ERAs and resource activities. The EP Act regulates the application of Environmental Authorities (EAs) for ERAs, and employs a number of mechanisms to achieve its objectives relating to biodiversity, including the Environmental Protection Regulation 2019 (Qld) (EP Reg). The EP Reg identifies prescribed ERAs that require an approval and provides the mechanism for levels of protection for Environmentally Sensitive Areas, which are defined in Schedule 12 of the EP Reg. The EP Act also regulates wetlands in wetland management areas under the subordinate Environmental Protection Policy (EPPs) including the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP (Water)). The EPP (Water and Wetland Biodiversity) establishes a process for identifying Environmental values to be protected and states standards for water quality in support of those values.	The identification of any prescribed ERAs that will require an EA has been identified in EIS Chapter 3: Project Approvals. Confirmation of these ERAs will be undertaken as part of the post-EIS approvals process. The EP Act also lists obligations and duties to prevent environmental harm, nuisances and contamination. ARTC will comply with the general environmental duty through the implementation of the environmental management plans for the construction and operation of the Project.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Nature Conservation Act 1992 (Qld) (NC Act)	Queensland	The NC Act provides for the conservation of nature through protection of all native plants, birds, reptiles, mammals and amphibians in QLD (along with a limited range of invertebrates and freshwater fish). The NC Act is based on principles aimed at conserving biological diversity, ecologically sustainable use of wildlife, ecologically sustainable development and international criteria developed by the International Union for the Conservation of Nature for establishing and managing protected areas. The NC Act has 14 subordinate regulatory instruments in the form of regulations, conservation plans and notices. Of particular relevance to the Project are three instruments that regulate disturbance to flora, fauna and habitat, including: ■ *Nature Conservation (Animals) Regulation 2020*, which prohibits the taking or destruction, without authorisation, of protected animals and lists all fauna species that are considered to be extinct in the wild, endangered, vulnerable, near threatened, least concern and special least concern wildlife (refer Glossary and Abbreviations for definitions of these terms). Also listed is international wildlife and prohibited wildlife. ■ *Nature Conservation (Plants) Regulation 2020*, which prohibits the taking or destruction, without authorisation, of protected plants and lists all flora species that are considered to be extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern and special least concern wildlife (refer Glossary and Abbreviations for definitions of these terms). Also listed is international wildlife and prohibited wildlife. ■ *Nature Conservation (Protected Plants) Conservation Plan 2000* which provides protection for protected flora species. Currently all species of native Australian flora are listed as protected plants, including those species that are considered of Least concern. The NC Act also includes provisions for protected areas such as national parks, nature refuges, and world heritage management areas.	The following permits and management plans may be required for the Project: ■ Wildlife Movement Permits (Sections 88 and 97 of the NC Act) - for wildlife protected under the NC Act, and those found in certain areas covered by conservation plans created and implemented under the NC Act ■ Clearing Permit (Protected Plants) (Section 89 of the NC Act) – for the clearing of vegetation contained within High risk areas identified on the Department of Environment Science (DES) flora survey trigger map ■ Rehabilitation Permit (spotter catcher endorsement) (Part 14 of the *Nature Conservation (Animals) Regulation 2020*) ■ Damage Mitigation Permit (removal and relocation) ((Part 10 of the *Nature Conservation (Animals) Regulation 2020*S) ■ Species management program must be submitted to the DES for approval for tampering with some animal breeding places (Section 33 of the *Nature Conservation (Animals) Regulation 2020*). For the purposes of this document only species listed solely under the NC Act (i.e. MSES) have been included. In instances where an NC Act listed species is also listed under the EPBC Act (i.e. identified as a controlling provision under the EPBC Act), this species has been included within EIS Appendix J: Matters of National Environmental Significance and has subsequently been excluded from this document to avoid repetition. Though it is noted that the above mentioned permits and plans will need to consider those species as well.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Nature Conservation (Koala) Conservation Plan 2017	Queensland	The Nature Conservation (Koala) Conservation Plan 2017 (Koala Plan) main purposes are: (a) to promote the continued existence of viable koala populations in the wild; and (b) to prevent the decline of koala habitats. This will be achieved through): (a) dividing the State into 3 koala districts based on the management strategies to be applied to each district; and (b) prescribing the objective for each koala district; and (c) enabling the chief executive to determine koala priority areas and koala habitat areas; and (d) prescribing requirements for clearing vegetation in particular areas; and (e) prescribing additional restrictions on the grant of particular animal authorities for koalas, including, in particular, the authorities authorising the release of koalas into the wild.	The Project is predominantly located in District A, with a small area (2,200 m^2) located in District C. The Project will require clearing within District A as identified in the Koala Plan. Clearing works in Koala habitat within District A require 'sequential clearing' and the presence of Koala spotters (refer Section 4.2.14). The Project also intersects koala priority areas and koala habitat areas (refer Section 4.2.14), with clearing in these areas prohibited unless it is an exempted development. Noting these areas are only relevant to Koala District A. Under the Planning Regulation 2017 a coordinated project is considered an exempted development.
Biosecurity Act 2014 (Qld) (Biosecurity Act)	Queensland	The Biosecurity Act seeks to provide a framework for an effective biosecurity system for QLD that helps to manage and minimise State biosecurity risks, as well as facilitate the response to biosecurity issues and events in a timely and effective way, so as to align with national and international obligations. The Act introduces the general biosecurity obligation which means: ■ *everyone is responsible for managing biosecurity risks that are under their control and that are known about or should reasonably be expected to known about.* ■ *Individuals and organisations whose activities pose a biosecurity risk must:* – take all reasonable and practical steps to prevent or minimise each biosecurity risk – minimise the likelihood of causing a 'biosecurity event ', and limit the consequences if such an event is caused – prevent or minimise the harmful effects a risk could have, and not do anything that might make any harmful effects worse.	The Project will involve interaction with biosecurity matters (including pests, diseases or contaminants): ■ restricted matters (Specific actions should be taken to limit its impact by reducing, controlling or containing it, depending on the category of the species) are known from the ecology study area (refer Section 4.3.1.4 and Section 4.3.2.3) There are no known biosecurity zones or prohibited matters (this matter is not found in Queensland and if found must be reported immediately) relevant to the Project. Ecological surveys have and will continue to identify biosecurity matters relevant to the Project. Pest and weed management plans will ensure that the potential spread of invasive species as a result of Project activities are minimised and managed appropriately. The pest and weed managements plans will consider operational impacts associated with movement of stock and produce on trains as a vector for spread of pest animals, plants and pathogens (refer Section 5.2.2).

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		The Biosecurity Regulation 2016 prescribe ways in which a person's general biosecurity obligation can be met to prevent or minimise a biosecurity risk, and includes measures to prevent or control the spread of biosecurity matter and sets maximum acceptable levels of contaminants in carriers.	
Public Health Act 2005 (Qld) (Public Health Act)	Queensland	The objective of the Public Health Act is to is to protect and promote the health of the QLD public by: ■ Preventing, controlling and reducing risks to public health; and ■ Providing for the identification of, and response to, notifiable conditions; and ■ Imposing obligations on persons and particular health care facilities involved in the provision of declared health services to minimise infection risks; and ■ Providing for persons who have a major disturbance in mental capacity to be transported to a treatment or care place; and ■ Protecting children who have been harmed or are at risk of harm when the children present at health service facilities; and ■ Restricting the performance of cosmetic procedures on children; and ■ Collecting and managing particular health information, and establishing mechanisms for health information held by a health agency to be accessed for appropriate research; and ■ Inquiring into serious public health matters; and ■ Responding to public health emergencies; and ■ Providing for compliance with this Act to be monitored and enforced.	The Project will traverse areas that potentially contain designated pests as defined under the Public Health Act. Measures to control and minimise the spread of these pests is required. Control measures for designated pests are provided in Section 5.2.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Vegetation Management Act 1999 (Qld) (VM Act)	Queensland. Specifically, activities that are regulated through the Planning Act	The VM Act regulates the conservation and management of vegetation communities and clearing of vegetation identified as "Regulated vegetation" identified as Category A, B, C and R. The VM Act It provides a framework for identification, description, and mapping of remnant Regional Ecosystems (REs) certified by DES as 'Endangered', 'Of concern' or 'Least concern' (refer Glossary for definitions of these terms). It also provides a framework for the identification, description and mapping of High Value Regrowth (HVR) vegetation as 'Endangered', 'Of concern' or 'Least concern'. Clearing of Category X is considered an exempt activity unless the clearing is associated with native vegetation mapped as a Category X area on State land tenures including Road, Trust land, unallocated state land, is assessable development (unless prescribed as accepted development).	The clearing of vegetation regulated under the VM Act (e.g. Category B and C regulated vegetation) will occur as a result of the Project. *'Clearing of any relevant remnant or regulated regrowth vegetation will constitute operational works under Schedule 10 of the Planning Regulation that will require development approval, unless an exemption applies. Under Schedule 21, Part 1, Item 14 of the Planning Regulation, the following clearing work is exempt clearing work for which a development permit is not required:* *(14) Clearing vegetation for the construction or maintenance of infrastructure stated in Schedule 5, if-* *(a) the clearing is on designated premises; or* (b) *the infrastructure is government supported transport infrastructure'*. The Project is considered to be Government Supported Infrastructure as per requirements of the Planning Regulation. Vegetation clearing for the Project is considered to be eligible for exemption under Schedule 21 of the Planning Regulation given the Project is for transport infrastructure (rail transport infrastructure) that is government supported transport infrastructure (for a public use and funded partly by the Commonwealth Government).
Environmental Offsets Act 2014 (Qld) (Offsets Act)	Queensland	Offsets Act and associated Environmental Offsets Regulation 2014 (Qld) seeks to 'counterbalance the significant residual impacts of particular activities on prescribed environmental matters through the use of environmental offsets'. Introduced on 1 July 2014, the Act is administered by DES, and establishes a new framework to regulate the delivery of offsets in Queensland, integrating the previous multiple sets of policies in a manner which provides an outcome-based approach and reducing duplication. Under the Offsets Act, an environmental offset is defined as 'an activity undertaken to counterbalance a Significant residual impact of a prescribed activity on a prescribed environmental matter'. The Act defines the type of activities for which offsets may be imposed (i.e. 'prescribed activities') where these activities are determined to result in a 'Significant residual impact'.	The Project will be required to deliver an environmental offset consistent with the Offsets Act. Environmental offsets for significant adverse residual impacts to a prescribed matter may be delivered through a proponent-Drive offset (e.g. land-based offset), a financial offset calculated in accordance with the Financial Settlement Offset Calculation Methodology, or a combination of proponent driven and financial offsets. Biodiversity offsets are discussed in Section 5.4. The EO Act (Qld) does not affect or limit the functions and powers of the Coordinator-General under the SDPWO Act, however ARTC will have regard to the principles of the QEOP in determining and implementing offset requirements for MSES and MLES. ARTC's Environmental Offset Delivery Strategy – QLD, is provided in Appendix J.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		To achieve the purpose of the Offsets Act, the Queensland Environmental Offsets Policy (Version 1.9, December 2020) has been developed to provide further guidance on the requirements for the assessment of 'Significant residual impacts', and accepted methods for the delivery of offsets, where required.	
QLD Environmental Offsets Policy Significant Residual Impact Guideline (*Nature Conservation Act 1992, Environmental Protection Act 1994, Marine Parks Act 2004*) (SRI Guideline (DEHP)) (Department of Environment and Heritage Protection (DEHP) 2014a)	Queensland	The purpose of this guideline is to assist in deciding whether or not a prescribed activity will or is likely to have a significant residual impact on a MSES. This guideline applies to any activity prescribed in the Environmental Offsets Regulation 2014 that requires an approval in relation to MSES, under any of the following: ■ *Nature Conservation Act 1992*; ■ *Marine Parks Act 2004*; or ■ EP Act.	The Project involves disturbance to features protected under one the ■ NC Act. As such, assessment against the SRI Guideline (DEHP 2014a) is required to determine if a Significant residual impact upon an MSES occurs. Assessment against the SRI Guideline (DEHP 2014a) for connectivity and threatened flora species is undertaken in Section 5.3.4, with the criteria for threatened flora similar to the MNES Guideline The SRI Guideline criteria in the DSDIP 2014 and DEHP 2014a for assessing significant impacts to 'Vulnerable' fauna species are the same, and are similar in some respects to the criteria set out for threatened fauna species in the MNES Guideline.
Significant Residual Impact Guideline for matters of State environmental significance and prescribed activities assessable under the Sustainable Planning Act 2009, Queensland Environmental Offsets Policy (SRI Guideline (DSDIP)) (Department of State Development, Infrastructure and Planning (DSDIP) 2014)	Queensland	The purpose of this guideline is to assist in deciding whether or not a prescribed activity (assessable under *Planning Act 2016*) will or is likely to have a significant residual impact on a MSES.	An assessment against the SRI Guideline (DSDIP 2014a) is required to determine if a Significant residual impact upon an MSES occurs. Assessment against the SRI Guideline (DSDIP 2014a) is undertaken in Section 5.3.4. The SRI Guideline criteria in the DSDIP 2014 and DEHP 2014a for assessing significant impacts to 'Vulnerable' fauna species are the same, and are similar in some respects to the criteria set out for threatened fauna species in the MNES Guideline. However, the criteria is different for a number of parameters including connectivity, koala habitat and threatened flora.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Water Act 2000 (Qld) (Water Act)	Queensland	The Water Act provides for the sustainable management of non-tidal waters and other resources, together with the establishment and operation of water authorities, and for other purposes. The QLD Government maintains Watercourse Identification Mapping (WIM), which identifies defined watercourses under the Water Act, as well as drainage features (not regulated under the Water Act). Through the Planning Act, certain water related development under the Water Act can be assessed. Where applications are made for the purposes of 'taking or interfering with water' (and including surface water, artesian water, and in some instances overland flow where regulated through a Water Resource Plan), a Water Licence is required as evidence prior to lodging a Development Application. In addition to the approvals triggered under Planning Act, the Water Act regulates the undertaking of works that involve the excavating or placing fill in a watercourse, lake or spring. Under the Water Act, a proponent must obtain a Riverine Protection Permit in order to lawfully undertake these works unless the works can be undertaken in accordance with Riverine Protection Permit Exemption Requirements (WSS/2013/726 Version 1.01) (Department of Natural Resources, Mines and Energy (DNRME) 2019a).	The Project involves works within defined watercourses and as such the provisions of the Water Act may apply. Further the Project involves the removal of vegetation, excavation or placing fill in a waterway, lake or spring. Watercourse diversions required by Project activities will require approval under a diversion for resource activities under works that take or interfere with watercourse, lake or spring (for interference with overland flow). ARTC or the construction contractor will obtain a water entitlement, water licences and/or development permits for watercourse diversion for the Project to enable the take of water for use during construction. No approval is required at this time for the removal of dams as a result of the Project (i.e. all dams are less than 5 ML and are for the purpose of stock use). Further the Project involves the removal of vegetation, excavation or placing fill in a waterway, lake or spring. ARTC is listed as an entity under Schedule 2 of the Riverine protection permit exemption requirements (WSS/2013/726) and therefore a riverine protection permit is not required when riverine protection exemption requirements are adhered to. A Riverine Protection Permit will be sought if exemption guidelines cannot be met. A water authorisation may also be required to take or interfere with water, including the extraction of surface water and groundwater to meet the construction water demand. Noting that this is one of the many options available to source water for the Project (refer Section 2.7.1). It is likely that is water was required from surfaces water or groundwater a water permit would be sourced. Further, the acquisition of land will result the annulment of any exiting water authorisation attached to the land parcel being acquired (in part of full). These authorisations will need to be re-established by the landholder and will form part of the acquisition process negotiations. Further consultation with DRDMW is recommended to resolve some of the complexities associated with the Water Act and supporting water plans relevant to the Project. Noting that most of the issues relate to groundwater allocations.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Fisheries Act 1994 (Qld) (Fisheries Act)	Queensland	The Fisheries Act provides for the management, use, development and protection of fish habitats and resources, together with the management of aquaculture activities. Administered by the Department of Agriculture and Fisheries (DAF) the following provision of the Act is relevant to the Project: ■ Waterway barrier works. **Waterway Barrier Works** Under the provisions of the Fisheries Act and Planning Act, a Development Permit for Operational Works involving Waterway Barrier Works is required for works which pose a barrier to fish passage (including permanent, partial and temporary barriers) within a waterway which is mapped by DAF on the spatial data layer *'QLD waterways for waterway barrier works'* unless: ■ The works have a low impact to fisheries productivity and comply with DAF's requirements for 'works which are not waterway barrier works' which include (subject to specific design and construction requirements): – New single or multi-span bridges – Maintenance of existing bridge structures not subject to an existing permit – Bank revetment – Road resurfacing at waterway crossings – Stormwater outlet construction ■ Any works that occur within waterways (as defined by the Fisheries Act), including, but not limited to, waterway crossings, diversions, filling and alterations to the bed and banks are likely to constitute waterway barrier works. Waterway barrier works must be undertaken in accordance with the relevant accepted development requirements or under a development approval (assessable development)	The Project traverses, and will require alterations to the flow paths and bed and banks of mapped waterways for waterway barrier works and therefore may trigger the requirement to obtain a Development Permit for Operational Works involving constructing or raising temporary and permanent waterway barrier works (refer Section 4.2.7). The crossings of a number of waterways in particular Gowrie, Oaky, Six Mile and Lockyer creeks are not considered a waterway barrier (i.e. large bridges and viaducts which span over the main channel and riparian zone, with limited infrastructure in the floodplain). However, there is the potential that some works may still be required within the waterways including erosion sediment control and temporary access. These works will aim to conform with the relevant accepted development requirements. On-ground assessments are required to confirm the status of all waterways under the Fisheries Act., noting that there are only 24 mapped waterways intersected by the Project. Further consultation with DAF is required to determine what works will constitute a waterway barrier and where works other than waterway crossings (refer Section 5.5.2) will trigger waterway barrier works and determine if any unmapped water features meet the definitions of a waterway for the purposes of the Fisheries Act. Waterways providing fish passage are also considered to be Matters of State Environmental Significance (MSES) under the Planning and Offset Legislation, with MSES assessed in EIS Appendix I: Terrestrial and aquatic ecology. For the purposes of the MSES assessment it has been assumed though unlikely that the entire portion of the waterway within the Project disturbance footprint may be subject to works for the purposes of the railway corridor, access or new roads which constitute a waterway barrier under the Fisheries Act (e.g. fill, culverts, diversions, alter the bed and banks of waterway and bridges).

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Qld) (EPP) (Water and Wetland Biodiversity))	Queensland	The quality of QLD waters is protected under the EPP (Water and Wetland Biodiversity). The EPP (Water and Wetland Biodiversity) seeks to achieve the objective of the EP Act in relation to QLD waters. The EPP (Water and Wetland Biodiversity) seeks to achieve this purpose by identifying environmental values (EVs) and management goals for QLD waters; stating water quality guidelines and objectives, to enhance or protect the EVs, provide a framework for decision making, and monitoring and report on the condition of QLD waters.	The EPP (Water and Wetland Biodiversity) lists the EVs and water quality objectives (WQOs) and as they are part of the legislation they are considered by planners and managers when making decisions about waters and/or water quality. The Project will be required to assess the referable wetland EVs and WQOs.
QLD Environmental Offsets Policy (Qld) (QEOP)	Queensland	The QEOP (DES 2020k) aims to provide a framework for environmental offsets in QLD, including principles and guidelines for using environmental offsets and guidance on when offsets should be used. The QLD Environmental Offsets Policy outlines seven principles that direct the way offsets must be used to contribute to ecologically sustainable development (ESD) as follows: ▪ Offsets will not replace or undermine existing environmental standards or regulatory requirements, or be used to allow development in areas otherwise prohibited through legislation or policy ▪ Impacts must first be avoided, then minimised, before considering the use of offsets for any remaining impact ▪ Offsets must achieve a conservation outcome that achieves an equivalent environmental outcome ▪ Offsets must provide environmental values as similar as possible to those being lost ▪ Offset provision must minimise the time-lag between the impact and delivery of the offset ▪ Offsets must provide additional protection to environmental values at risk, or additional management actions to improve environmental values ▪ Where legal security is required, offsets must be legally secured for the duration of the impact on the prescribed environmental matter.	The Project will deliver environmental offsets consistent with the QEOP. Information related to the provisions of offsets are provided in Section 5.4. ARTC's Environmental Offset Delivery Strategy – Qld (Strategy) is provided in Appendix J. This Strategy informs the development of offset delivery components including an Environmental Offset Delivery Plan and Offset Area Management Plans.

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
Back on Track species prioritisation framework	-	The Back on Track species prioritisation framework is an initiative of the DES, based on the method of Marsh et al. (2007), that ranks species (regardless of their NC Act or EPBC Act classification) as Critical, High, Medium, or Low priority for the State and for the Natural Resource Management (NRM) region. There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery. Although it is not legislated, the Back on Track priority species provides a framework for biodiversity assessment and species prioritisation when determining ecological values.	Priority Back on Track species have been identified for each of the 14 NRM regions across QLD. The Project is located in the SEQ NRM region. A total of 105 priority Back on Track species (56 flora species and 49 fauna species) are known to occur within the SEQ NRM region through the prioritisation framework (DERM 2010). A total of 36 priority Back on Track species (12 flora species and 24 fauna species) are known to occur within the Condamine NRM region through the prioritisation framework (Department of Environment and Resource Management (DERM) 2010). Sections 4.2.1.2 and 4.2.2.3 list the NRM State Back on Track species and their rank for the NRM.
Biodiversity Planning Assessments (BPAs)	-	BPAs for each of QLD's bioregions have been prepared based on the methodology outlined in the Biodiversity Assessment and Mapping Methodology (BAMM) (DEHP 2014b). The BPAs draw upon the DEHP certified 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. The BPA assigns areas to one of three biodiversity significance levels, including: ■ 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. Although it is not legislated, the BPA provides a framework for biodiversity assessment when determining environmental values.	The Project is located within the SEQ and Brigalow Belt BPA areas. The following reports outline the BPAs conducted within the ecology study area: ■ Biodiversity Planning Assessment for the SEQ Bioregion: Fauna Expert Panel Report (Version 4.1) (DEHP 2016a) ■ Biodiversity Planning Assessment for the SEQ Bioregion: Flora Expert Panel Report (Version 4.1) (DEHP 2016b) ■ Biodiversity Planning Assessment for the SEQ Bioregion: Landscape Expert Panel Report (Version 4.1) (DEHP 2016c) ■ Biodiversity Planning Assessment for the Brigalow Belt Bioregion: Expert Panel Report v2.1 (DES 2018a). Aquatic assessment associated with the ecology study area considered the information and outlined within the following report: *"Aquatic Conservation Assessment using the Aquatic Biodiversity Assessment and Mapping Method (AquaBAMM) for the riverine and non-riverine wetland of South-East Queensland (DEHP 2015)".*

Legislation/ policy	Legislative jurisdiction	Intent	Applicability
		In addition to terrestrial BPAs, aquatic BPAs utilises and 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/ecosystem, special features, connectivity and representativeness to provide aquatic conservation assessments for SEQ (DEHP 2015).	

3 Assessment methodology

3.1 Overview

An overview of the stages involved in the assessment of sensitive environmental receptors (i.e. MSES (not listed as threatened under the EPBC Act) and migratory species under the EPBC Act (not listed as threatened under the EPBC Act) is provided in Figure 3.1. Further information regarding the development of predictive habitat mapping to support the assessment process provided in Appendix A.

The initial step of the assessment was to identify the sensitive environmental receptors relevant to the Project. This was undertaken using a combination of desktop-based datasets and validation of predictive, species-specific mapping. This was supplemented by field surveys at defined locations in addition to results from publicly available datasets from other projects in the ecology study area (refer Section 3.4.1).

Predictive habitat modelling for each flora and fauna species that constituted a sensitive environmental receptor (refer Section 3.3.4, as well as Appendix A) and associated constraints mapping, was developed based on the desktop and field survey results. It should be noted from the outset that detailed onsite surveys for threatened fauna and flora have not necessarily been carried out as per the relevant Commonwealth and State survey guidelines for each species. As such, the threatened species habitat modelling was based on a conservative approach to mapping habitat. That is, unless there is sufficient and robust scientific information to support a species from being excluded from the area, it has been assumed to be present if habitat for the species is known or there are local records for the species. The approach is also conservative given 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 (DotE 2013) (migratory species) or the relevant SRI guidelines (DEHP 2014a and DSDIP 2014) – refer Sections 5.3.3 and 5.3.4 respectively.

The predictive habitat modelling and constraints mapping, along with relevant scientific information was used to inform the significant impact assessment (direct and indirect) and identify applicable measures to avoid, minimise and mitigate impacts. As part of this assessment the maximum potential area of disturbance was determined for each sensitive environmental receptor (i.e. non-threatened MNES and MSES) using the predictive habitat modelling (i.e. the total extent of habitat to be cleared irrespective of habitat type and 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 sensitive environmental receptor.

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 sensitive environmental receptors. It is based on the assumption that the Project will clear the entire Project disturbance footprint, which allows flexibility in placing infrastructure during detailed design and construction with the intent to avoid or minimise impacts on a specific area, community or population

That is, during the detailed design, the design and construction methodology will be refined (in particular the Project disturbance footprint) with due consideration to the Project's impacts and mitigation measures, approval conditions and additional information on the ecological values of the Project (e.g. additional ecological surveys in accordance with Commonwealth and State threatened species survey guidelines). As such the significance of the impacts on sensitive environmental receptors will also change. All of which will be done in consultation with relevant stakeholders (Commonwealth and State government) and where applicable the community.

The approach adopted for this assessment is designed to be dynamic and will evolve in response to changes to the design and disturbance 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. DEHP 2016d) 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.

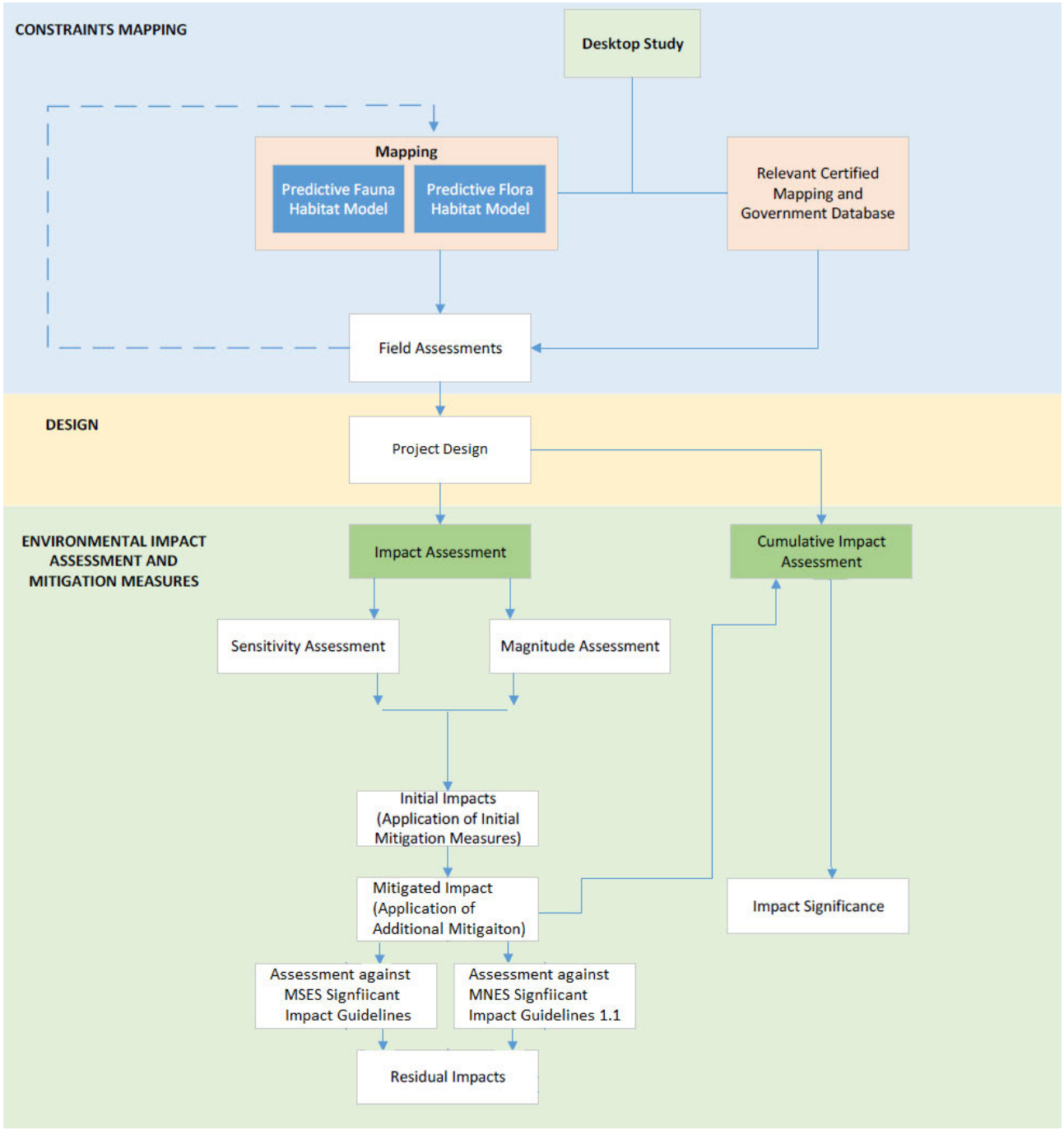


Figure 3.1 **Assessment methodology**

3.2 Stakeholder engagement

Flora, fauna and habitat matters have been raised regularly by stakeholders and the community in discussions, meetings and correspondence with the Project team. This includes habitat for fauna (e.g. Koala) and habitat connectivity across the corridor. The project team also held a workshop about how to provide species record information or data collected by community members to the Queensland government, so it can be recorded and recognised in the WildNET database from where it could be drawn to be used as part of the EIS investigations. 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 Project development.

3.3 Desktop study

This section details the desktop analysis undertaken to identify sensitive environmental receptors located within the ecology 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 as well as field data collected during the 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 identified as sensitive environmental receptors within the ecology study area.

3.3.1 Database review

A database review was undertaken in 2017 prior to field investigations to identify sensitive environmental receptors that were known or likely to be present within the ecology study area. However, to ensure that the most recent data was obtained, searches were re-run in 2019 and 2020 to ensure that any relevant updates or new 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. Results associated with database searches are provided in Appendix D and have been incorporated into this document.

Table 3.1 Database review summary

Database/data source name	Database search date	Database search areas	Data type
Atlas of Living Australia (AoLA) (2020a and 2020b)	13/03/2020	Ecology study area	Records of flora and fauna, including conservation significant species listed under the EPBC Act and/or NC Act and those identified as MLES
Flying Fox Monitoring Program: https://data.qld.gov.au/dataset/flying-fox-monitoring-program (DES 2020b)	24/04/2020	Ecology study area	Shows the general location of Flying-fox roosts in QLD recorded by the DES and includes camp and survey data 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: https://www.ehp.qld.gov.au/wildlife/livingwith/flyingfoxes/roost-locations.html#flying_fox_roost_locations (DES 2020c)	24/04/2020	Ecology study area	Shows the general location of Flying-fox roosts in QLD recorded by the DES and includes 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	Ecology study area	Records of avian fauna, including threatened and migratory species listed under the EPBC Act

Database/data source name	Database search date	Database search areas	Data type
BPA mapping (DNRME 2020g)	25/03/2020	Ecology study area	State, regional (MSES) and locally (MLES) significant biodiversity matters mapping. This mapping has been used to indicate the location of bioregional corridors (i.e. in the State, regional and local context). This mapping has also been used in the predictive modelling to identify core habitat areas (refer Section 3.3.4)
Back on Track species prioritisation framework (DERM 2010)	25/03/2020	SEQ NRM	The Back on Track species are categorised as Critical, High, Medium, or Low priority for the State and for the NRM regions. There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery. Data is presented as a list of species (refer Sections 4.2.1.2 (flora) and 4.2.2.3 (fauna)).
EPBC Act Protected Matters Search Tool (DAWE 2020a)	25/03/2020	Ecology study area	Provides a "predictive" account of MNES identified within a specific area. Includes: ▪ 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
Groundwater Dependent Ecosystems Atlas (BoM 2020)	25/03/2020	Ecology study area	Provides information related to 3 types of Ground water dependent ecosystems: Aquatic, Terrestrial and Subterranean.
Wildlife Habitat Map, version 6.0 (DES 2020c)	25/03/2020	Ecology study area	Modelled habitat under the VM Act for a conservation significant species listed under the EPBC Act and/or the NC Act
Regulated Vegetation Management Map (Qld Government 2020a)	25/03/2020	Ecology study area	Mapping of REs and HVR that provide habitat for threatened species under the EPBC Act and/or NC Act
Register of critical habitat (DAWE 2020b)	25/03/2020	Australian extent	Critical habitat listed under the EPBC Act
Map of Referable Wetlands (DNRME 2020a)	25/03/2020	Regional extent	Includes State significant, referable wetlands, important wetlands in the Great Barrier Reef catchments and wetland REs
Wildlife Online database (DES 2020a) incorporating WildNet and Herbrecs datasets	25/03/2020	Ecology study area	Records of flora and vertebrate fauna, including conservation significant species listed under the EPBC Act and/or NC Act and MLES
QLD waterways for waterway barrier works (DNRME 2020b)	25/03/2020	Ecology study area	Waterways where proposed waterway barrier works require assessment and approval under the Fisheries Act.
Watercourse Identification Mapping (DNRME 2020c)	25/03/2020	Ecology study area	Known extent of watercourses and drainage features that are managed under the Water Act
Wetland Info database (Wetland info 2013)	25/03/2020	Impact assessment area	Provides interactive maps, species records, case studies and legislation associated with QLD wetlands

Database/data source name	Database search date	Database search areas	Data type
Fish Habitat Areas (DRNME 2020d)	25/03/2020	Ecology study area	Boundaries of gazetted, declared fish habitat areas
QLD Springs Database (DRNME 2019e)	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 (GDEs).
Matters of State Environmental Significance (DRNME 2020f)	25/03/2020	Ecology study area	Location of MSES including: ▪ Protected areas ▪ Marine parks ▪ Management A and Management B declared fish habitat areas ▪ Threatened and 'Special least concern' wildlife listed under the NC Act ▪ Regulated vegetation under the VM Act ▪ Wetlands in a wetland protection area or wetlands of high ecological significance ▪ Wetlands and watercourses in high ecological value waters as defined in the *Environmental Protection (Water) Policy 2009, S*chedule 2 ▪ Legally secured offset areas.

It is acknowledged that the resolution currency of database information has its limitations, however these were minimised wherever possible by ensuring that the most recent datasets were used, datapoints with ambiguous metadata or of very low precision were excluded from analysis, and that any ground-truthed data was prioritised over that of desktop based datasets. In addition, specimen backed records in excess of 30 years were excluded from analysis due to concerns related to currency and recent human induced disturbance to the broader area.

3.3.2 Review of existing literature and previous studies

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

In addition, seasonal variation was also captured in the modelling approach (refer Section 3.3.4) 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 threatened flora and fauna to align with that prescribed by relevant conservation advice (refer Appendix A and Appendix B). Survey methodology, incorporating surveys over multiple seasons (refer Section 3.4.1.1) as well as the use of habitat modelling (refer Section 3.3.4) is considered to adequately account for seasonal variation and detectability related to threatened species.

The findings of each of the existing background studies were used to inform this impact assessment, particularly the likely extent of habitat for threatened species listed under the EPBC Act (non-threatened migratory species) and/or the NC Act within the ecology 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.

Table 3.2 Project related assessments and reports

Document title	Reference	Summary of significant findings related to ecology
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 praelta* and *Sarcochilus weinthalii*. ▪ 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 and MSES. 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 (scratches/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 (2019)	▪ Confirmation of the presence of Brush sophora (*Sophora fraseri*)* (two individuals) in the Toowoomba Range area ▪ Confirmation of the presence of Brush sophora* (*Sophora fraseri*)* in the Toowoomba Range area ▪ Observations of NC Act listed flora Finger panic (*Digitaria porrecta*) detected during preclearance surveys for geotechnical works ▪ Identification of Slender milk-vine (*Marsdenia coronata*) ▪ Identification of the planted specimen of Plunket mallee (*Eucalyptus curtsii*) – note species is considered to be outside of the jurisdiction of the NC Act as it is not considered to be “in the wild”
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey reports (2019) Preclearance survey reports (2018 and 2019)	EMM (2018b, 2018c; 2019a, 2019b, 2019c)	▪ Observations of NC Act listed flora Finger panic (*Digitaria porrecta*) detected during preclearance surveys for geotechnical works ▪ Identification of Slender milk-vine (*Marsdenia coronata*) ▪ Identification of the planted specimen of Plunket mallee (*Eucalyptus curtsii*) – note species is considered to be outside of the jurisdiction of the NC Act as it is not considered to be “in the wild”

Document title	Reference	Summary of significant findings related to ecology
Inland Rail – Gowrie to Helidon Geotechnical investigations. Protected plant survey report – 29 May 2019 Preclearance survey report (30 July 2019)	Eco Logical Australia (ELA) (2019a, 2019b)	▪ Koalas (*Phascolarctos cinereus*)* observed as well as evidence of presence (scratches/scats) within ecology study area ▪ Collared delma* recorded as well as evidence of presence (skins) within ecology study area ▪ Lowland Rainforest of subtropical Australia TEC* confirmed within ecology study area

Table notes:

\# Based on the Gowrie to Grandchester future State transport corridor alignment

* MNES are discussed further within EIS Appendix J: Matters of National Environmental Significance

^ 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

3.3.3 Assessment of the likelihood of occurrence of conservation significant species

The likelihood of sensitive environmental receptors that may occur within the ecology study area was determined based on the results of the desktop study and review of existing literature which was later supplemented with data derived from field assessments (refer Section 3.4) and used to refine the predictive habitat mapping (refer Section 3.3.4). The likelihood of occurrence assessment is central to determining which sensitive environmental receptors were identified for the Project and were subject to predictive habitat modelling (refer Sections 4.2.1.1 and 4.2.2.1, and Appendix A).

Species of conservation significance considered possibly or likely to occur, or which were identified in the ecology study area during the field assessment, were assessed as sensitive environmental receptors applicable to the Project. Species of conservation significance which were considered unlikely to occur within the ecology study area, were not considered further as part of this 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 ecology study area is beyond the current distributional limits for the species
- Use specific habitat types or resources that are known not to be present in the ecology study area (e.g. intertidal saltmarshes and estuarine wetlands for the waders)
- Are considered locally extinct based on expert knowledge and/or literature.

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

- Have infrequently been recorded previously in the ecology study area (i.e. sporadic records with no recent sightings within the past 10 years within 20 km of the ecology study area)
- Use habitat types or resources that are present in the ecology study area, although generally 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 ecology study area opportunistically during variable seasons or migration. Note that species that can be identified as sporadically utilising areas of the ecology study area (e.g. bats) 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 ecology study area (i.e. sightings within the past 10 years within 20 km of the ecology study area)

- Use habitat types or resources that are present in the ecology 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 ecology study.

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

3.3.4 Predictive habitat modelling for conservation significant flora and fauna species

Predictive habitat modelling was undertaken to identify and map areas that were determined as having the potential to provide habitat for conservation significant species in accordance with Section 11.91 of the EIS ToR. State-based GIS layer datasets were 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.

In addition, to adequately capture known records of conservation significant 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 ecology study area, the 1 km buffer area for the record would still be integrated into the predictive habitat mapping where it intersected the ecology study area. In some instances, the mapped habitat contained areas of agricultural land, attenuated grassland (i.e. potential habitat) and open woodland and habitat (i.e. considered critical to the survival of the species). The model was designed to recognise specific requirements of each threatened species, which were identified through the broader desktop analysis. This approach to habitat mapping represents a highly conservative methodology (i.e. 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) so as not to underestimate potential habitat for conservation species.

Databases and other information that were used to feed into the predictive GIS based model are identified in Table 3.1 (refer Section 3.3.1), Appendix A and Appendix B. In addition to database information, data collected during field-based assessments (refer Section 3.4) was used to verify and “fine-tune” model outputs (refer Figure 3.1).

3.3.4.1 Habitat mapping for species listed under the NC Act

The habitat in the predictive threatened species habitat model for NC Act listed species was categorised using current scientific knowledge and pre-existing data derived from historic surveys, State based mapping, scientific publications and advice from industry recognised experts. The specific habitat assumptions for each species are provided in Appendix A.

As part of the predictive habitat modelling for NC Act listed species, species-specific assumptions allowed the following areas to be identified for each conservation significant species:

- Core habitat
- Essential habitat
- General habitat
- Unlikely habitat.

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

Core habitat

Core habitat consists of essential habitat in which the species is known, and the habitat is recognised under relevant recovery plans or other relevant plans/policies/regulations. Where essential habitat intersects with areas identified as important within the relevant bioregion specific BPA, these areas have been elevated to the core habitat category. Species specific assumptions associated with the mapping of core habitat areas are detailed in Appendix A.

Aquatic fauna values were excluded from predictive core habitat modelling, with the highest tier of habitat modelling capped at essential habitat (as per Appendix A). There are currently no GIS datasets that are tractable to facilitate analysis of habitat to elevate essential habitat (i.e. known to support a species) to core habitat (i.e. areas of essential habitat contained within a protected area (e.g. BPA)). However, any core terrestrial habitat in proximity to the aquatic ecosystem (i.e. watercourse), will flag significance of the aquatic values (as proximal core habitat) due to the scaling of core terrestrial habitat mapping. As such, standalone aquatic core habitat is not possible (in the absence of any observation of species) in regard to core habitat predictive modelling.

Essential habitat

Essential habitat consists of areas containing resources that are considered essential for the maintenance of populations of the species (e.g. potential habitat for breeding, roosting, foraging, shelter) or areas that have been confirmed as containing suitable habitat as identified by a specimen backed record or indirect evidence of the species (i.e. scat, trace, track, fur/feather, distinctive vocalisation or other site based evidence). Essential habitat has been defined from known location-specific records (i.e. low location error information and from within the last 30 years), with a 1 km buffer or site-based observation of the species during site investigations. In addition, if the 1 km buffer from the known record intersects an area identified as general habitat, the general habitat rating was elevated to essential habitat. Species specific assumptions associated with the mapping of essential habitat, and instances that deviate from the above criteria are detailed in Appendix A.

General habitat

General habitat consisted 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 essential/core habitat (i.e. records of the species are considered anomalies as general microhabitat features are not considered to be present from a desktop perspective). General 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. General habitat may include areas of suboptimal habitat for a species. Species specific assumptions that define the general habitat category are identified in Appendix A.

Unlikely habitat

Unlikely habitat consisted 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.

3.3.4.2 Habitat mapping for EPBC Act listed migratory species

The habitat in the predictive species habitat model for EPBC Act listed migratory species was categorised habitat using current scientific knowledge and pre-existing data derived from historic surveys, State based mapping and scientific publications and industry recognised experts. The specific habitat assumptions for each species are provided in Appendix A.

The predictive habitat modelling provides greater certainty in predicting the migratory species habitat occurring with the ecology study area, when compared to limited and or sporadic field investigations.

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

- Important habitat.
- Potential habitat
- Unlikely habitat.

The use of these habitat categories aligns with DAWE's habitat definitions for species protected under the EPBC Act as identified in the *Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a).

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

Important habitat

In line with the DAWE guidelines, important habitat has been identified for migratory species under the *Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a).

Species specific assumptions that define the Important habitat category for the abovementioned species is provided in Appendix A.

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 (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. Potential habitat may include areas of suboptimal habitat for 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.*

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.

3.4 Field assessments

This section outlines the methods adopted for the field assessment in recognition of relevant departmental guidelines or policies. Field surveys were undertaken with due consideration of the following guidelines:

- Commonwealth published guidelines for threatened species where applicable (refer: http://www.environment.gov.au/epbc/policy-statements)
- State published guidelines including:
  - Methodology for survey and mapping of regional ecosystem and vegetation communities in Queensland (Neldner et al 2019)

- Terrestrial vertebrate fauna guidelines for Queensland (Eyre et al 2018)
- Flora Survey Guidelines - Protected Plants, Nature Conservation Act 1992 (DEHP 2016d).

As noted previously, detailed onsite surveys for threatened flora and fauna have not necessarily been carried out as per the relevant State survey guidelines. For example under the *Terrestrial Vertebrate Fauna Survey guidelines for Queensland* (Eyre et al 2018), surveys to detect small mammals require the use of 20 "Type A" Elliot traps per each sample location, placed 10 m apart in two parallel lines, baited with vegetable or meat-based products, and operate for a period of four consecutive nights, being checked within 2 hours of sunrise. A comparison of the Project survey effort with the required survey effort for each species as per the relevant survey guidelines is not presented within this report. The information within this document is based on desktop information and targeted field-based information from several surveys over a number of years.

The approach to assessing the presence of species of conservation significance and habitat modelling for species of conservation significance has adopted a conservative approach in order to avoid underestimating the available habitat potentially present within the Project disturbance footprint. As such, it is considered that this approach complies with 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 Appendix A), are considered sufficient to provide confidence in predictions of potential impacts to sensitive environmental receptors.

The location of terrestrial and aquatic survey sites was dictated by land access agreements with landholders which was provided on a voluntary basis. This significantly reduce the areas that were accessible to ecological investigations. However, where access agreements existed, these locations were surveyed in addition to publicly accessible areas. As noted in Section 6, 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. The additional surveys will also inform design requirements and secondary approvals including supporting management plans.

Whist not specifically detailed within this document, 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 2019 and ELA 2019a, ELA 2019b) which occurred concurrently with the EIS investigations reported in this document, have been incorporated within the EIS reporting. Refer to Figure 3.2 for the locations of areas investigated 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 2016)* and in addition, habitat assessments (including breeding and foraging habitat for threatened species), focussing on those listed as threatened (e.g. Glossy black-cockatoo (*Calyptorhynchus lathami*) and Powerful owl (*Ninox strenua*)). This data has been used to assist in the predictive habitat mapping and refinement within the ecology study area.

3.4.1 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. 2015). 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 fulfil the seasonal requirements.

The survey timings are considered adequate to measure taxa diversity and their repetition throughout the ecology study area. In addition, when combined with the predictive habitat modelling (refer Section 3.3.4) which has been supplemented with field based datasets, a highly conservative approach has been adopted to the assessment of threatened species. Field-based surveys associated with the Project complemented previous and concurrent ecological studies undertaken in the Project disturbance footprint (refer Section 3.4.1.1 and Table 3.3).

Field investigations (terrestrial and aquatic) specifically undertaken by FFJV for the Project EIS occurred over a nine-consecutive day period during spring, between 18 September 2017 and 27 September 2017 (refer Section 3.4.1.2 and Table 3.4).

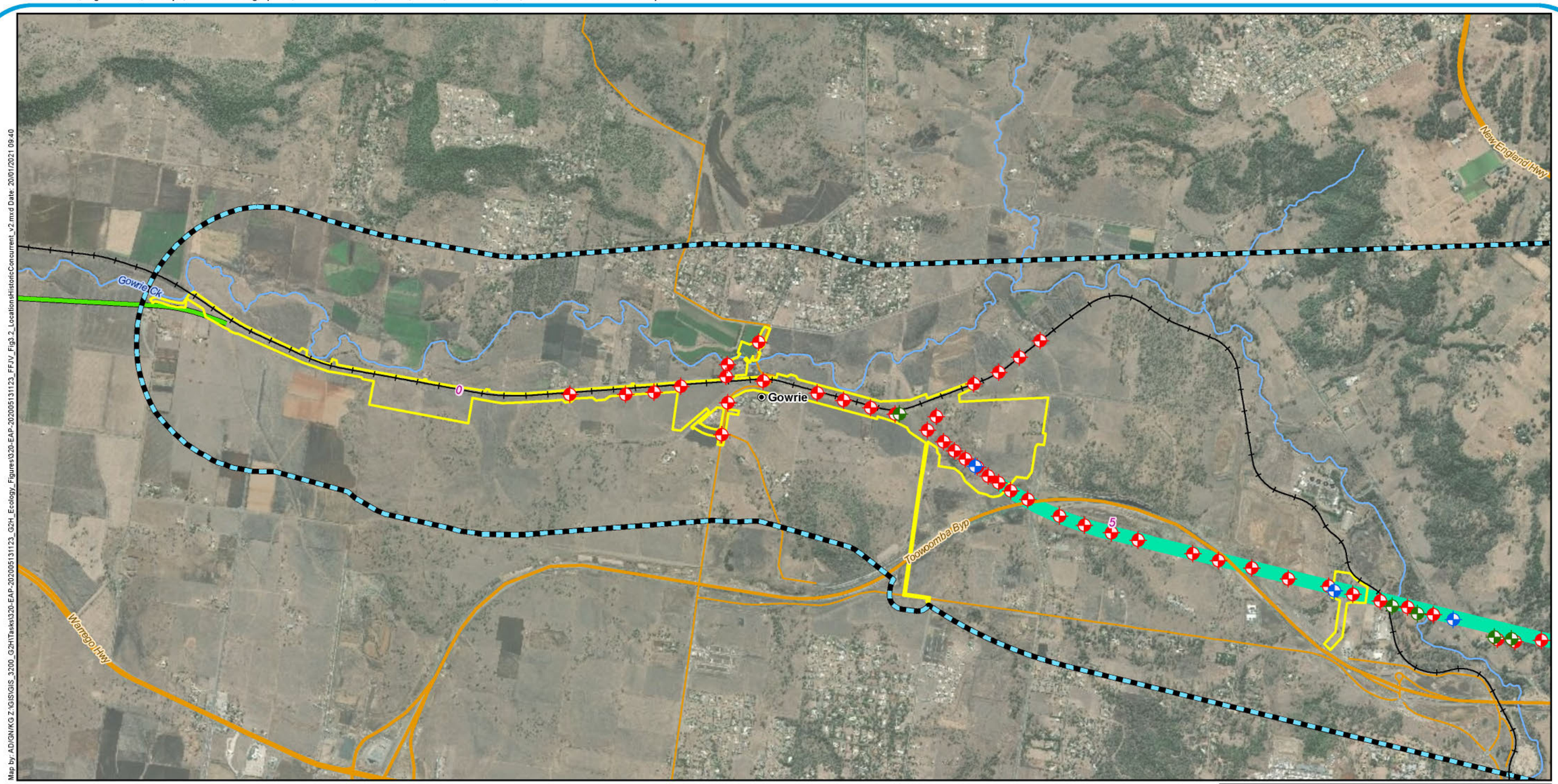
3.4.1.1 Previous and concurrent ecological surveys undertaken for the Project

Table 3.3 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 Eco Logical Australia (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 3.3 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 threatened species searches (Koala) – 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
Pre-clearing surveys associated with geotechnical investigations to inform the Gowrie to Kagaru Geotechnical Investigations Environmental Management Plan	EMM (2018a, 2018b, 2019c)	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 ▪ Vegetation community confirmation ▪ Fauna observations ▪ Carried out at 57 sites throughout the ecology study area
Pre-clearing surveys associated with geotechnical investigations for G2H alignment	ELA (2019a)	Various from 18 December 2018 – 16 April 2019	Summer 2018/2019 –	▪ Threatened fauna habitat surveys within/adjacent to alignment ▪ Habitat assessments (Koala) ▪ Searches for fauna breeding places ▪ Fauna observations ▪ Vegetation community confirmation ▪ Carried out at 214 sites and additional access tracks throughout the ecology study area
Protected plant surveys associated with geotechnical investigations for G2H alignment	ELA (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)

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



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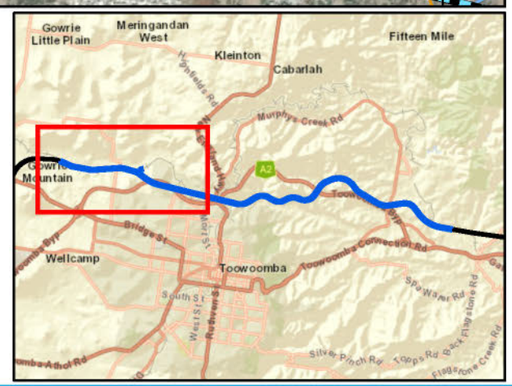
Legend

- 5 Chainage (km)
- Chainage point
- 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)
- Ecology study area
- Local Government Areas



A3 scale: 1:30,000

0 0.5 1 1.5km

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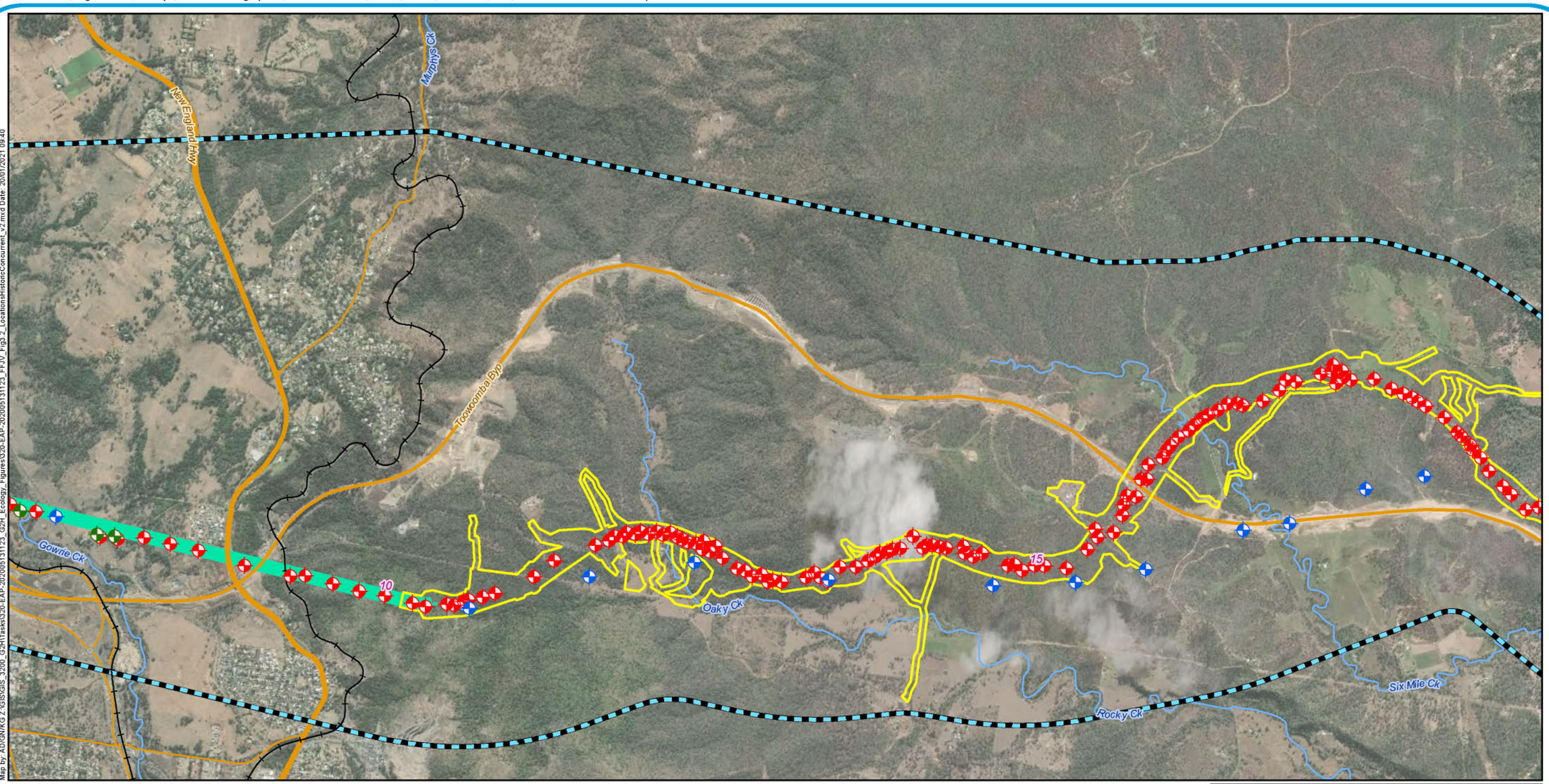
Gowrie to Helidon

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

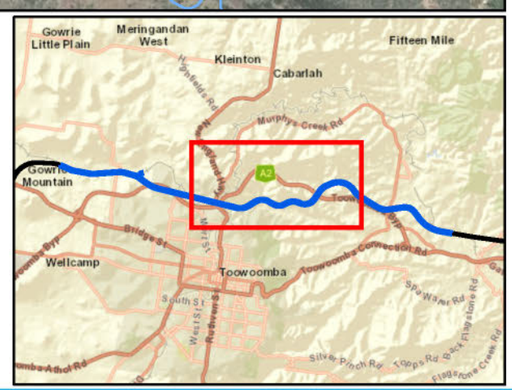
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA,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



Map by: AD/GN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig3.2_LocationsHistoricConcurrent_v2.mxd Date: 20/01/2021 09:40

Legend

- 5 Chainage (km)
- Chainage point
- 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)
- Ecology study area
- Local Government Areas



A3 scale: 1:30,000

0 0.5 1 1.5km

Future Freight
Integrating Community, Environment and Engineering

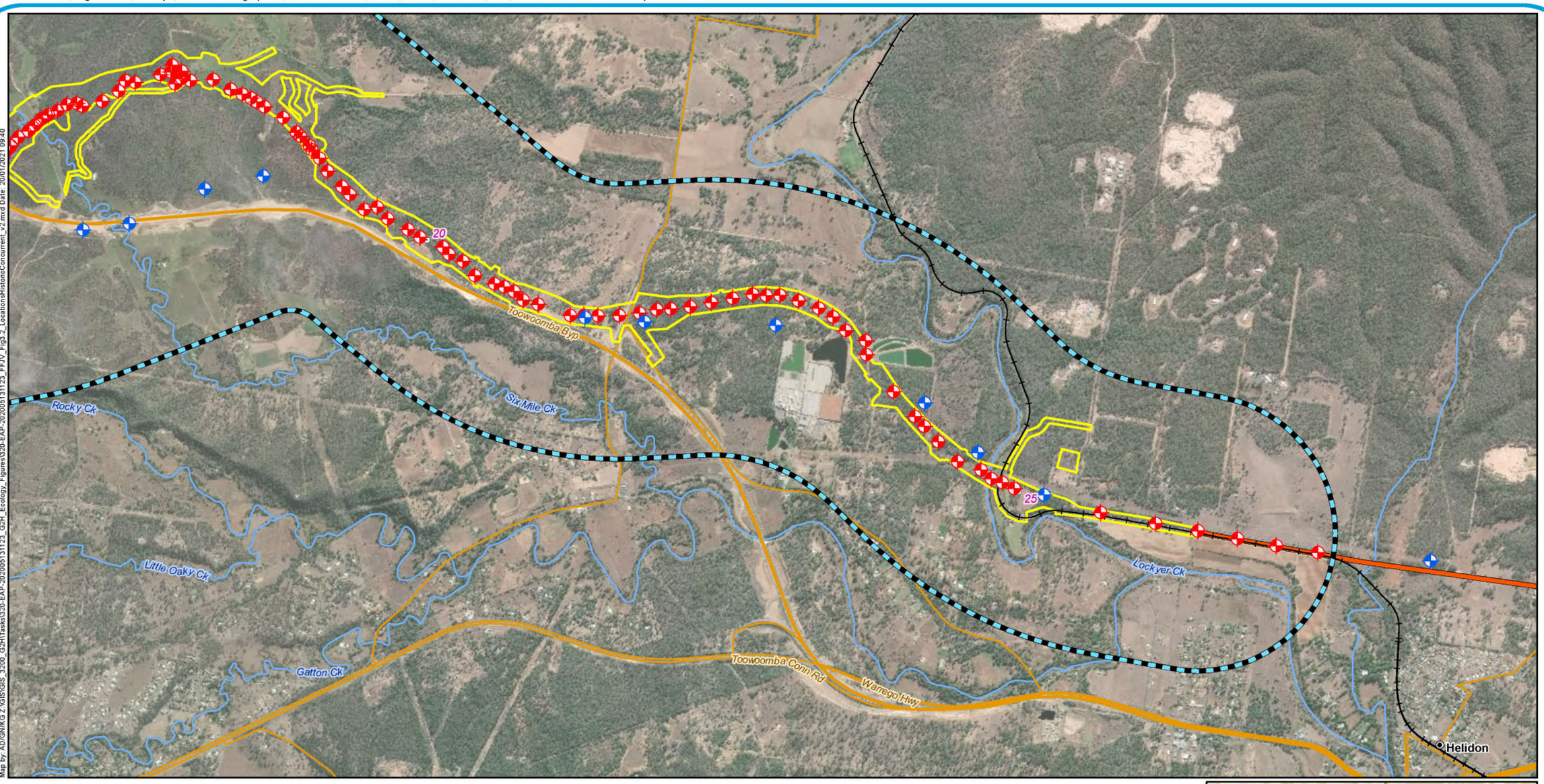
Issue date: 20/01/2021 Version: 0
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

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

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

Map by: AD/GN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig3.2_LocationsHistoricConcurrent_v2.mxd Date: 20/01/2021 09:40



Legend

- 5 Chainage (km)
- Chainage point
- 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)
- Ecology study area
- Local Government Areas

A3 scale: 1:30,000

0 0.5 1 1.5km

Future Freight
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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

3.4.1.2 Project ecological studies

Following the desktop study, sites were selected which were specifically identified as containing features of interest. Specifically, the following features were used to target areas:

- 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)
- Areas containing landscape features that were considered likely to support threatened species when viewed from aerial photography (i.e. Gilgai areas, wetlands and escarpments)
- Areas known or predicted to support threatened and/or conservation significant/migratory and special least concern species
- Areas 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 Section 3.4.2.2). In instances where wetland indicators were present (e.g. macrophytes, topography consistent with wetlands or areas mapped as a wetland), an assessment of the potential of the area to be a wetland was undertaken, recording site-based attributes as required.

At each aquatic ecology sampling location, an Australian River Assessment System (AUSRIVAS) physical assessment protocol was completed to assess the existing physical habitat values of the waterway (refer Section 3.4.4). Where water was present, a surface water quality sample was collected, and baited traps were deployed for a maximum period of 2 hours to target vertebrate species such as fish and turtles in accordance with animal ethic approvals.

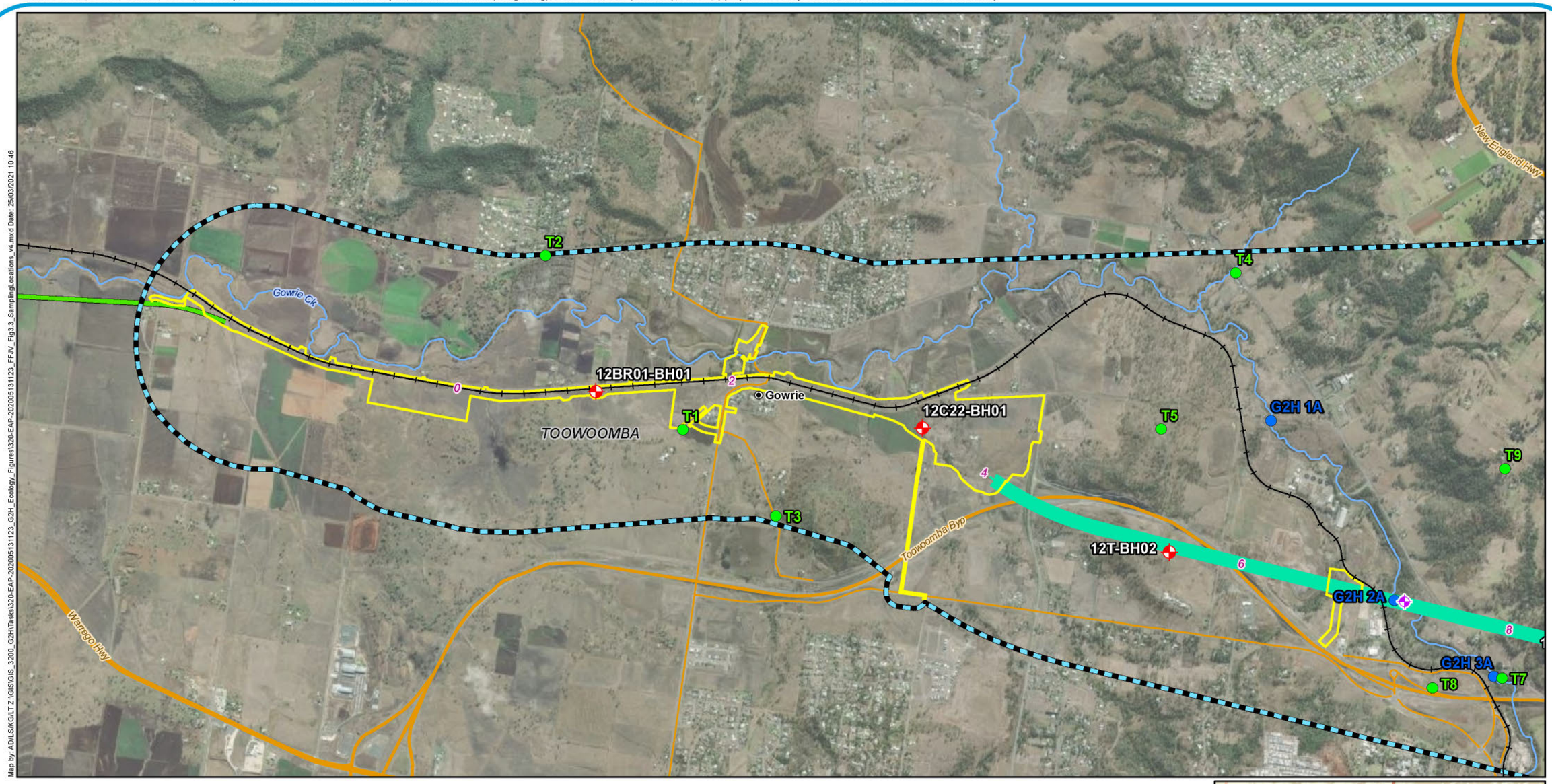
The location of FFJ's survey sites within the ecology study area, and the date of assessment, are presented in Table 3.4 and shown in Figure 3.3. Results associated with field investigations are presented in Section 4.3.

Table 3.4 FFJV field survey sites and date of assessment

Site ID	Site location			Date assessed
	Zone	Latitude	Longitude	
Terrestrial ecology survey sites				
T1	56J	-27.5017696	151.8835596	27 September 2017
T2	56J	-27.49025197	151.8735738	27 September 2017
T3	56J	-27.50747469	151.8903356	27 September 2017
T4	56J	-27.49179064	151.9242918	24 September 2017
T5	56J	-27.50200213	151.9187158	24 September 2017
T7	56J	-27.51849641	151.9436339	27 September 2017
T8	56J	-27.51908925	151.9385050	24 September 2017
T9	56J	-27.50479588	151.9439673	26 September 2017
T12	56J	-27.51820331	151.9658914	23 September 2017
T15	56J	-27.49577278	151.9722255	19 September 2017
T16	56J	-27.51831262	151.9708921	21 September 2017
T17	56J	-27.51906263	151.9758869	21 September 2017
T18	56J	-27.52004720	151.9796545	21 September 2017
T21	56J	-27.52049681	152.0208500	20 September 2017
T22	56J	-27.51786742	152.0179370	18 September 2017
T26	56J	-27.51481438	152.0488447	20 September 2017
T27	56J	-27.51312591	152.0527573	20 September 2017
T28	56J	-27.50763816	152.0528751	22 September 2017

Site ID	Site location			Date assessed
	Zone	Latitude	Longitude	
T29	56J	-27.52986675	152.0627299	22 September 2017
T31	56J	-27.52687918	152.0844754	18 September 2017
T33	56J	-27.53759657	152.0861588	19 September 2017
T34	56J	-27.51725747	152.1026892	21 September 2017
T35	56J	-27.53643839	152.1079817	19 September 2017
Aquatic ecology survey sites				
Condamine River Basin				
G2H 1A (Gowrie Creek)	56J	-27.5015	151.9268	19 September 2017
G2H 2A (Gowrie Creek)	56J	-27.5133	151.9358	19 September 2017
G2H 3A (Gowrie Creek)	56J	-27.5184	151.9430	19 September 2017
Lockyer Creek Catchment				
G2H 4A (Rocky Creek)	56J	-27.5202	151.9865	21 September 2017
G2H 5A (Rocky Creek)	56J	-27.5234	151.9976	21 September 2017
G2H 6A (Rocky Creek)	56J	-27.5275	152.0253	20 September 2017
G2H 7A Alt (Six Mile Creek)	56J	-27.5261	152.0386	22 September 2017
G2H 8A (un-named tributary of Lockyer Creek)	56J	-27.5078	152.0557	21 September 2017
G2H 9A (Lockyer Creek)	56J	-27.5071	152.0808	20 September 2017
G2H 10A Alt (Rocky Creek)	56J	-27.550999	152.120565	22 September 2017
H2C 11A (Lockyer Creek)	56J	-27.550999	152.120565	9 October 2017

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

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

A3 scale: 1:30,000

0 0.5 1 1.5 2 2.5km

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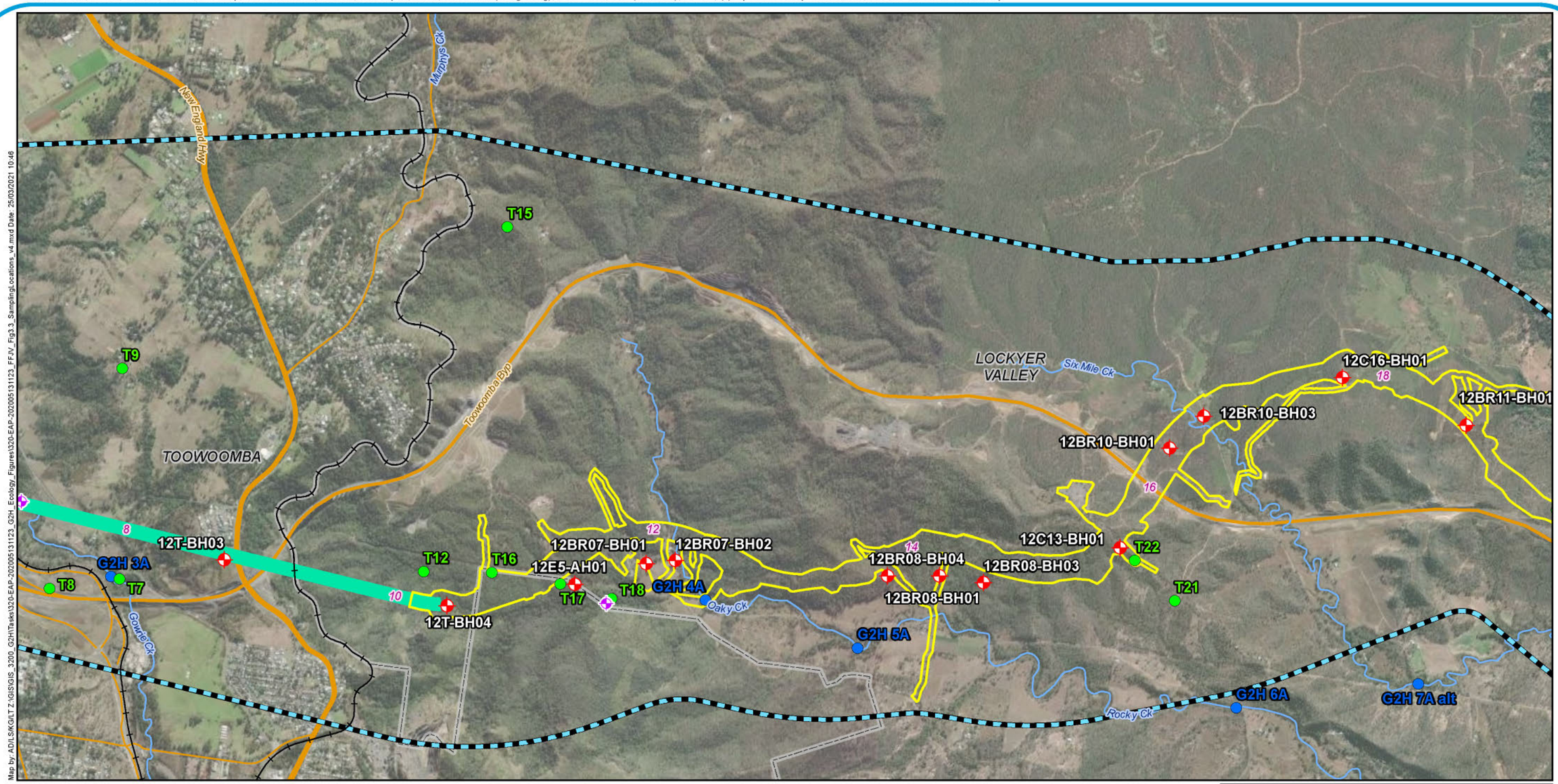
Gowrie to Helidon

Figure 3.3a: Location of sampling locations within ecology 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: ADL S/KG/LT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig3.3_SamplingLocations_v4.mxd Date: 25/03/2021 10:46

Legend

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

A3 scale: 1:30,000

0 0.5 1 1.5 2 2.5km

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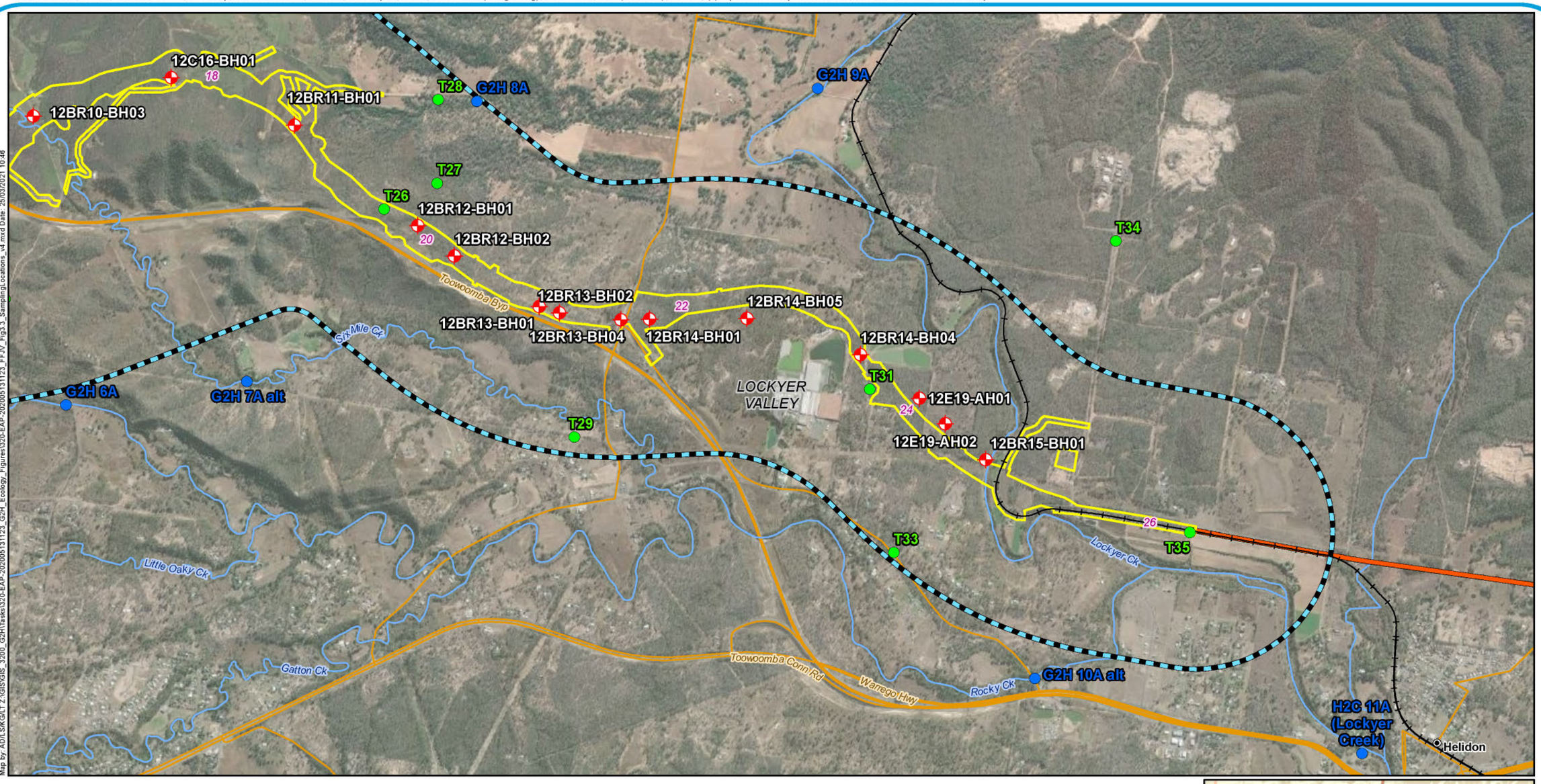
Gowrie to Helidon

Figure 3.3b: Location of sampling locations within ecology 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: AD/LSK/GIS/LT Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig3.3_SamplingLocations_v4.mxd Date: 25/03/2021 10:46

Legend

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

A3 scale: 1:30,000

0 0.5 1 1.5 2 2.5km

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Gowrie to Helidon

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

3.4.2 Terrestrial flora field assessment

The location of terrestrial survey sites was dictated by land access agreements with landholders which were provided on a voluntary basis. This reduced the areas within the ecology study area that were accessible for environmental investigations. However, adoption of the precautionary principle and the modelling approach suitably accounted for deficiencies in land access.

At each target terrestrial survey site for the FFJV studies, a list of all flora species and vegetation communities encountered, were recorded and documented. In addition, opportunistic observations across the ecology study area were used to supplement site specific datasets. Conservation 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 C). As per 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 environmental assessment of a representation of distinctly different vegetation communities identified during the desktop assessments was undertaken in the field. The following approach to sampling was applied:

- Within a representative of each different type of vegetation determined from aerial imagery, an intensive survey occurred, which included an assessment of the relative species density and diversity within the emergent stratum (E), canopy (T1, T2, T3), shrub (S1, S2, S3) and ground (G) strata layers when they were present. Methodologies used were consistent with 'Tertiary level' sites as described by Neldner et al. (2019). Survey transects approximated 100 m in length and 20 m in width.
- 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' site as described by Neldner et al (2019).

A representation of the predictive flora habitat modelling for threatened flora species[3] (refer Section 3.3.4) was verified where applicable during field investigations throughout the ecology study area. This information was fed back into the predictive modelling and refined the model inputs (refer Figure 3.1).

Field verification and refinement of predictive flora habitat mapping were undertaken by comparing the species-specific habitat assumptions derived from the desktop phase (refer Appendix A), to characteristics observed in the field). Where site-based field observations significantly deviate from the desktop derived habitat assumptions, these areas were removed from the predictive habitat mapping.

3.4.2.1 Protected plant surveys

In addition to the methodologies presented above, a random meander survey was undertaken at each target site and each opportunistic site (regardless of their inclusion/exclusion from "High Risk" areas identified in the Queensland Government Protected Plants flora survey trigger map) to specifically target threatened flora species. At each site, the random meander survey was undertaken (as per the QLD Protected plants survey guidelines (DEHP 2016d)) 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 threatened flora species encountered were submitted with the Queensland Herbarium for verification and subsequent 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 protected plant survey guidelines, surveys were carried out within the targeted clearing area with an additional 100 m buffer area applied (i.e. clearing impact area). As outlined in Table 3.3 surveys were undertaken at 50 sites within the Project disturbance footprint.

[3] Species listed as Critically Endangered, Endangered, Vulnerable or Near Threatened under the Nature Conservation Act 1992 (Qld)

3.4.2.2 Survey effort

In addition to the targeted EIS study survey locations identified in Table 3.4 (34 sites within the ecology 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 Project 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 (a, b, c) included 30 sites and ELA (2019a) included 23 sites within the ecology study area). The methods employed are considered to provide an acceptable level of survey effort to sufficiently inform an assessment against the relevant assessment guidelines.

3.4.3 Terrestrial fauna field assessments

Terrestrial fauna and habitat assessments were conducted using the following methodologies as described in the survey guidelines identified at the beginning of this section:

- A general habitat assessment and a record of all fauna encountered (i.e. observed/heard) was undertaken at every vegetation assessment survey site
- Validation of the predictive habitat mapping was undertaken where applicable
- Use of specific techniques to identify conservation significant species and where applicable other fauna species (e.g. identification of scats, specific scratch marks and diggings).

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

Field based methodologies are further described in the sections below. A list of species encountered at each site was recorded (refer Appendix E and Appendix I).

3.4.3.1 Fauna habitat assessments

At each vegetation assessment location (refer ‘terrestrial sampling sites’ in Figure 3.3), 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 ecology 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 = “no disturbance” and 3 = “severe disturbance”) relating to the following:
  - Fire
  - Grazing
  - Clearing
  - Erosion
- List of conservation significant fauna species (i.e. threatened, special least concern and/or migratory species) that are likely to utilise the area based on available habitat types (based on database search results and predictive habitat mapping)
- Availability of tree hollows present in the following categories:
  - > 30 centimetres (cm) diameter
  - >15 cm but < 30 cm diameter
  - >10 cm but <15 cm diameter

  - >5 cm but <10 cm diameter
  - < 5 cm diameter
- Amount of fallen logs (>10 cm diameter)
- Amount of coarse woody debris (<10 cm diameter)
- Quantity 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/quantity of:
  - Soil banks (e.g. riverbeds/road cuttings)
  - Boulders
  - Wetlands/drainage features
- Relative abundance of the following:
  - Flowers
  - Fruit.

All species of fauna observed were identified to the species level where possible.

3.4.3.2 Targeted fauna survey methods

When areas were identified as containing habitat considered likely to support conservation significant 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 conservation significant species, without increasing the species risk of harm or placing stress upon the animal (i.e. animals sampled ethically and humanely).

Specific techniques adopted as part of the ecological assessments include:

- 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 those of birds of prey in suitable riparian areas during the EIS studies and by EMM (2018a, 2018b, 2019c) and ELA (2019a) during targeted pre-clearance surveys (2018 and 2019). Refer to Table 3.3 for details.
- 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 and MSES species including but not limited to the Swift parrot (*Lathamus discolor*), Painted honeyeater (*Grantiella picta*) and Australian painted snipe (*Rostratula australis*), Powerful owl (*Ninox strenua*) and Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) and migratory birds such as the Black-faced monarch (*Monarcha melanopsis*), Glossy ibis (*Plegadis falcinellus*), Rufous fantail (*Rhipidura rufifrons*), Satin flycatcher (*Myiagra cyanoleuca*) and Spectacled monarch (*Symposiachrus trivirgatus*) 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 arboreal mammals (e.g. Koala and gliders) 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), EMM (2018a, 2018b, 2019c) and ELA (2019a) (refer Figure 3.2a-c for locations). Refer to Table 3.3 for details.
- Active searches for Powerful owl (*Ninox strenua*) pellets and Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) orts (chewed *Allocasuarina littoralis* and *Allocasuarina torulosa* cones) within suitable habitat
- Active search for latrine sites and dens for the terrestrial mammals within suitable rocky habitat as part of the EIS studies and ELA (2019a)
- Active search for scats and breeding dens for the Short-beaked echidna (*Tachyglossus aculeatus*).
- Active searches for macropods 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 2010). Carried out for the EIS studies, Arup (2016) and ELA (2019a).
- Active searches for reptiles at all EIS assessment sites including cryptic species. 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.

In addition to these techniques, analysis of observed scats and scratch marks on trees were used to assess/confirm the presence of other conservation significant species (e.g. Koala). Other species encountered during these works were recorded, along with opportunistic observations (all fauna species), refer Appendix I for more details.

Field based fauna surveys aided in the identification of sensitive environmental receptors for the Project. In addition, extant fauna species were identified and predictive fauna habitat modelling (refer Section 3.3.4) was verified where applicable.

A representation of the predictive fauna habitat mapping was undertaken by comparing the species-specific habitat assumptions derived from the desktop phase, to characteristics observed in the field. The predictive habitat mapping values were re-assessed based on field observations to include important values that may not have been mapped during the desktop phase. In addition, where a conservation significant species was observed, these areas were elevated in status to either general habitat (for areas that were not currently mapped as general habitat for the species), or essential habitat (for locations that were already included within the general habitat mapping layer) (refer Section 3.3.4 and Appendix A for further details).

3.4.3.3 Pre-clearance habitat surveys

In addition to the fauna survey methods employed for the EIS studies identified above (i.e. FFJV 2017) a large number of 'preclearance surveys' associated with vegetation clearing for geotechnical works (largely boreholes and access tracks) have been completed during 2018 and 2019 (i.e. EMM and ELA). These surveys were assessed to further inform the Project EIS studies and as part of requirements under QLD legislation. Surveys undertaken by EMM and ELA included approximately 140 km of random meander searches, incorporating an area of approximately 604 ha. Noting that some areas were surveyed multiple times between 2016 and 2020.

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.

3.4.4 Aquatic field assessment

A total of 11 sites were selected for aquatic habitat assessments based on wetland and watercourse mapping and land access (refer Table 3.4). 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 ecology study area. The AUSRIVAS Physical Assessment Protocol (Parsons et al. 2002) a physical and geomorphological assessment protocol, was used to assess the physical condition of the major watercourse (Gowrie Creek, Rocky Creek, Six Mile Creek and Lockyer Creek) traversed by the Project.

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 bank full 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.

The habitat value of each aquatic ecology assessment site was assessed to predict the nature of faunal assemblages utilising the watercourse. Due to the locality of the Project disturbance footprint, the habitat assessment was conducted for low gradient flow watercourses. Habitat scores were produced as a sum of the scores for each of the assessment parameters and were then broadly associated with category thresholds of poor (0-25 per cent), fair (25-50 per cent), good (50-75 per cent), and excellent (75-100 per cent). The percentage is a function based on the sum of scores (i.e. out of a potential total sum of scores).

Recordings of incidental fauna and flora 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 and did not exceed two hours at any site to reduce risk of harm to species and minimise field survey effort, whilst dip netting was completed on an incidental basis to address size-specific constraints associated with baited traps.

During the aquatic ecology field investigations, data was collected with respect to any aquatic invasive species and other disturbances present within or affecting the aquatic environments.

Macroinvertebrate sweeps were excluded as part of the aquatic ecology field survey methodology due to the highly ephemeral nature of watercourses in the ecology study area.

The aquatic ecology field investigations were conducted at the same locations and at the same time as the first round of the Project's surface water quality monitoring works. At each aquatic ecology field investigation site, the surface water quality information as identified in Section 4.3.5 was collected where possible (i.e. pending the availability of water).

3.4.4.1 In-situ analysis of surface water quality

Three discrete water sampling events were undertaken: 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.

A fully serviced and calibrated YSI Professional Plus water quality meter and a TPS WP-88 Turbidity Meter were employed to record the following *in situ* water quality parameters at each surface water quality monitoring site:

- pH
- Temperature
- Electrical conductivity (actual and specific)
- Salinity
- Dissolved oxygen (dissolved and saturated)
- Turbidity.

Additionally, the following qualitative data was recorded:

- Time
- Water flow (none/low/moderate/high/flood/dry)
- Clarity (clear/slight/turbid/opaque/other)
- Odour (normal/sewage/hydrocarbon/chemical)

- Surface condition (none/dust/oily/leafy/algae)
- Algae cover (none/some/lots)
- Other visual observations/comments (e.g. colour, fish, presence of litter)
- A photograph and GPS point.

3.4.4.2 Laboratory analysis of surface water quality

Surface water quality samples were collected at each surface water quality monitoring site in accordance with the DES Monitoring and Sampling Manual (DES 2018c) and Australian standards.

Where practical, surface water quality samples were collected from the centre of the watercourse, where the velocity was the highest. The mouth of the sampling container was held above the base of the channel to avoid disturbing or collect any settled solids or materials.

The surface water quality samples were collected directly into the appropriate sampling bottles provided by the laboratory to avoid potential contamination associated with the use of intermediate containers. Where a sampling pole was required to be used to enable safe sample collection, the sampling bottle was placed on the pole and the sample was collected directly into the sampling bottle. In instances where preservatives were contained within a sample bottle, these were filled by pouring water from a site-specific clean collection bottle. Syringes and filters were flushed with water from the sampling site prior to use.

The surface water samples were placed directly into a clean, insulated box and kept cool via the use of ice and freezer blocks. One duplicate sample was collected per sampling visit for quality assurance/quality control purposes. The surface water quality samples were submitted to a National Association of Testing Authorities (NATA) accredited laboratory (Eurofins) for analysis.

- Field and laboratory results were compared against Lockyer Creek catchment and Condamine River Basin WQO and trigger values as well as the Australia and New Zealand Environment and Conservation Council (ANZECC)/Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines (ANZECC/ARMCANZ 2000).
- Further information regarding the assessment of surface water quality against water quality objectives is provided in EIS Appendix L: Surface water quality.

3.4.5 Permits to conduct works

The FFJV ecological field surveys reported in this document were conducted under the provisions of FFJV Partners Aurecon and AECOM via 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). These permits were issued by the QLD Government.

3.4.6 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 the Flora Survey Guidelines (DEHP 2016d) was present within each survey team
- A portion of any threatened flora species (as listed under the NC Act) encountered, or species that could not be confidently identified during field recognisance, was submitted to the QLD Herbarium for verification/identification
- 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.
- Scats/pellets that were collected in the field were taken to the QLD Museum for species confirmation

- Any conservation significant fauna species had to be sighted/confirmed by both members of the field team to produce a confirmed record. Where applicable/possible, proof (e.g. photograph, scat or other evidence) was collected.
- At least one suitably qualified person with AUSRIVAS accreditation was present within each survey team for the aquatic ecology habitat surveys
- 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 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.

3.4.7 Nomenclature

3.4.7.1 Flora

The source of nomenclature for the flora sections of this report is the Census of the QLD Flora (QLD Government 2016). 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).

3.4.7.2 Fauna

The sources of nomenclature for the fauna sections of this report follows the Birdlife Australia working list V3 (Birdlife Australia 2019) (for birds) and DES' WildNet database taxonomy (for all other fauna), unless otherwise noted.

3.5 Impact assessment methodology

The terrestrial and aquatic impact assessment of the Project uses a significance-based impact assessment approach to identify and assess Project related impacts in relation to sensitive environmental receptors.

For the purpose of this assessment, terrestrial and aquatic ecology was assessed both quantitatively (e.g. flora) and qualitatively (e.g. fauna/habitat). A significant impact depends upon the sensitivity of the sensitive environmental receptor, the quality of the environment which is impacted, and upon the magnitude of the potential impact. These key factors are discussed below.

3.5.1 Magnitude of impacts

The magnitude of a potential impact is essential to the determination of its level of significance on a sensitive environmental receptor. 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 3.5). The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the **extent**, **duration** (refer Table 3.6) and **frequency** of the impacts.

Table 3.5 Criteria for magnitude

Magnitude	Description
Major	An impact that is widespread, permanent and results in substantial irreversible change to the sensitive environmental receptor. Avoidance through appropriate design responses or the implementation of environmental management controls are required to address the impact. (e.g. greater than 50 per cent 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 sensitive environmental receptor. 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 per cent 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 per cent 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 per cent 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 per cent of the habitat within the greater area disturbed).

Table 3.6 Timeframes for duration terms

Duration term*	Timeframe – to be defined for each activity type (refer Table 5.1)
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 10 years[1]
Long term/long lasting	From 10 to 21 years[2]
Permanent	More than 21 years[3]

Table notes:

* Duration terms are applicable to project activities, and not specific to species and their associated habitats

1 Derived from the term 'moderate' Environmental Assessment and Management (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)

3.5.2 Sensitivity

To assess the significance of potential impacts on sensitive environmental receptors, sensitivity categories are applied to each of the features. The sensitivity categories are split into five discrete groups as described in Table 3.7. These groupings are based on qualitative assessments utilising information related to the sensitivity of the sensitive environmental receptor, in addition to the potential of a sensitive environmental receptor's occurrence within the receiving environment.

Through the determination of sensitivity categories for each of the sensitive environmental receptors, 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.

Each particular sensitive environmental receptor is treated individually even where overlap of more than one sensitive environmental receptor in the same location occurs. In the case where there are conflicting classes, the "worst-case" is taken.

Table 3.7 Sensitivity criteria for sensitive environmental receptors within the ecology study area

Sensitivity	Description
Major	▪ The sensitive environmental receptor is listed on a recognised or statutory state, national or international register as being of conservation significance ▪ The sensitive environmental receptor is entirely intact and wholly retains its intrinsic value ▪ The sensitive environmental 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 environmental receptor is listed on a recognised or statutory state, national or international register as being of conservation significance ▪ The sensitive environmental receptor is relatively intact and largely retains its intrinsic value ▪ The sensitive environmental 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 environmental 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 environmental receptor is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers ▪ The sensitive environmental 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 environmental 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 environmental 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.
Low	▪ The sensitive environmental receptor is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations (e.g. historical societies) ▪ The sensitive environmental receptor is in a poor to moderate condition as a result of threatening processes, which have degraded its intrinsic value ▪ It is not unique or uncommon and numerous representative examples exist throughout the system/area ▪ It is abundant and widely distributed throughout the host systems/areas ▪ There is no detectable response to change or change does not result in further degradation of the environmental value ▪ The abundance and wide distribution of the sensitive value ensures replacement of unavoidable losses is achievable.
Negligible	▪ The sensitive environmental receptor is not listed on any recognised or statutory register and is not recognised locally by relevant suitably qualified experts or organisations ▪ The sensitive environmental receptor is not unique or uncommon and numerous representative examples exist throughout the system/area ▪ There is no detectable response to change or change does not result in further degradation of the sensitive value.

3.5.3 Significance of impact

The significance of a potential impact is a function of an impacted sensitive environmental receptor’s **sensitivity** and the **magnitude** of the potential impact. Although the sensitivity of the sensitive environmental receptor will not change (i.e. is generally determined qualitatively by the interaction of its 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 **sensitivity** of the relevant sensitive environmental 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 five matrix (refer Table 3.8).

Table 3.8 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 note:
Significance categories as identified in Table 3.8 are defined in Table 3.9.

Table 3.9 Significance classifications

Significance rating	Description
Major	Arises when an impact will potentially cause irreversible or widespread harm to a sensitive environmental receptor 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 sensitive environmental receptor. 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 sensitive environmental receptor 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 a sensitive environmental receptor 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 a sensitive environmental receptor. This typically occurs where the activities are located in already disturbed areas.

Significance ratings of Low, Moderate, High and Major are considered to constitute a potential significant residual impact to sensitive environmental receptors, and were subsequently assessed against the relevant significant impact guidelines (i.e. MNES or MSES guidelines) where available, to confirm the initial impact assessment results (refer Section 5.3.3 and Section 5.3.4).

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

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

- Construction (including pre-construction)
- Commissioning and reinstatement
- Operation.

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

3.5.4 Significant residual impact assessment

An assessment under the relevant significant impact guidelines (MNES (DotE 2013) or MSES (DSDIP and 2014a)) was only undertaken for sensitive environmental receptors that returned a Major, High, Moderate or Low significance rating for the Project. Sensitive environmental receptors that returned a significance rating of Negligible for the Project (as well as those for which habitat had not been identified within the ecology study area), were omitted from further assessment.

Sensitive environmental receptors were assessed against the following guidelines as relevant:

- Significant Residual Impact Guidelines for matters of state environmental and prescribed activities assessable under the Sustainable Planning Act 2009, Queensland Environmental Offsets Policy December 2014 (DSDIP 2014)
  - MSES – Section 5.3.4.
- Significant Residual Impact Guideline (*Nature Conservation Act 1992 Environmental Protection Act 1994 Marine Parks Act 2004*) (DEHP 2014a)
  - MSES – Section 5.3.4.
- Significant impact guidelines 1.1 – Matters of National Environmental Significance: *Environmental Protection and Biodiversity Conservation Act 1999* (DotE 2013)
  - EPBC Act Migratory species – Section 5.3.3.

Following the identification of the level of significance using initial impact mitigation measures, proposed mitigation measures were then applied to the potential impacts to identify the residual (mitigated) impacts in a tabular form. Assessment of significant residual impacts to MNES (migratory species) and MSES was undertaken using the MNES and SRI guidelines respectively.

3.6 Cumulative impact assessment methodology

When numerous projects occur in a region, they may 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.

3.6.1 Project selection

Projects for inclusion in the cumulative impact assessment are all those within the Project region 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 (formerly Department of State Development, Manufacturing, Infrastructure and Planning (DSDMIP)) website.
- Are currently being assessed under Part 1 of the Chapter 3 of the EP Act.
- 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 3.10 identified 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 3.10 include infrastructure development projects located in proximity to the Project.

Table 3.10 Projects 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.

Table notes:

Unknown = information not publicly available
Selection criteria based on the criteria detailed in EIS Chapter 22: Cumulative impacts

a) 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, Manufacturing, Infrastructure and Planning (DSDMIP) website.
b) 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 ARTC Inland Rail Project.
c) Could potentially compound residual impacts that the ATRC Inland Rail Project may have on environmental or social values

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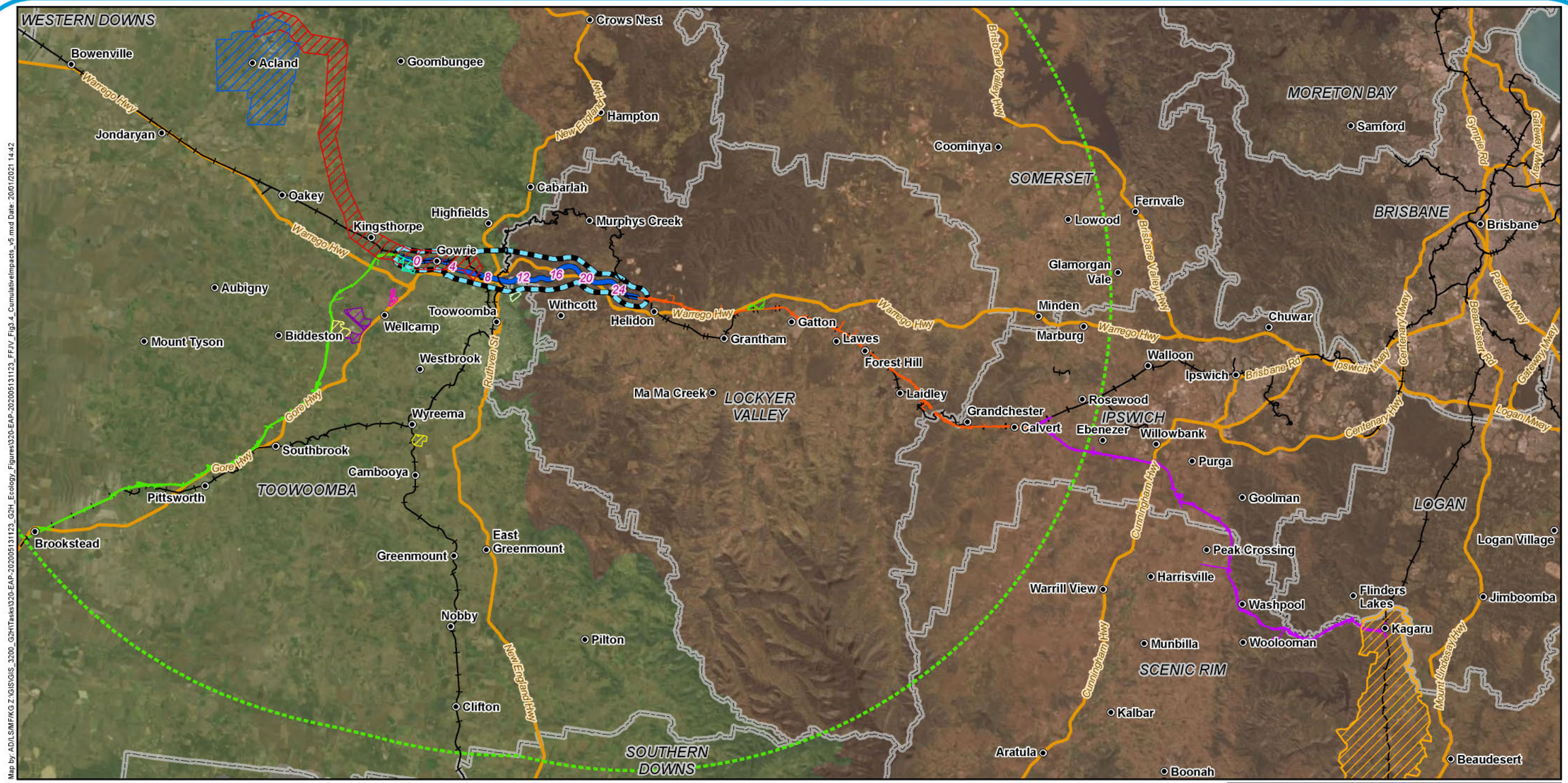

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Legend

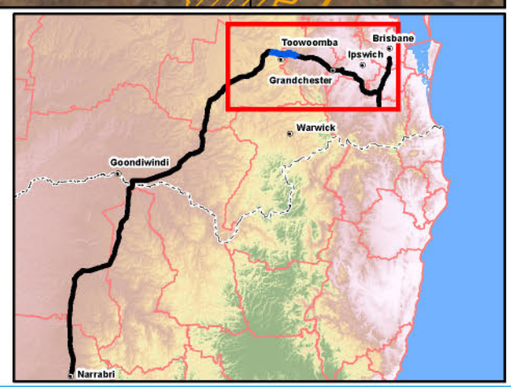
- Localities
- G2H project alignment
- Existing rail
- Major roads
- Ecology study area
- Local Government Areas
- Cumulative project area

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

- Brigalow Belt South
- South Eastern Queensland



A3 scale: 1:450,000

0 5 10 15 20 25 km

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Gowrie to Helidon

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

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.

3.6.2 Approach

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

- A review of the potential impacts identified within the EIS assessments:
  - The environment at the time of the Project 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:
  - Identification of projects outside of the Inland Rail Program
  - Only projects that are in the public domain as being planned, constructed or operated at the time of the EIS ToR have been considered
  - Where additional projects worthy of consideration have arisen after the finalisation of the EIS ToR, the Coordinator-General has been consulted to determine if assessment is required
  - The Inland Rail projects immediately adjacent to the project within the assessment. For this Project, the B2G and H2C 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 3.6.3) has been used to determine the significance of cumulative impacts with respect to detrimental effects
- Where cumulative impacts are deemed to be of ‘medium’ or ‘high’ significance, additional mitigation measures are proposed, beyond those already proposed by the relevant technical impact assessments.

3.6.3 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 3.11.

The significance of the impact has been determined by using professional judgement to select the most appropriate relevance factor for each aspect in Table 3.11 and summing the relevance factors. The sum of the relevance factors determines the impact significance and consequence which are summarised in Table 3.12. 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 3.11 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 3.12 Impact significance

Impact significance	Sum of relevant factors	Consequence
Low	1 to 6	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	7 to 9	Mitigation measures likely to be necessary and specific management practices to be applied. Specific approval conditions are likely. Targeted monitoring program required, where appropriate.
High	10 to 12	Alternative actions should be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary, where appropriate.

4 Description of environmental values

4.1 Overview

This section describes the environmental values of the ecology study area including the results of the desktop analysis, field survey and predictive habitat mapping. This section then defines the sensitive environmental receptors of the ecology study area which are the scope of the impact assessment presented in Section 5.

4.1.1 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 ecology study area). The ecology study area is characterised by non-remnant vegetation comprised of cleared pastures and cropping in the west (i.e. Brigalow Belt Bioregion) and larger, contiguous extents of remnant vegetation in the east (i.e. SEQ Bioregion). The ecological value of this habitat varies depending on extant land use and its intensity.

The ecology 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, 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 ecology 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.

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

Photograph 4.2 **Intact mature forest associated with the Toowoomba range within the ecology study area**

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 ecology study area provide for habitat connectivity.

Vegetation in the ecology study area, particularly within the Toowoomba Range, provides habitat for a variety of conservation significant flora and fauna species listed at both the commonwealth and State levels (e.g. Koala, Brush-tailed rock-wallaby, Glossy black-cockatoo and Powerful owl).

There are a number of protected areas to the north and northeast of the ecology 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 northeast of the eastern extent of the Project).

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 ecology 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.

4.1.2 Geology

The geology of the ecology study area includes three broad geological divisions; Tertiary Main Range Volcanics, Jurassic Marburg Formation (Koukandowie Formation and Gatton Sandstone) and Quaternary Alluvium and Colluvium.

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 Main Range Volcanics (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.

4.1.3 Surface water catchment values

The Project travels through two catchment areas, the Lockyer Creek Catchment and the Condamine River Basin.

The western extent of the Project (Ch -1.76 km to Ch 8.8 km), including the majority of the Toowoomba Range Tunnel, is located in Gowrie Creek catchment which is part of the Upper Oakey sub-catchment. The Healthy Waters Management Plan: Condamine River Basin (DES 2019a) notes that the trunk streams of Oakey Creek sub-catchment have differing water chemistry to that of tributaries and floodplains. The catchment has been heavily influenced by the adjacent land use (sewage treatment plant, urban) with the majority of the catchment cleared, including in parts the riparian zone of Gowrie Creek and associated tributaries.

The Condamine River Basin is one of the largest catchments in the Murray Darling Basin (Murray Darling Basin Authority (MDBA) 2018). The main rivers of the catchment, the Condamine and the Maranoa, rise in elevated country in Queensland. However, two-thirds of the catchment is flat floodplain country, with a complex system of rivers and creeks joining and breaking away from the Balonne River across the catchment. The catchment's extensive floodplains provide habitat for a diverse range of plants and endangered plant communities (MDBA 2018). The region also provides habitat for water birds, native fish and many vulnerable and endangered species. The region is significant for its agricultural diversity, with a wide range of winter and summer crops produced on the Darling Downs, as well as very large cotton production areas in the west (MDBA 2018). Gowrie Creek is the largest of Toowoomba's urban creeks. The catchment drains northerly through the city of Toowoomba and includes East and West creeks which converge to form Gowrie Creek near the city centre. North of urban extent of Toowoomba the Gowrie

Creek floodplain traverses a primarily rural landscape, until Birnam (east) where the watercourse flows easterly through Gowrie Junction and Kingsthorpe towards the township of Oakey. The Project is primarily located within the Gowrie Creek floodplain between Charlton and Mount Kynoch. Flows within the Gowrie Creek are also influenced by releases from Wetalla Wastewater Treatment Plant and by Groundwater-surface water interactions between the Main Range Volcanic aquifer and surrounding Quaternary Alluvium (refer EIS Appendix N – Groundwater Technical Report for further information).

Gowrie Creek is a perennial system which 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 eastern extent of the Project (Ch 8.8 km to Ch 26.2 km) is located east of the GDR and as such many of the waterways can experience high flows despite the relatively low rainfall (DES 2015). The upper catchment remains mostly forested whereas the mid and lower catchment of Lockyer Creek catchment has been largely cleared. Lockyer Creek enters the Brisbane River below Wivenhoe Dam and in high flow events it can impact downstream areas through flooding and siltation. Of significance is the potential impact on the Mt Crosby Weir and surrounding catchment, which is the main water supply intake for the region and provides drinking water for three million people in SEQ.

The Project crosses Oaky Creek, Rocky Creek, Six Mile Creek, and Lockyer Creek.

4.1.4 Groundwater values

The groundwater 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 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.

Groundwater quality within the ecology 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 ecology 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 ecology study area. There are numerous moderate potential terrestrial GDEs (from regional studies) in the ecology study area (refer Section 4.3.8).

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).

4.2 Results of desktop study

The following subsections provide a comprehensive description of the desktop study results within the ecology study 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.

4.2.1 Flora

4.2.1.1 NC Act threatened flora species

A total of 25 threatened flora species identified under the provisions of the NC Act have been identified from database searches applicable to the Project (refer Table 4.1). Of these species 20 have the potential to occur within the ecology study area based on known populations and distribution and habitat requirements, with the remaining five species unlikely to occur given the species distribution range relevant to the Project (refer Appendix B).

Of these 25 threatened flora species, 20 are also listed as MNES (i.e. identified as threatened species under the EPBC Act). For further information related to these 20 MNES flora species, refer to EIS Appendix J: Matters of National Environmental Significance as they are not discussed further within this document.

The remaining five threatened flora species (i.e. those species listed solely under the provisions of the NC Act) have been identified from databases searches associated with the ecology study area (refer Table 4.1 and Appendix B for species profiles) and are considered to have a likely or possible occurrence within the ecology study area.

- Bailey's cypress (*Callitris baileyi*) which is listed as Near Threatened under the NC Act and has the possibility to occur within the ecology study area
- Caustis (*Caustis blakei subsp. macrantha*) which is listed as Vulnerable under the NC Act and has the possibility to occur within the ecology study area
- *Cyperus clarus* which is listed as Vulnerable under the NC Act and is likely to occur within the ecology study area
- Finger panic grass (*Digitaria porrecta*) which is listed as Near Threatened under the NC Act and is likely to occur within the ecology study area
- Slender milk vine (*Marsdenia coronata*) which is listed as Vulnerable under the NC Act and is likely to occur within the ecology study area.

The location of desktop-derived species records in the ecology study area are shown in Figure 4.1. Noting that a number of the records are from ecological surveys undertaken in the area to support the Project (refer Section 4.3.1).

Table 4.1 Threatened flora species identified from the desktop assessment and their likelihood of occurrence within the ecology study area

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Apocynaceae	*Marsdenia coronata**	Slender milk vine	V				Likely
Asteraceae	*Picris evae*#	Hawkweed	V	✓		✓	Likely#
Asteraceae	*Rhaponticum australe*#	Austral cornflower	V	✓		✓	Likely#
Brassicaceae	*Lepidium peregrinum*#	Wandering pepper-cress	E			✓	Possible#
Cupressaceae	*Callitris baileyi**	Bailey's cypress	NT				Possible
Cyperaceae	*Caustis blakei* subsp. *macrantha**	Caustis	V				Possible

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Cyperaceae	*Cyperus clarus**	A sedge	V				Likely
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	NT			✓	Possible[#]
Orchidaceae	*Sarcochilus hartmannii*[#]	Waxy sarcochilus	V			✓	Possible[#]
Orchidaceae	*Sarcochilus weinthalii*[#]	Blotched sarcochilus	E			✓	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	*Digitaria porrecta**	Finger panic grass	NT		✓		Likely
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*	E			✓	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 2020c)

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Surianaceae	*Cadellia pentastylis*[#]	*Ooline*	V			✓	Unlikely[#], outside of its range. Occurs west of the Great Dividing Range

Table notes:

V = Vulnerable NT = Near threatened PMST = EPBC Act Protected matters search tool
✓ = species present within database record within the ecology study area
* = species identified from Back on Track datasets or field based surveys

[#] = MNES species. These species are discussed further in EIS Appendix J: Matters of National Environmental Significance and are not discussed further within this technical report.

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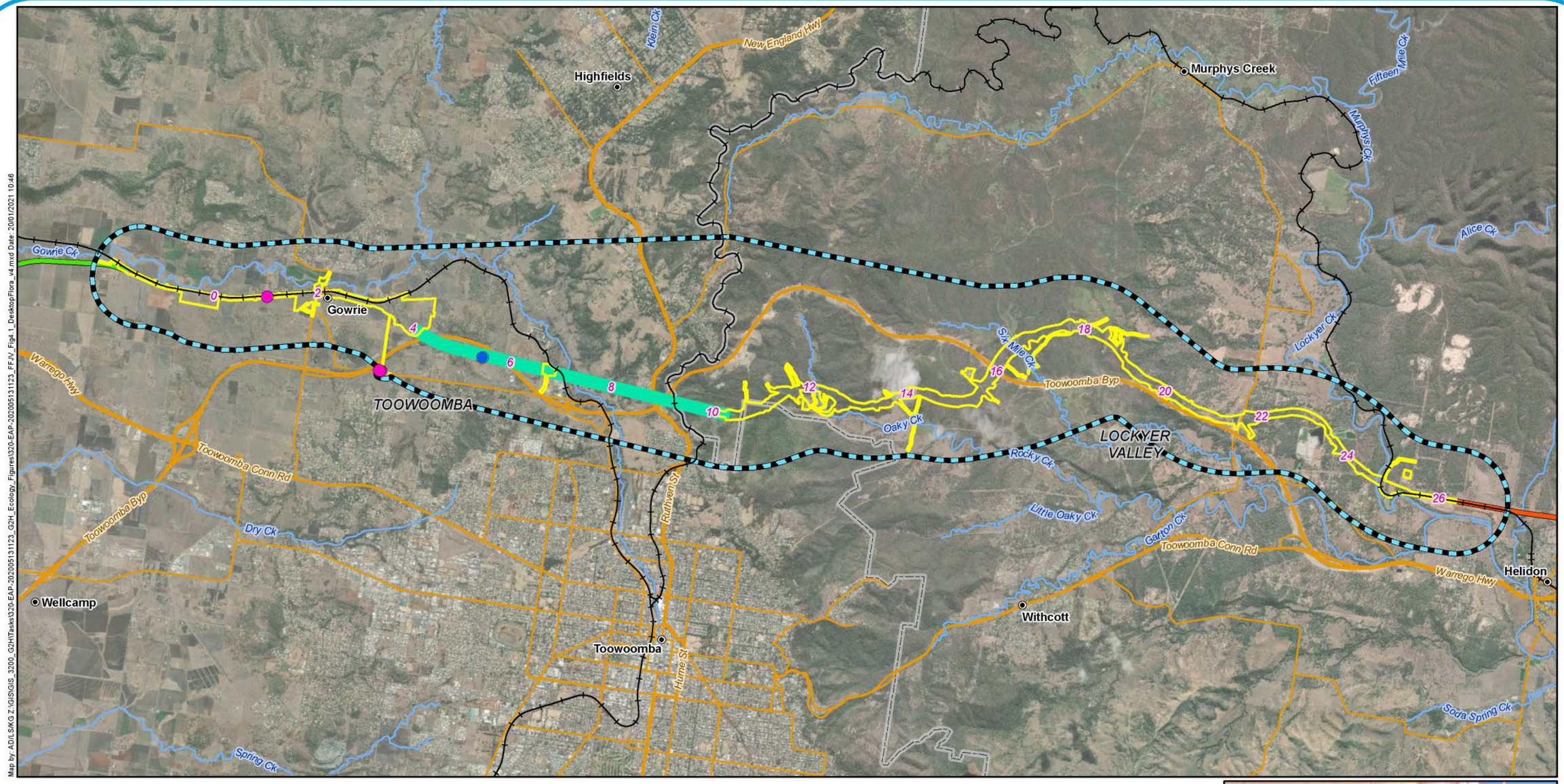

Map by: AD/LS/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4_1_DesktopFlora_v4.mxd Date: 20/01/2021 10:46

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)
- Ecology study area
- Local Government Areas

Flora species records

- Finger Panic Grass (*Digitaria porrecta*)
- Cyperus Clarus (*Cyperus clarus*)

A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.1: Location of specimen backed records of conservation significant flora species derived from desktop assessments (excluding MNES species)

4.2.1.2 Priority back on track flora species

A total of 34 non-MNES, Back on Track priority flora species are listed across the SEQ and Condamine NRM regions (DERM 2010) (refer Table 4.2). This includes two threatened species (i.e. Bailey's cypress (*Callitris baileyi*) and Caustis (*Caustis blakei subsp. macrantha*)) identified from databases searches summarised in Table 4.1.

Flora species that are listed as threatened under the EPBC Act (i.e. MNES), which are also listed as Back on Track species (e.g. 29 species including Austral cornflower (*Rhaponticum australe*)) have not been included within in Table 4.2. These species are assessed within EIS Appendix J: Matters of National Environmental Significance.

Of the 34 Back on Track priority flora taxa five species have potential to occur within the ecology study area based on known populations and distribution and habitat requirements, with the remaining 29 species unlikely to occur given the species distribution range relevant to the Project (refer Table 4.2). It is noted that many of the species listed in Table 4.2 are not geographically located within proximity to the ecology study area as the Back on Track priority species are identified on a bioregional scale.

Where those Back on Track species are identified as being potentially present in the ecology study area, but not listed under either the NC Act or the EPBC Act, they have been considered as sensitive environmental receptors potentially impacted by the Project (refer Section 4.4.2) and are assessed as such within the impact assessment section (refer Section 5.2.3).

Table 4.2 Back on Track priority flora species for the SEQ and Condamine natural resource management regions and likelihood of occurrence within the ecology study area

Species name[1]		Back on Track status (SEQ/ Condamine NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Acacia baueri subsp. *baueri*	Tiny wattle	High priority	V	Found on infertile and often seasonally waterlogged sands in coastal heath (wallum) habitat and adjacent plateaus and low open woodland (Wetland Info 2013).	Unlikely, outside of the species extant distribution
Acacia saxicola	Mt. Maroon wattle	High priority	E	Occurs in heath at an altitude of approximately 900 m above sea level. It grows on rocky slopes, in soil pockets within rock crevices (Wetland Info 2013).	Unlikely, outside of the species extant distribution
Aponogeton elongatus subsp. *elongatus*	-	High priority	NT	Grows in rivers and streams with thick sediments or in floodplain billabongs (Wetland Info 2013).	Unlikely, outside of the species extant distribution
Arthropodium sp. (Mt Cordeaux P.I.Forster+ PIF22065)	-	Critical priority	LC	The following description has been inferred from information on the genus as no species-specific information was available. Moderately widespread in open-forests of foothill country (Royal Botanic Gardens Foundation Victoria 2015).	Possible – information deficient species
Blandfordia grandiflora	Christmas bells	High priority	E	It is usually found in wet coastal heaths on sandy soils (Australian Native Plants Society 2017).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution

Species name[1]		Back on Track status (SEQ/ Condamine NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Boronia safrolifera	-	High priority	LC	Occurs in swamps or badly draining, wet, sandy areas in heath (wallum) (Wetland Info 2013).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Brunoniella spiciflora	-	High priority	LC	Grows along creeks and gullies in rainforest, vine forest and wet sclerophyll forest. It has been recorded growing in dark, loamy, alluvium and volcanic soils (Wetland Info 2013).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Callitris baileyi	Bailey's cypress	Critical priority/ High priority	NT	Grows on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, blue gum and spotted gum. The NSW population occurs in an open grassy eucalypt forest near a creek (Wetland Info 2013).	Possible
Caustis blakei subsp. *macrantha*	-	Critical priority	V	Inhabits tall open eucalypt forests with a sparse canopy, on sandstone ridges and soils derived from weathered sandstone (Wetland Info 2013).	Possible
Chamaecrista maritima	-	High priority	LC	Grows in open situations on grassy windswept headlands and hillsides near the sea. It also occurs in open eucalypt forest, wallum heath, grassy shrubland and sandstone rocks. It occurs mainly on sandy soils and near sandstone rocks (Wetland Info 2013).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Corynocarpus rupestris subsp. *arborescens*	Southern corynocarpus	High priority	V	Inhabits dry rainforest on steep, rocky basaltic slopes. Persists in areas where fire is excluded due to the terrain and lack of ground litter (Threatened Species Scientific Committee (TSSC) 2008a).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Cupaniopsis newmanii	Long-leaved tuckeroo	High priority	NT	Grows on the margins and in warmer rainforest (PlantNet 2018).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Discaria pubescens	-	High priority	NT	Grows in woodland and forest on soils derived from granite or traprock, or sometimes on heavy, sometimes rocky, basalt-derived soils in woodland and grassland vegetation (Wetland Info 2013).	Unlikely, there are no current records for this species in proximity to the ecology study area

Species name[1]		Back on Track status (SEQ/ Condamine NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Diuris parvipetala	-	High priority	V	*Diuris parvipetala* grows among grass in open forests, on ridges and gentle to steep slopes, among basalt boulders and on granite pavements. It grows in shallow, brown, basalt loam soils. (Stanley & Ross 1983; Herbrecs 2008).	Unlikely, there are no current records for this species in proximity to the ecology study area
Durringtonia paludosa	-	Critical priority	NT	Grows in closed sedgeland communities in coastal swamps (PlantNET 2018).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Eleocharis blakeana	-	High priority	LC	*Eleocharis blakeana* occurs on plains and low undulating country on poorly drained, clayey soils. It commonly grows in ephemeral wet habitats in melon hole country in brigalow and belah woodlands, and in small depressions along drainage lines in open forest and woodland communities. (Halford 1996; Wilson 2006)	Unlikely, the extant distribution of this species is to the west of the ecology study area
Eucalyptus bancroftii	Bancroft's red gum	High priority	LC	Occurs on a variety of landforms, but mostly on wallum flats on sandy soils in coastal lowlands or on low rises close to the coast (Wetland Info 2013).	Unlikely, the extant distribution of this species occurs to the east and south of the ecology study area
Glycyrrhiza acanthocarpa	Native liquorice	High priority	LC	Grows in various habitats, especially on heavy soils prone to flooding (PlantNet 2018).	Unlikely, the ecology study area is beyond the extant distribution of this species
Hydrocharis dubia	Frogbit	High priority	LC	Inhabits dams, lakes and slow-moving streams. It may be floating in deep water or be rooted in shallows by the edges of calm water (Wetland Info 2013).	Possible
Lepidosperma quadrangulatum	-	Critical priority	LC	Grows in coastal wet heath or swampy forest dominated by eucalypt or melaleuca species with a shrubby understorey. It occurs among sedges in the seepage area at the base of mountain slopes and in association with *Allocasuarina emuina* (Wetland Info 2013).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Lilaeopsis brisbanica	-	High priority	E	Grows along tidal riverbanks in grey saline mud, in association with mangrove trees. Although occurring naturally in areas near saline waters, fresh water is satisfactory (Wetland Info 2013).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution

Species name[1]		Back on Track status (SEQ/ Condamine NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Macarthuria complanata	-	High priority	NT	Information deficient.	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Melaleuca groveana	-	High priority	NT	Grows on exposed rocky ridges, high mountain slopes and the summits of mountains, at altitudes between 340 to 600 m above sea level. It generally occurs in heaths and eucalypt woodlands and forests with heath understoreys. It is also found in tall open forest with a grassy understorey and in microphyll vine forests. It has been recorded growing on red sandy loams, brown loams, skeletal rocky soils and sandy soils over sandstone rock (Wetland Info 2013).	Unlikely, the ecology study area is beyond the extant distribution of this species
Melaleuca irbyana	Swamp tea-tree	High priority	E	Grows in flat areas that are periodically waterlogged, in eucalypt forest, mixed forest and Melaleuca woodland with a sparse and grassy understorey. It grows on poorly draining, heavy clay soils (Wetland Info 2013).	Unlikely, the ecology study area is beyond the extant distribution of this species
Pararistolochia praevenosa	Richmond birdwing vine	High priority	NT	Found in subtropical rainforests on the eastern coast and lower ranges (<600 m), with plant communities on nutrient-rich volcanic, alluvial or, uncommonly, sandy soils (Grimshaw et. al. 2015).	Unlikely, there are no current records for this species in proximity to the ecology study area
Picris conyzoides	-	High priority	V	Information deficient.	Unlikely, there are no current records for this species in proximity to the ecology study area
Platysace sp. (Mt Ninderry P.R.Sharpe+ 2092)	-	Critical priority	LC	A mountain top specialist, probably inhabiting heathland (Wetland Info 2013).	Unlikely, suitable habitat is not contained within the ecology study area
Seringia sp. (Chermside S.T.Blake 23068)	-	High priority	LC	The following description has been inferred from information on the genus as no species-specific information was available. According to other species of *Seringia*, it grows mostly on sandstone in moist eucalypt forests (PlantNET 2018).	Unlikely, the ecology study area is beyond the extant distribution of this species

Species name[1]		Back on Track status (SEQ/ Condamine NRM)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Solanum stenopterum	-	High priority	V	*Solanum stenopterum* inhabits grassland or woodlands of Bellah and poplar box (*Eucalyptus populnea*) on black, brown or red clay loam soils. It also grows on loamy ridges, along roadsides and in paddocks (Bean 2004).	Unlikely, suitable habitat is not present within the ecology study area
Swainsona fraseri	-	High priority	LC	Occurs in grassy pastures on loamy soils, tall open eucalypt forest in disturbed areas and along creek flats and riverbanks with eucalypts. It may also grow on loose rocky slopes (Wetland Info 2013).	Possible
Tephrosia sp. (Wyreema R.J.Fensham 2082)	-	High priority	LC	Information deficient	Unlikely, there are no current records for this species within proximity to the ecology study area
Thismia rodwayi	-	High priority	NT	Restricted to damp humus and leaf-litter in deeply shaded tall forests and fern gullies (Royal Botanic Gardens Foundation Victoria 2015).	Unlikely, the ecology study area is beyond the extant distribution of this species
Zieria exsul	-	High priority	E	Occurs in the ecotone between complex notophyll vineforest and open forest of *Eucalyptus propinqua, Corymbia intermedia* and *Lophostemon confertus*, in loamy soil on metasediments (TSSC 2008b).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution
Zieria furfuracea subsp. *gymnocarpa*	-	Critical priority	E	Occurs as an understorey shrub in open forest of *Acacia disparrima, Allocasuarina littoralis, Eucalyptus* species and brush box (*Lophostemon confertus*). It has also been found in regrowth vegetation dominated by guinea grass (*Megathyrsus maximus var. pubiglumis*) and *A. disparrima* (Wetland Info 2013).	Unlikely, is a coastal species and the ecology study area is outside of the species extant distribution

Table notes:

1 = Excludes back on track species listed under the EPBC Act
- = No common name or conservation listing CE = Critically Endangered E = Endangered
LC = Least concern NT = Near threatened V = Vulnerable

4.2.2 Fauna

4.2.2.1 NC Act conservation significant

In total, 30 threatened fauna species listed under the provisions of the NC Act have been identified from database searches associated with the ecology study area (refer Table 4.3).

Of these 30 threatened fauna species, 25 are also listed as MNES (i.e. identified as threatened species under the EPBC Act). For further information related to these 25 MNES fauna species, refer to EIS Appendix J: Matters of National Environmental Significance as they are not discussed further within this document.

The remaining five threatened fauna species (i.e. those species listed solely under the provisions of the NC Act) have been identified from database searches associated with the ecology study area (refer Table 4.3 and Appendix B for species profiles).

- Glossy black cockatoo (*Calyptorhynchus lathami*) which is listed as Vulnerable under the NC Act and is likely to occur within the ecology study area
- Major Mitchell's cockatoo (*Lophochroa leadbeateri*) which is listed as Vulnerable under the NC Act but is unlikely to occur within the ecology study area
- Powerful owl (*Ninox strenua*) which is listed as Vulnerable under the NC Act and is likely to occur within the ecology study area
- Pale imperial hairstreak (*Jalmenus eubulus*) which is listed as Vulnerable under the NC Act but is unlikely to occur within the ecology study area
- Grey snake (*Hemiaspis damelii*) which is listed as Endangered under the NC Act and has the possibility to occur within the ecology study area

Two special least concern species under the NC Act (Platypus and Short-beaked Echidna) have also been identified as potentially occurring within the ecology study area. Noting that the alignment via the township of Murphys Creek was originally identified by locals as a potential risk to local platypus populations inhabiting Murphys Creek and the upper reaches of Lockyer Creek (See Table 4.3).

The location of historic specimen backed records for non-MNES conservation significant fauna species in the ecology study area is provided in Figure 4.2.

Table 4.3 Threatened and special least concern fauna species identified from the desktop assessment and their likelihood of occurrence within the ecology study area

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence^
				WildNet	Atlas of Living Australia	PMST	
Birds							
Accipitridae	*Erythrotriorchis radiatus*#	Red goshawk	E	✓		✓	Possible#
Apodidae	*Hirundapus caudacutus*#	White-throated needletail	V	✓	✓	✓	Possible#
Ardeidae	*Botaurus poiciloptilus*#	Australasian bittern	E			✓	Possible#
Cacatuidae	*Calyptorhynchus lathami lathami*	Glossy black-cockatoo (eastern)	V	✓	✓		Likely
Cacatuidae	*Lophochroa leadbeateri*	Major Mitchell's cockatoo	V	✓			Unlikely. The ecology study area does not support the species preferred habitat (semi-arid to arid woodlands) and is outside of the species natural range.

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence^
				WildNet	Atlas of Living Australia	PMST	
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*[#1]	Eastern bristlebird	E				Unlikely[#], outside of species natural range.
Falconidae	*Falco hypoleucos*[#]	Grey falcon	V	✓		✓	Possible[#]
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*[#1]	Swift parrot	E				Possible[#]
Rostratulidae	*Rostratula australis*[#]	Australian painted snipe	E	✓	✓	✓	Possible[#]
Scolopacidae	*Calidris ferruginea*[#]	Curlew sandpiper	CE			✓	Possible[#]
Scolopacidae	*Numenius madagascariensis*[#]	Eastern curlew	E			✓	Unlikely[#]. Species is essentially a coastal specialist.
Strigidae	*Ninox strenua*	Powerful owl	V	✓	✓		Likely
Turnicidae	*Turnix melanogaster*[#]	Black-breasted button-quail	V	✓	✓	✓	Possible[#]
Invertebrates							
Lycaenidae	*Jalmenus eubulus*	Pale imperial hairstreak	V	✓			Unlikely, requires mature stands of brigalow that are not present within the ecology study area

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence^
				WildNet	Atlas of Living Australia	PMST	
Mammals							
Dasyuridae	*Dasyurus maculatus maculatus*[#]	Spotted-tail quoll	E			✓	Possible[#]
Macropodidae	*Petrogale penicillata*[#]	Brush-tailed rock-wallaby	V	✓	✓	✓	Possible[#]
Muridae	*Pseudomys novaehollandiae*[#]	New Holland mouse	V			✓	Possible[#]
Ornithorhynchidae	*Ornithorhynchus anatinus*	Platypus	SLC	✓	✓		Likely
Petauridae	*Petauroides volans*[#]	Greater glider	V			✓	Possible[#]
Phascolarctidae	*Phascolarctos cinereus*[#]	Koala	V	✓	✓	✓	Likely[#]
Potoroidae	*Potorous tridactylus tridactylus*[#]	Long-nosed potoroo	V			✓	Possible[#]
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	SLC	✓	✓		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
Elapidae	*Hemiaspis damelii*	Grey snake*	E	✓			Possible
Pygopodidae	*Delma torquata*	Collared delma	V			✓	Likely

Table notes:

E = Endangered V = Vulnerable SLC = Special least concern PMST = EPBC Act Protected matters search tool
✓ Species present within database record within the ecology study area
* Species identified from Back on Track datasets
^ Species noted as Unlikely to occur are not discussed further in this report.
1 Species identified only within the ToR
[#] MNES species. These species are discussed further in EIS Appendix J – Matters of National Environmental Significance and are not discussed further within this technical report.

4.2.2.2 Migratory species

Twenty-one (21) migratory species listed under the EPBC Act (also listed as SLC under the NC Act), are predicted to occur within the ecology study area (refer Table 4.4).

Of the 21 migratory species identified, 18 are considered possible to occur. Three are considered marine and estuarine specialists (i.e. Black-tailed godwit (*Limosa limosa*), Whimbrel (*Numenius phaeopus*), Red-necked phalarope (*Phalarops lobatus*)) and are unlikely to occur and are not discussed further in this report (refer Table 4.4).

The location of historic specimen backed records for non-marine migratory species is provided in Figure 4.2. The majority of the records, wetland birds, are associated with a palustrine dam (i.e. Hoods Dam) approximately 500 m to the north east of the eastern extent of the of the Project within the Helidon Magazine Reserve. This dam is located upstream of the Project, with additional details provided in Section 4.2.8.

Table 4.4 Migratory species identified from database searches and their likelihood of occurrence within the ecology study area

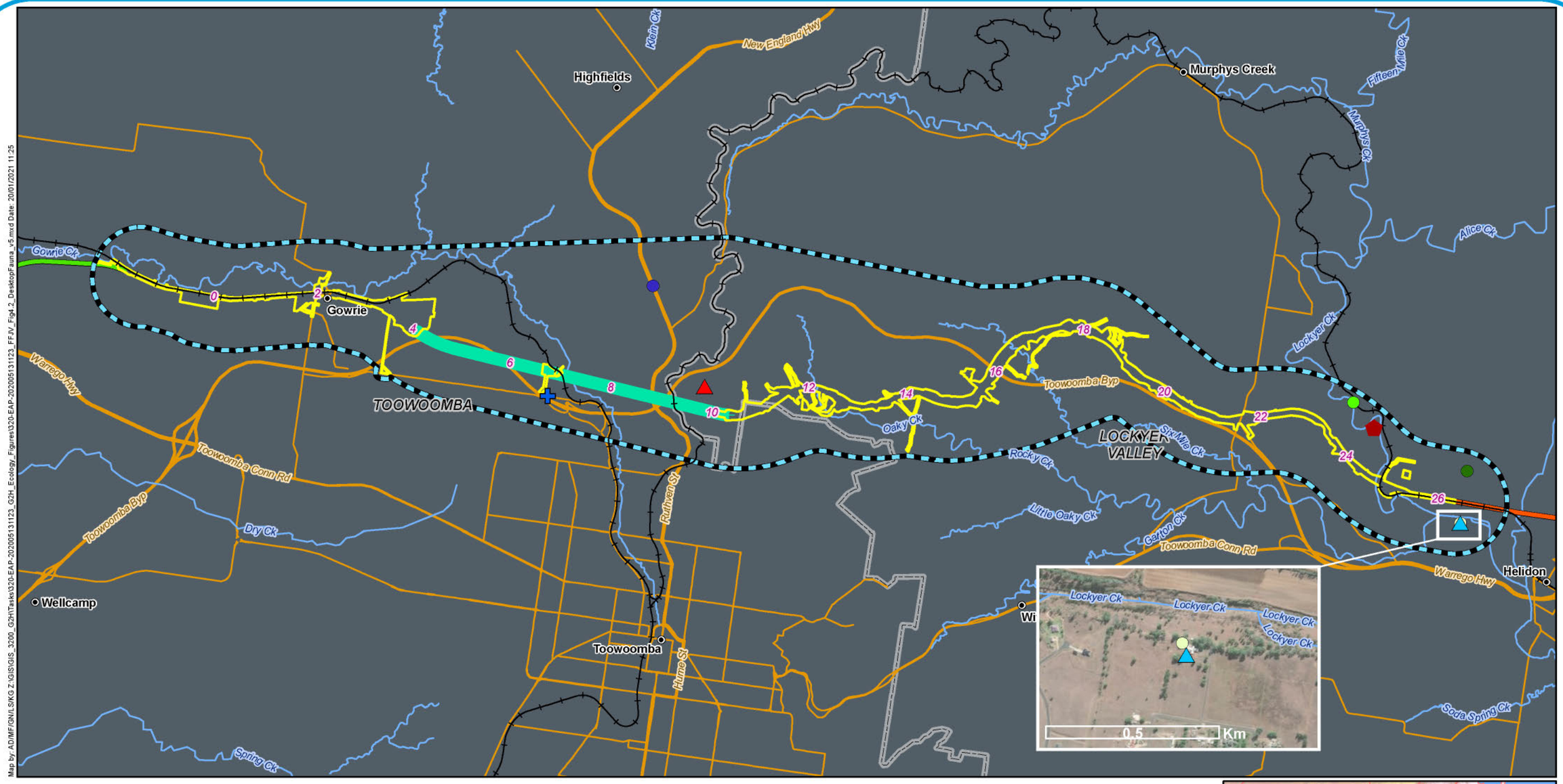
Family	Species name	Common name	Conservation status		Data source			Likelihood of occurrence^
			EPBC Act	NC Act	WildNet	PMST	ALA	
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	M	SLC	✓	✓		Possible
Apodidae	*Apus pacificus*	Fork-tailed swift	M	SLC	✓	✓		Possible
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	M	SLC	✓	✓		Possible
Scolopacidae	*Calidris melanotos*	Pectoral sandpiper	M	SLC		✓		Possible
Scolopacidae	*Calidris ruficollis*	Red-necked stint	M	SLC	✓			Possible
Cuculidae	*Cuculus optatus*	Oriental cuckoo	M	SLC		✓		Possible
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	M	SLC	✓	✓		Possible
Laridae	*Hydroprogne caspia*	Caspian tern	M	SLC	✓		✓	Possible
Scolopacidae	*Limosa limosa*	Black-tailed godwit	M	SLC	✓			Unlikely – Predominantly occurs in coastal habitats
Monarchidae	*Monarcha melanopsis*	Black-faced monarch	M	SLC	✓	✓		Possible
Motacillidae	*Motacilla flava*	Yellow wagtail	M	SLC		✓		Possible
Dicruridae	*Myiagra cyanoleuca*	Satin flycatcher	M	SLC	✓	✓		Possible
Scolopacidae	*Numenius phaeopus*	Whimbrel	M	SLC	✓			Unlikely – Entirely occurs in coastal habitats
Pandionidae	*Pandion haliaetus*	Osprey	M	SLC	✓	✓		Possible
Scolopacidae	*Phalarops lobatus*	Red-necked phalarope	M	SLC			✓	Unlikely – Occurs in coastal to pelagic habitats and rarely occurs in QLD
Threskiornithidae	*Plegadis falcinellus*	Glossy ibis	M	SLC	✓		✓	Possible
Charadriidae	*Pluvialis fulva*	Pacific golden plover	M	SLC	✓			Possible
Muscicapidae	*Rhipidura rufifrons*	Rufous fantail	M	SLC	✓	✓		Possible
Monarchidae	*Symposiachrus trivirgatus*	Spectacled monarch	M	SLC		✓		Possible
Scolopacidae	*Tringa nebularia*	Common greenshank	M	SLC		✓		Possible
Scolopacidae	*Tringa stagnatilis*	Marsh sandpiper	M	SLC	✓			Possible

Table notes:

M = Migratory SLC = Special Least Concern

^ Species noted as Unlikely to occur are not discussed further in this report.

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



Map by AD/MF/GN/LS/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.2_DesktopFauna_v5.mxd Date: 20/01/2021 11:25

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)
- Ecology study area
- Local Government Areas

Non-MNES Significant fauna

- Glossy black-cockatoo (eastern) (*Calyptorhynchus lathami lathami*)
- Platypus (*Ornithorhynchus anatinus*)
- Short-beaked echidna (*Tachyglossus aculeatus*)

Migratory Species

- Caspian tern (*Hydroprogne caspia*)
- Latham's snipe (*Gallinago hardwickii*)
- Fork-tailed swift (*Apus pacificus*)
- Marsh sandpiper (*Tringa stagnatilis*
- Rufous fantail (*Rhipidura rufifrons*)

A3 scale: 1:80,000

0 1 2 3 4 5km

Future Freight
Integrating Community, Environment and Engineering

Issue date: 20/01/2021 Version: 5

Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.2: Location of specimen backed records of conservation significant fauna (non-MNES) and migratory species

4.2.2.3 Priority back on track fauna species

A total of 26 non-MNES, Back on Track priority fauna species are listed across the SEQ and Condamine NRM regions (DERM 2010) (refer Table 4.5). This includes two threatened species (i.e. Grey snake (*Hemiaspis damelii*) and Glossy black-cockatoo (eastern) (*Calyptorhynchus lathami lathami*)) identified from databases searches summarised in Table 4.3.

Species that are listed as threatened under the EPBC Act (i.e. MNES), which are also listed as Back on track species have not been included within in Table 4.5. These species (e.g. 27 species including Collared delma (*Delma torquata*)) are assessed within EIS Appendix J: Matters of National Environmental Significance.

Nine of the of the 26 Back on Track priority fauna taxa were identified as having a potential to occur (i.e. possible or likely occurrence) within the ecology study area based on known populations and distribution and habitat requirements. The remining 17 fauna species are considered unlikely to occur within the ecology study area based on distributional limitations or the absence of habitat of suitable type/size/quality (refer Table 4.5 and Appendix B).

Where those Back on Track species are identified as being potentially present in the ecology study area, but not listed under either the NC Act or the EPBC Act, they have been considered as sensitive environmental receptors potentially impacted by the Project (refer Section 4.4.2) and are assessed as such within the impact assessment section (refer Section 5.2.3).

Table 4.5 Back on Track priority fauna species for the SEQ and Condamine natural resource management regions and likelihood of occurrence within the ecology study area

Species name		Back on Track status (SEQ/ Condamine NRM region)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Molluscs					
Camaenidae BL 64 (known as *Jimbouria rodhobsoni*)	Jimbour black-soil snail	High priority	-	Information deficient	Unlikely, this species Is not known to occur within proximity of the ecology study area
Pallidelix bennetti (Brazier, 1872) comb. nov	Bennett's woodland snail	High priority	-	Information deficient.	Possible. A record of this species is known from the Toowoomba region.
Butterflies and moths					
Acrodipsas illidgei	Illidge's ant-blue butterfly	Critical priority	V	Occurs in mangroves and adjacent areas (Redland City Council 2018).	Unlikely, this is a coastal species.
Ornithoptera richmondia	Richmond birdwing butterfly	High priority	V	Breeds in moist subtropical rainforests wherever the two food plants occur. Habitats are nearly always on rich soils, such as those of volcanic origin (e.g. basalt-derived) or of alluvial origin (e.g. in riparian zones near watercourses). Depending on food plant availability, habitats are distinctly lowland (to 600 m altitude) near the coast or occasionally and seasonally at altitudes above 600 m (Wildlife Preservation Society of QLD 2019).	Unlikely, this is a coastal species.

Species name		Back on Track status (SEQ/ Condamine NRM region)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Tisiphone abeona rawnsleyi	Varied sword-grass brown (QLD subspecies)	High priority	LC	Inhabits glades and clearings in open woodland habitats at elevations between about 50 to 1,200 m according to locality (Hoskins 2018).	Unlikely, this is a coastal species.
Fish					
Achoerodus viridis	Eastern blue groper	High priority	-	Found in coastal, marine waters. Adults are found in a wide range of habitats from shallow waters, down to 40 m. Juveniles are usually found in estuarine seagrass beds (Australian Museum 2018).	Absent. This is an aquatic marine species. No habitat present within the ecology study area.
Dasyatis fluviorum	Estuary stingray	High priority	-	Estuaries with significant mangrove forests (Australian Museum 2018).	Absent. This is an aquatic marine species. No habitat present within the ecology study area.
Heteroscyllium colcloughi	Colcloughs shark	High priority	-	Tropical or subtropical, inshore bottom shark of the QLD continental shelf, most records from shallower than 6 m depth on soft bottom or around wrecks (Last and Stevens 2009).	Absent. This is an aquatic marine species. No habitat present within the ecology study area.
Rhadinocentrus ornatus	Ornate rainbowfish	High priority	-	It is usually found in slow-flowing streams, ponds and dune lakes (Australian Museum 2018).	Unlikely, this is a coastal species
Frogs					
Crinia tinnula	Wallum Froglet	High priority	V	Restricted to freshwater swamps in lowland coastal areas and is found in associated vegetation communities such as heath, sedgeland and woodland on nutrient-poor sandy soils. Acidic swamps and lakes in these areas provide essential breeding habitat for wallum-dependent frog species. The wallum froglet has also been observed in disturbed heath habitat (DES 2018d).	Unlikely, this is a coastal species
Reptiles					
Delma inornata	-	High priority	LC	Known from grasslands in the southern brigalow belt in Darling Downs west to Culgoa (Wilson 2005).	Likely, records are known from the Toowoomba region
Delma plebeia	Common delma	High priority	LC	Inhabitant of ground debris and leaf-litter in heaths, dry sclerophyll forests and savannah woodlands, and tolerant of disturbed areas adjacent to brigalow communities and Spinifex sand-plains west of Brisbane (Wildlife QLD 2018).	Likely, records are known from the Toowoomba region
Eroticoscincus graciloides	Elf skink	High priority	LC	Information deficient.	Unlikely, this is a coastal species

Species name		Back on Track status (SEQ/ Condamine NRM region)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	**Common name**				
Hemiaspis damelii	Grey snake	High priority	E	Favours woodlands, usually on heavier, cracking clay soils, particularly in association with water bodies or in areas with small gullies and ditches. It shelters under rocks, logs and other debris as well as in soil cracks (DES 2018d).	Possible
Hoplocephalus bitorquatus	Pale-headed snake	Medium priority	LC	Found in wet and dry sclerophyll forest, and open woodlands (especially *Callitris* woodland) on floodplains and near watercourses. They are strictly arboreal and rely heavily on old and dead standing trees with hollows and exfoliating bark for shelter sites (Australian Museum 2018).	Possible
Hoplocephalus stephensii	Stephens' banded snake	Critical priority/ High priority	LC	Lives in rainforests, moist forests, heaths and vine thickets (QLD Museum 2019).	Unlikely, habit of suitable quality is absent from the ecology study area.
Birds					
Calyptorhynchus lathami lathami	Glossy black-cockatoo (eastern	High priority	V	Prefers woodland areas dominated by she-oak (*Allocasuarina* spp.), or open sclerophyll forests/woodlands with a stratum of *Allocasuarina* spp. beneath a canopy of *Eucalyptus* spp., *Corymbia* spp. or *Angophora* spp.	Likely
Esacus magnirostris	Beach stone-curlew	High priority	V	Usually found on open, undisturbed beaches, islands, reefs, and estuarine intertidal sand and mudflats, preferring beaches with estuaries or mangroves nearby. Also frequents river mouths, offshore sandbars associated with coral atolls, reefs and rock platforms, and coastal lagoons (DES 2018d).	Unlikely, this is a coastal species
Melanodryas cucullata cucullata	Hooded robin (south-eastern)	High priority	LC	Prefers lightly wooded country, usually open eucalypt woodland, acacia scrub and mallee, often in or near clearings or open areas.	Unlikely, the ecology study area is outside of the species extant distribution
Pezoporus wallicus wallicus	Ground parrot	High priority	V	Occurs mostly in coastal heathland or sedgeland with very dense cover and a high density of the parrot's food plants (DotEE 2018).	Unlikely, this is a coastal species
Stagonopleura guttata	Diamond firetail	High priority	LC	Found in grassy eucalypt woodlands, including Box-Gum Woodlands and Snow Gum *Eucalyptus pauciflora* Woodlands.	Possible

Species name		Back on Track status (SEQ/ Condamine NRM region)	NC Act Status	Habitat association	Likelihood of occurrence within the ecology study area
Scientific name	Common name				
Sternula albifrons	Little tern	High priority	C	Inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits, and also on exposed ocean beaches (DotEE 2018).	Unlikely, this is a coastal species
Mammals					
Dugong dugon	Dugong	Critical priority	V	Seagrass community specialists within wide, shallow protected bays, wide, shallow mangrove channels and in the lee of large inshore islands (DotEE 2018).	Absent. This is an aquatic marine species. No habitat present within the ecology study area.
Kerivoula papuensis	Golden-tipped bat	High priority	LC	Found in rainforest and adjacent wet and dry sclerophyll forest up to 1,000 m. Roost mainly in rainforest gullies in usually abandoned hanging Scrub wren and Gerygone nests. Bats may also roost under thick moss on tree trunks, in tree hollows, dense foliage and epiphytes (OEH 2020a).	Possible
Scoteanax rueppellii	Greater broad-nosed bat	High priority	LC	Utilises a variety of habitats from woodland through to moist and dry eucalypt forest and rainforest, though it is most commonly found in tall wet forest. Usually roosts in tree hollows and buildings (OEH 2017).	Possible
Sousa chinensis	Indo-Pacific humpback dolphin	Critical priority	V	Found in relatively shallow and protected coastal habitats such as inlets, estuaries, major tidal rivers, shallow bays, inshore reefs and coastal archipelagos (DotEE 2018).	Absent. This is an aquatic marine species. No habitat present within the ecology study area

Table notes:

LC = Least concern E = Endangered - = Not listed V = Vulnerable NT = Near threatened

4.2.3 Matters of state environmental significance wildlife habitat and essential habitat

Habitat for threatened flora and fauna (including some SLC animals) as listed under the NC Act and the *Nature Conservation (Wildlife) Regulation 2006* are defined as MSES under the QLD SPP 2017 (DILGP 2017). This includes areas listed as 'essential habitat' for threatened species as mapped under the VM Act. This mapping layer includes modelled or known habitat for species that meet the following criteria:

- Threatened wildlife under the NC Act including:
  - 'Endangered' species
  - 'Vulnerable' species

- ‘Special least concern’ animals under the NC Act including:
  - Echidna (*Tachyglossus aculeatus*)
  - Platypus (*Ornithorhynchus anatinus*)
  - Migratory birds (JAMBA, CAMBA, Bonn Convention).

The extent of mapped MSES wildlife habitat (incorporating essential habitat) within the ecology study area Project disturbance footprint is presented in Table 4.6 and illustrated in Figure 4.3. The mapping generally reflects the presence of remnant and regrowth mapping.

Much of this habitat has been mapped for the Koala (*Phascolarctos cinereus*) especially in the Lockyer Valley, but also includes habitat for the Collared delma (*Delma torquata*) and *Sophora fraseri*. These species are discussed in detail in EIS Appendix J: Matters of National Environmental Significance.

While on Toowoomba Plateau where there has been significant anthropogenic activity, wildlife habitat is limited. With the majority of the MSES wildlife habitat associated with protected plants (e.g. Finger panic grass (*Digitaria porrecta*) and Austral cornflower (*Rhaponticum australe*)), noting that the mapping for threatened flora species does not align with the actual records (refer 4.2.1.1).

There is no MSES wildlife habitat for ‘Special least concern’ species within the Project disturbance footprint.

Table 4.6 Matters of state environmental significance wildlife habitat and essential habitat present within the ecology study area

Identified wildlife habitat	Extent (ha)	
	Ecology study area	Project disturbance footprint
MSES Wildlife habitat*	1,020.97	105.66
Essential habitat*	2,208.36	112.36

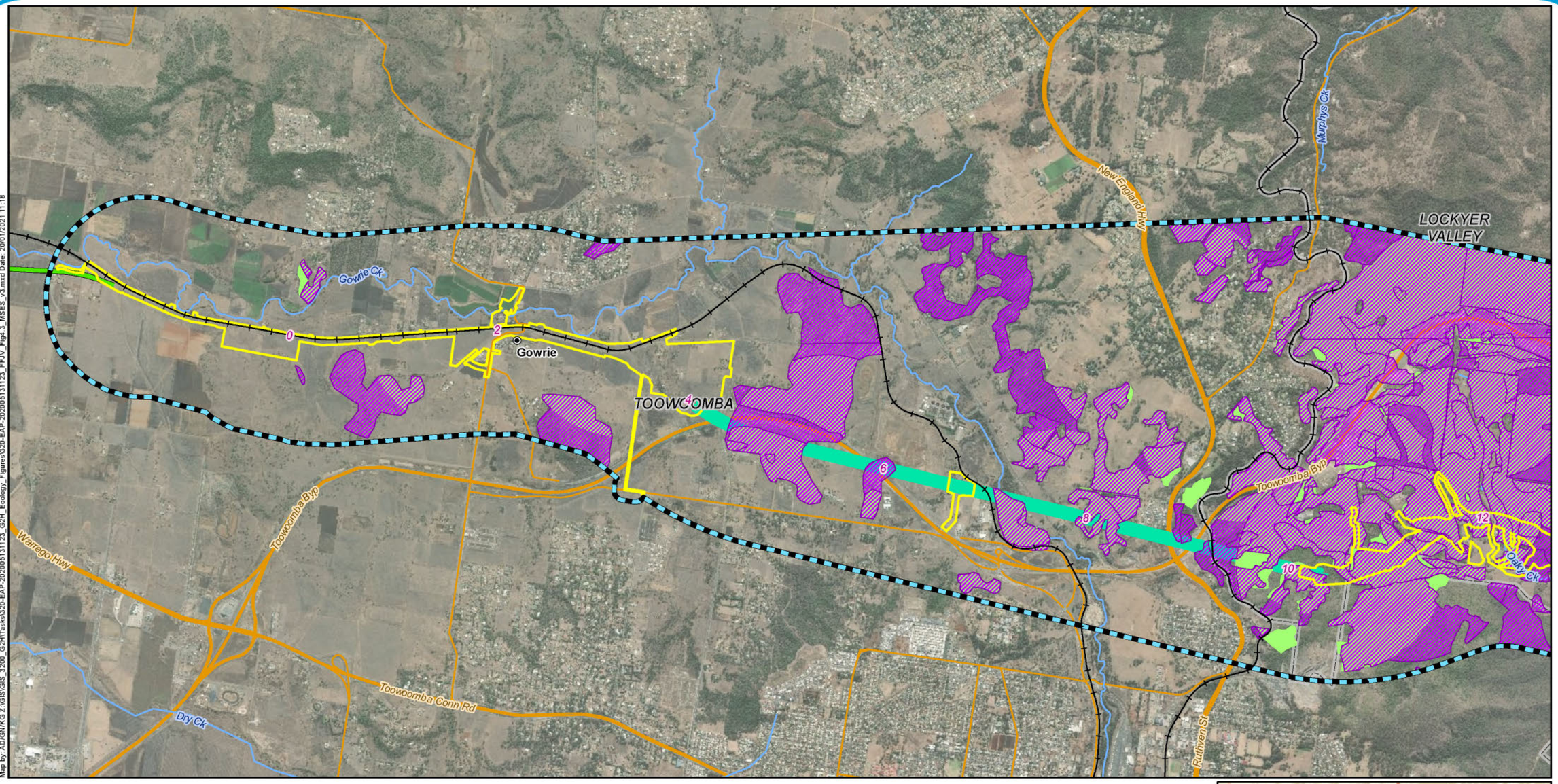
Table note:

* There is significant overlap in the distribution of MSES wildlife habitat and Essential habitat. Given that Essential habitat constitutes the largest area and overlaps MSES wildlife habitat, this is discussed further throughout this document

4.2.4 Invasive species biosecurity areas

The ecology study area is not contained within any fire ant biosecurity zone. The closest fire ant biosecurity zone (i.e. Fire and biosecurity zone 2) is located approximately 10 km east of the eastern extent of the Project, at the mid-point between Gatton and Forest Hill, from which point the zone continues in an eastward direction (refer Figure 4.4). Fire ant biosecurity zones are in place in areas of QLD to restrict the movement of materials that could spread the red imported fire ant (*Solenopsis invicta*). In addition to the species’ potential impact on agricultural and lifestyle activities, the species is also a threat to native flora and fauna, along with the supporting vegetation communities.

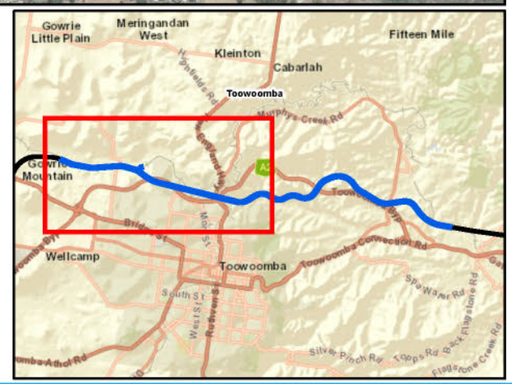
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA,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



Map by: AD/GN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.3_MSES_v3.mxd Date: 20/01/2021 11:18

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- MSES wildlife habitat
- MSES essential habitat



A3 scale: 1:40,000

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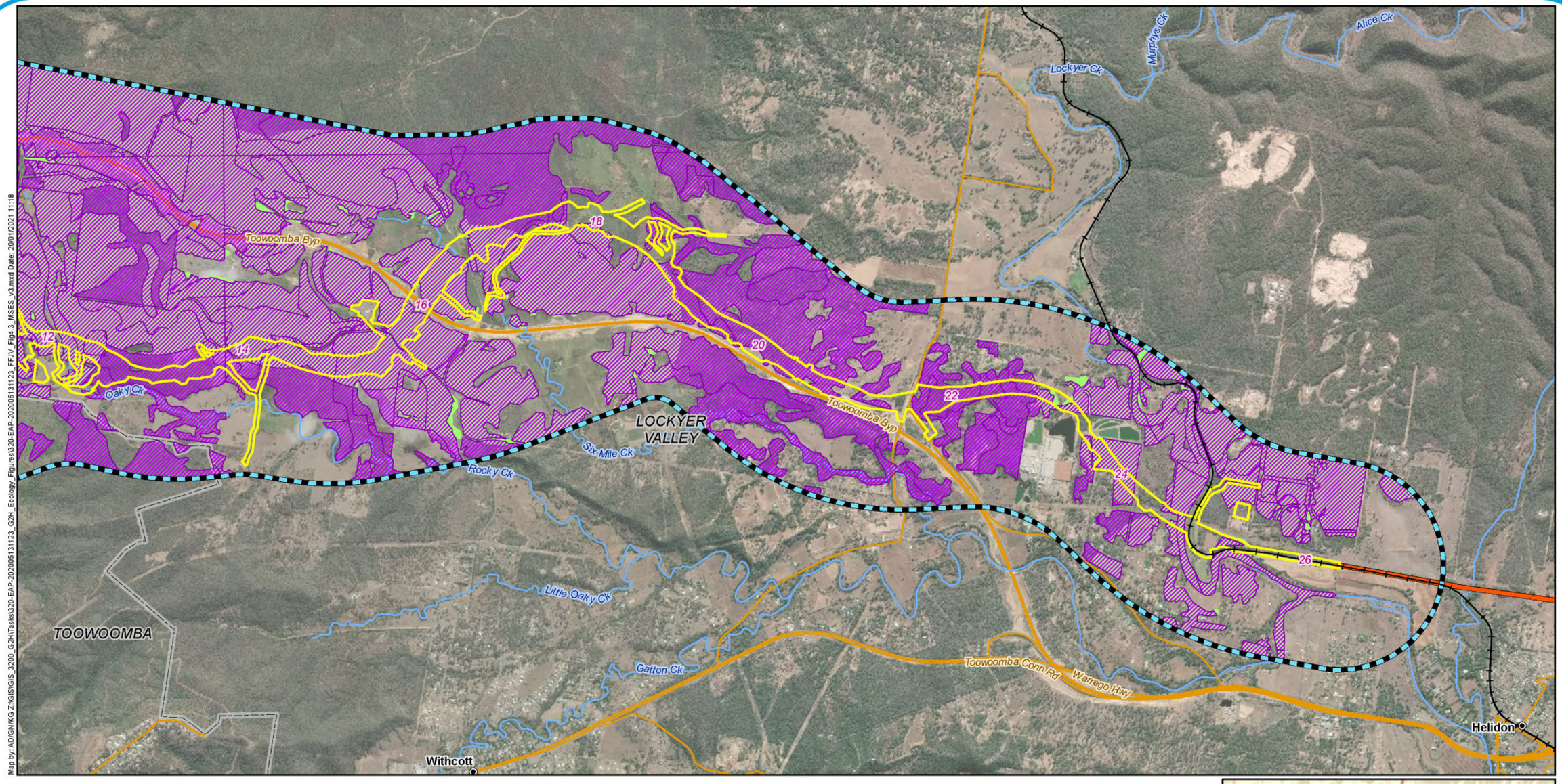
Gowrie to Helidon

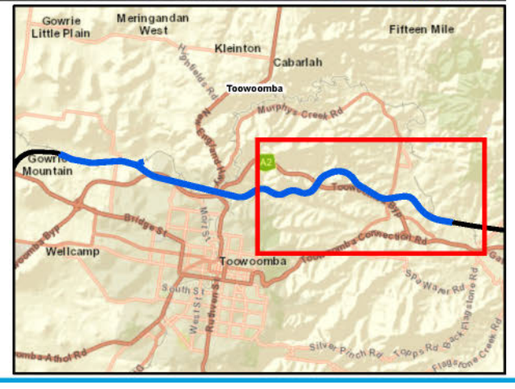
Figure 4.3a: Matters of state environmental significance (MSES) wildlife habitat and essential habitat mapping

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



Legend

- 5 Chainage (km)
- Localities
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- MSES wildlife habitat
- MSES essential habitat



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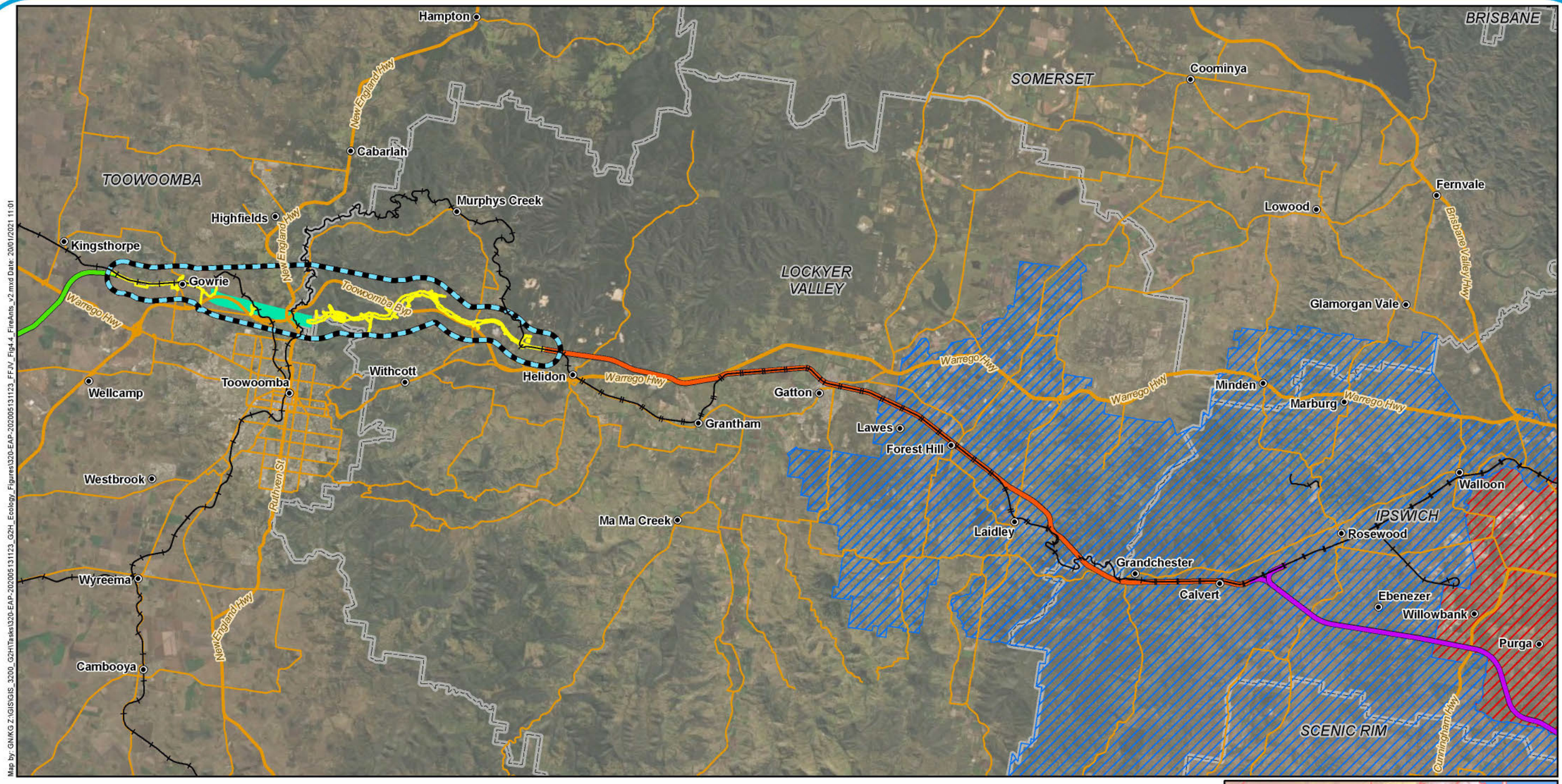
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.3b: Matters of state environmental significance (MSES) wildlife habitat and essential habitat mapping

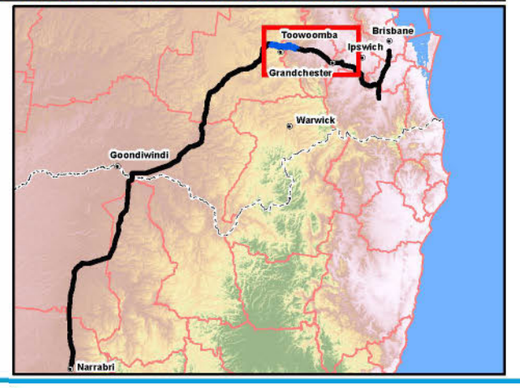
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Map by: GN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.4_FireAnts_v2.mxd Date: 20/01/2021 11:01

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- H2C project alignment
- C2K project alignment
- Existing rail
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Fire ant biosecurity zone 1
- Fire ant biosecurity zone 2



A3 scale: 1:250,000

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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.4:

Fire ant biosecurity zones

4.2.5 Defined watercourses

Under the Water Act a watercourse is defined as a river, creek or other stream which includes a stream in the form of an anabranch or a tributary where water flows either permanently or intermittently regardless of flow frequency. A watercourse however does not include any section of a feature that has a tidal influence or is downstream of a defined limit (Department of Natural Resources and Mines (DNRME) 2014).

A number of defined watercourses (refer Figure 4.5) and waterbodies occur within the ecology study area. Defined watercourses that intersect the Project alignment include:

- Gowrie Creek – at Ch 2.00 km and Ch 7.20 km (note Project alignment in tunnel at this location). A new access track is also proposed under the existing rail bridge over Gowrie Creek at the western extent of the Project footprint.
- There is an access road across Rocky Creek at approximate Ch 14.40 km, which is the upper limit of the watercourse
- Lockyer Creek – at Ch 24.75 km (Lockyer Creek Viaduct).

The Project also intersects the main channel of Oaky Creek (Oaky Creek Viaduct), upper reaches of Rocky Creek (access roads) and Six Mile Creek (TSRC and Six Mile Creek Viaduct) which may be considered defined watercourses under the Water Act are currently unmapped. Noting that the upper limit of Six Mile Creek is less than 50 m downstream of the Project disturbance footprint.

Viaducts and bridges are proposed over Gowrie Creek, Oaky Creek Six Mile Creek and Lockyer Creek, avoiding or at least minimising the impacts to the main channel and limiting the extent of infrastructure in the surrounding floodplains.

The Project footprint also intersects an additional 24 unmapped watercourses under the Water Act in Gowrie Creek catchment and approximately 80 unmapped watercourses under the Water Act in Lockyer Creek Catchment. The unmapped watercourse, totally about 13.5 linear kilometres, will be required to be verified during the detailed design phase to determine their status (i.e. defined or not) under the Water Act with initial discussions with the Department of Resources indicating that the majority, if not all, are drainage lines under the Water Act.

Defined watercourses within the water quality study area have been identified in reference to DRDMW's Water identification map – watercourses – Queensland, last published 01 April 2020. Further consultation with DRDMW, along with Department of Transport and Main Roads (DTMR) is required to determine the status of the unmapped watercourses (i.e. defined watercourses or drainage lines under the Water Act) relevant to the Project (including watercourses impacted by the Toowoomba Range Bypass). Noting that ARTC sought advice from DRDMW on the status of the unmapped watercourses under the Water Act intersecting the Project disturbance footprint in October 2020.

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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
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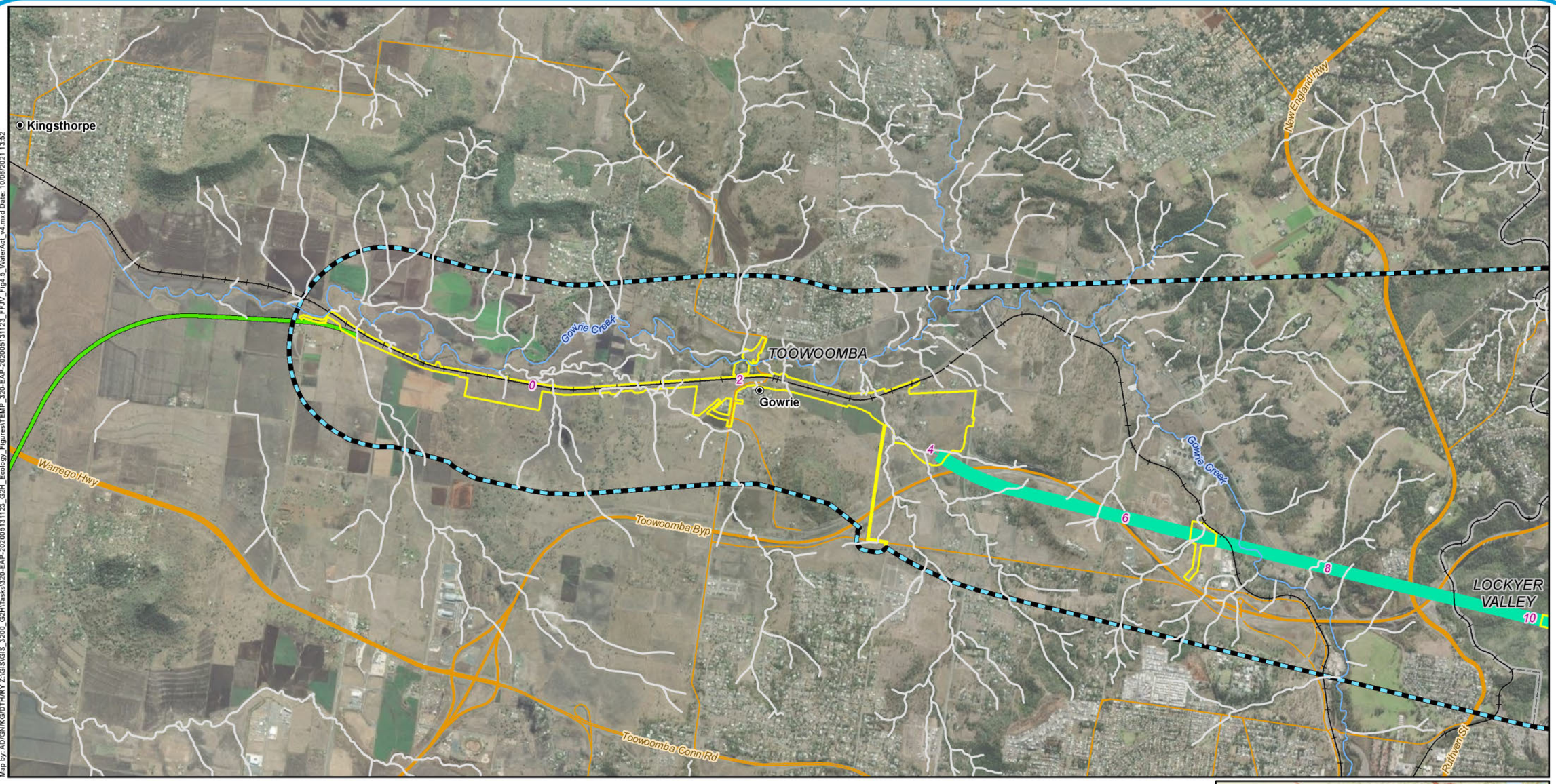
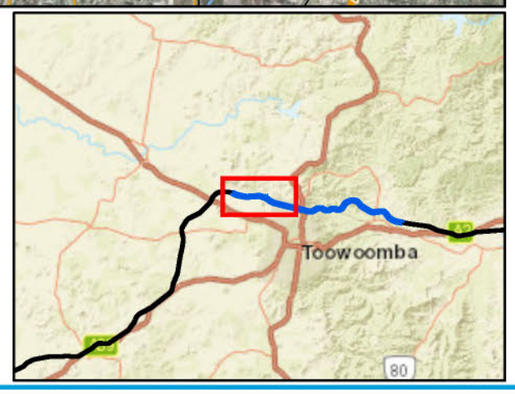


Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- Existing rail
- Major roads
- Minor roads
- Unmapped watercourses (Water Act 2000)
- Defined watercourses (Water Act 2000)
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

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Gowrie to Helidon

Figure 4.5: Water Act 2000 watercourses

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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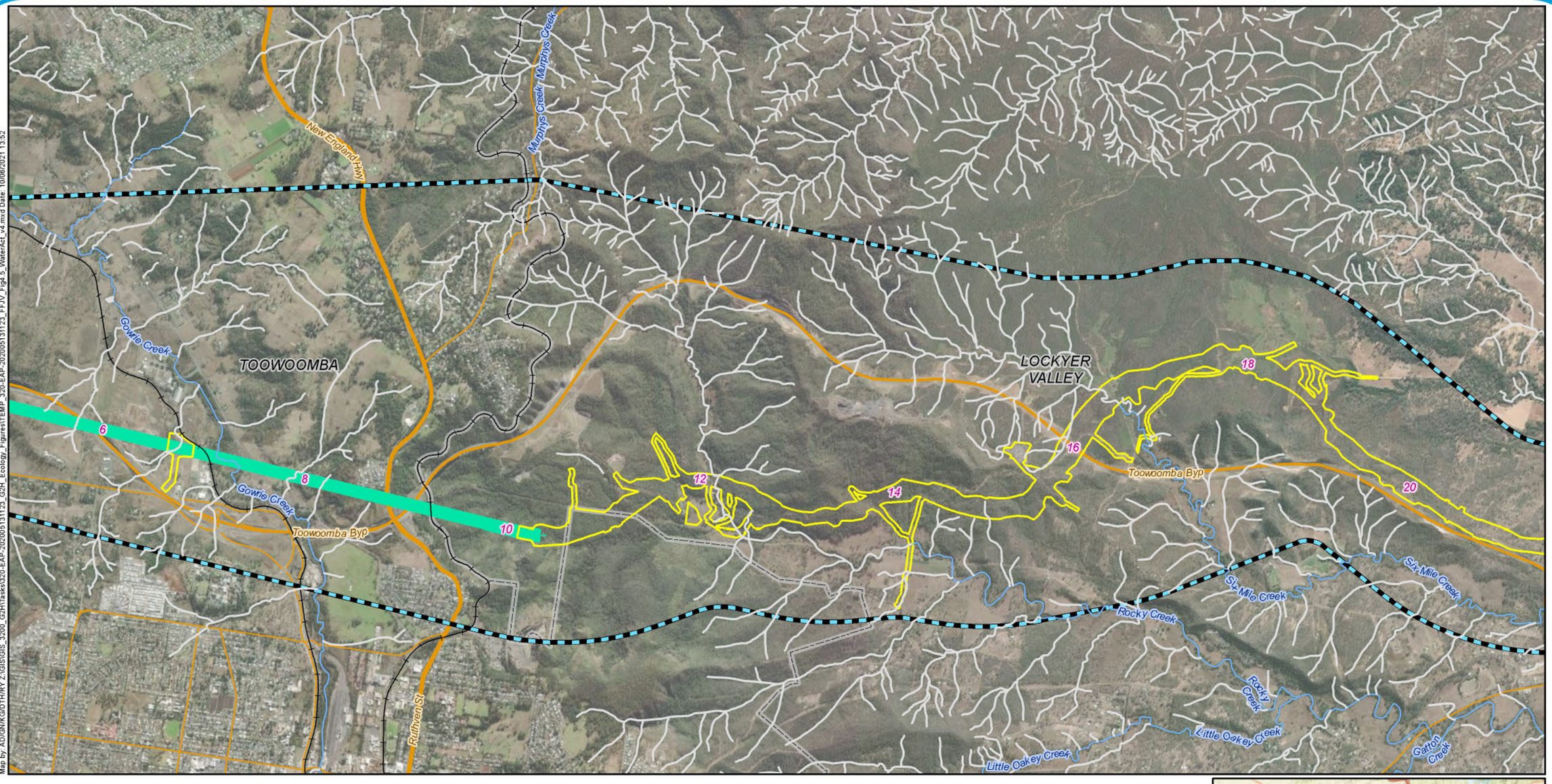
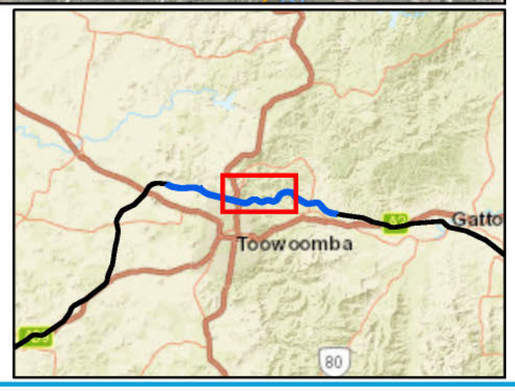
Map by: AD/GN/KG/DTH/RY Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513112 3_G2H_Ecology_Figures\TEMP_320-EAP-20200513112 3_FFJV_Fig4.5_WaterAct_v4.mxd Date: 10/06/2021 13:52



Legend

- 5 Chainage (km)
- Localities
- Existing rail
- Major roads
- Minor roads
- Unmapped watercourses (Water Act 2000)
- Defined watercourses (Water Act 2000)
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.5: Water Act 2000 watercourses

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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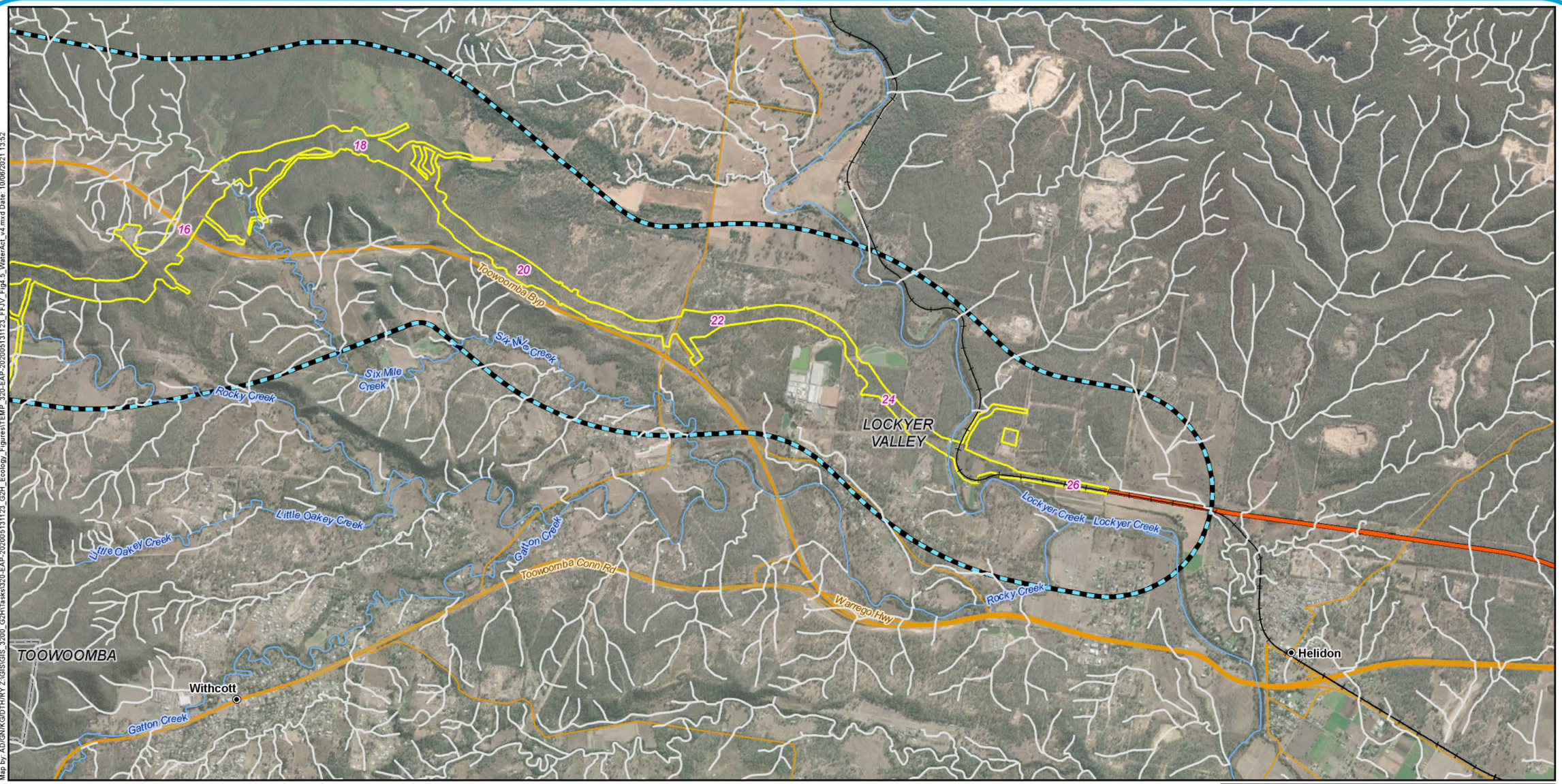

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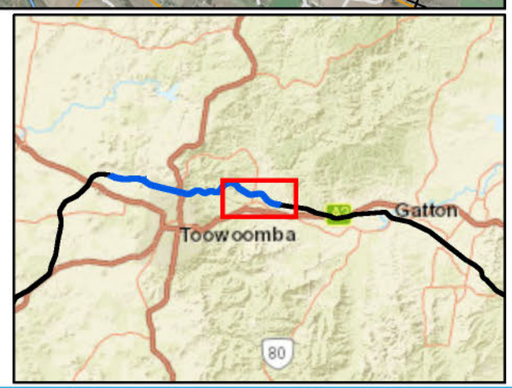
Legend

- 5 Chainage (km)
- Localities
- H2C project alignment
- Existing rail
- Major roads
- Minor roads
- Unmapped watercourses (Water Act 2000)
- Defined watercourses (Water Act 2000)
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

Future Freight
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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.5: Water Act 2000 watercourses

4.2.6 Stream order mapping

Queensland uses the stream ordering system adopted from Strahler (1952) in which watercourses are given an 'order' according to the number of additional upstream tributaries associated with each watercourse. This system is used to provide an indication on watercourse complexity and therefore the potential aquatic habitat present. In addition to providing for an indication of habitat complexity, stream order mapping identifies waterways that may be currently unmapped under the Water Act.

Headwaters or 'new' flow paths are given a stream order of one (or 'first order'), where two first order flow paths converge, the new stream is referred to as a second order stream. Where two second order streams join, a third order stream is formed. Third order streams and above are considered likely to reflect valuable fish habitat, capable of supporting viable population (McCabe 2011).

The stream orders for watercourses intersected by the Project alignment are outlined in Table 4.7. From Ch 4.10 km to Ch 10.34 km, the alignment is within the tunnel and is not expected to directly impact watercourses intersecting the alignment. The exception is the works proposed for the intermediate ventilation shaft at Cranley (Ch 6.83 km). It should be noted that the mapping is no consistent with the watercourse mapping under the Water Act or the Queensland Waterways for Waterway Barrier Works.

Table 4.7 Stream orders present within the Project disturbance footprint

Stream order (DNRME)	Waterway (approximate chainage (km))
5	Lockyer Creek at Ch 24.74 km
4	Gowrie Creek at Ch 2.0 km
3	Gowrie Creek at Ch 7.27 km Un-named tributary of Gowrie Creek at Ch 3.47 km Un-named tributary of Rocky Creek at Ch 12.30 km Rocky Creek at Ch 12.80 km, Ch 14.40 km
2	Un-named tributaries of Gowrie Creek at Ch -1.74 km, Ch 1.03 km and Ch 7.97 km (in tunnel) Un-named tributaries of Rocky Creek at Ch 10.52 km Un-named tributary of Oaky Creek at and Ch 11.77 km and Ch 12.10 km Oaky Creek at Ch 12.16 km Six Mike Creek at 16.55 km Un-named tributary of Six Mile Creek at 16.60 km Un-named tributary of Six Mile Creek at Ch 16.76 km Un-named tributary of Lockyer Creek at Ch 22.51 km
1	Un-named tributaries of Gowrie Creek at Ch 0.26 km, Ch 4.05 km (western tunnel portal), Ch 4.92 km (in tunnel), Ch 5.75 km (in tunnel) and Ch 6.55 km (intermediate ventilation shaft) Un-named tributaries of Oaky/Rocky Creek at Ch 11.10, Ch 10.50 km, Ch 14.23 km, Ch 14.80, Ch 15.05 km and Ch 15.40 km Oaky Creek at Ch 13.75 km Un-named tributaries of Six Mile Creek at Ch 15.55, Ch 15.7 km and Ch 17.53 km Un-named tributary of Lockyer Creek at Ch 18.40-18.80 km Un-named tributaries of Lockyer Creek at Ch 18.95 km, Ch 19.33 km, Ch 19.80 km, Ch 20.08 km, Ch 20.40, 20.53 km, Ch 20.79 km, Ch 21.43 km, Ch 23.45 km, Ch 24.59 km

Source: DRDMW (formerly DNRME) Watercourse Identification Mapping (2019a)

4.2.7 Waterways for waterway barrier works mapping

Under the Fisheries Act a waterway is defined as a river, creek, stream, watercourse or inlet of the sea. Waterways for waterway barrier works are regulated under the Fisheries Act and the Planning Act when barriers to fish movement including partial barriers are installed across waterways. Barrier works include construction, raising, replacement and some maintenance works on structures such as culverts crossings, bed level and low-level crossings, weirs and dams, along with works that will alter the bed and banks of a waterway, such as diversions, filling and rock lining, both permanent and temporary.

A review of the DAF *QLD Waterways for Waterway Barrier Works* spatial data layer was undertaken, identifying a total of 24 waterways for waterway barrier works which intersect the Project disturbance footprint (refer Table 4.8). Noting that the mapping generally does not align with the actual watercourse channel and that not all watercourses under the Water Act are mapped as waterways under the Fisheries Act.

This mapping also represents MSES waterways providing for fish passage which has been assessed in this report (refer Section 5.3.4). Waterways providing for fish passage are a prescribed environmental matter under Queensland Environmental Offsets legislation, unless the area waterway is within an urban area as defined under the Planning Regulation.

The 24 waterways intersecting the Project disturbance footprint are classified (derived from DAF mapped waterways) as follows:

- The alignment intersects eight (8) waterways mapped as green
- The alignment intersects nine (9) waterways mapped as 'orange
- The alignment intersects four (5) waterways mapped as red
- The alignment intersects three (3) waterway mapped as purple.

The majority of the interactions (17) occur within the Lockyer Creek catchment and include access roads over Rocky Creek a purple waterway and the use of existing roads such as Jones Road, with the locations illustrated in Figure 4.6.

Table 4.8 identifies where Project intersects the waterways and the relevant classification. The Toowoomba Range tunnel also traverses under an additional five (5) waterways, including Gowrie Creek. As noted in Section 5.5.1, some of these waterways have also been impacted by the Toowoomba Bypass and further consultation with DAF and DTMR is warranted to understand the relationship between the two projects, including requirements under the Fisheries Act and managing impacts on the waterways and fish passage.

Refer to EIS Appendix L: Surface water quality for more detail on the water quality and condition of some of these waterways.

Table 4.8 Waterways for waterway barrier works that intercept the Project disturbance footprint

Waterway classification	Waterway (approximate chainage (km))
Purple waterway	Gowrie Creek at Ch 2.00 km (Gowrie Junction Road Bridge) Lockyer Creek at Ch 24.74 km (Lockyer Creek Viaduct) Rocky Creek at Ch 12.80 km and Ch 14.40 km (New access)
Red waterway	Un-named tributary of Gowrie Creek at Ch 3.47 km (UT1 Gowrie Creek Rail Bridge) Oaky Creek at Ch 12.40 km (Access off Jones Road) Un-named tributary of Rocky Creek (Jones Road) Six Mile Creek at Ch 16.60 km (Existing road access)
Orange waterway	Un-named tributaries of Gowrie Creek at Ch -1.74 km and Ch 1.03 km (collocated with the Western Line) Un-named tributary of Gowrie Creek at the western tunnel portal (subject to diversion works) Un-named tributary of Rocky Creek at Ch 10.52 km (cut and fill area near eastern tunnel portal) Un-named tributary of Oaky Creek at Ch 11.77 km (Oaky Creek Viaduct and access)) Oaky Creek at Ch 12.16 km (Oaky Creek Viaduct) Six Mile Creek at Ch 16.55 km (TSRC and Six Mile Creek Viaduct) Un-named tributary of Six Mile Creek at Ch 16.76 km (TSRC and Six Mile Creek Viaduct) Un-named tributary of Lockyer Creek at Ch 22.51 km (Withcott Seedlings Viaduct)

Waterway classification	Waterway (approximate chainage (km))
Green waterway	Un-named tributary of Gowrie Creek at Ch 0.26 km (collocated with the Western Line) Un-named tributary of Gowrie Creek at Ch 6.55 km (intermediate ventilation shaft) Un-named tributaries of Lockyer Creek at Ch 19.80 km, Ch 20.53 and Ch 20.79 km (cut and fill area) Un-named tributary of Lockyer Creek at Ch 21.43 km (Murphys Creek Road Viaduct) Un-named tributary of Lockyer Creek at Ch 23.45 km (Withcott Seedlings Viaduct) Un-named tributary of Lockyer Creek at Ch 24.59 km (Lockyer Creek Viaduct)

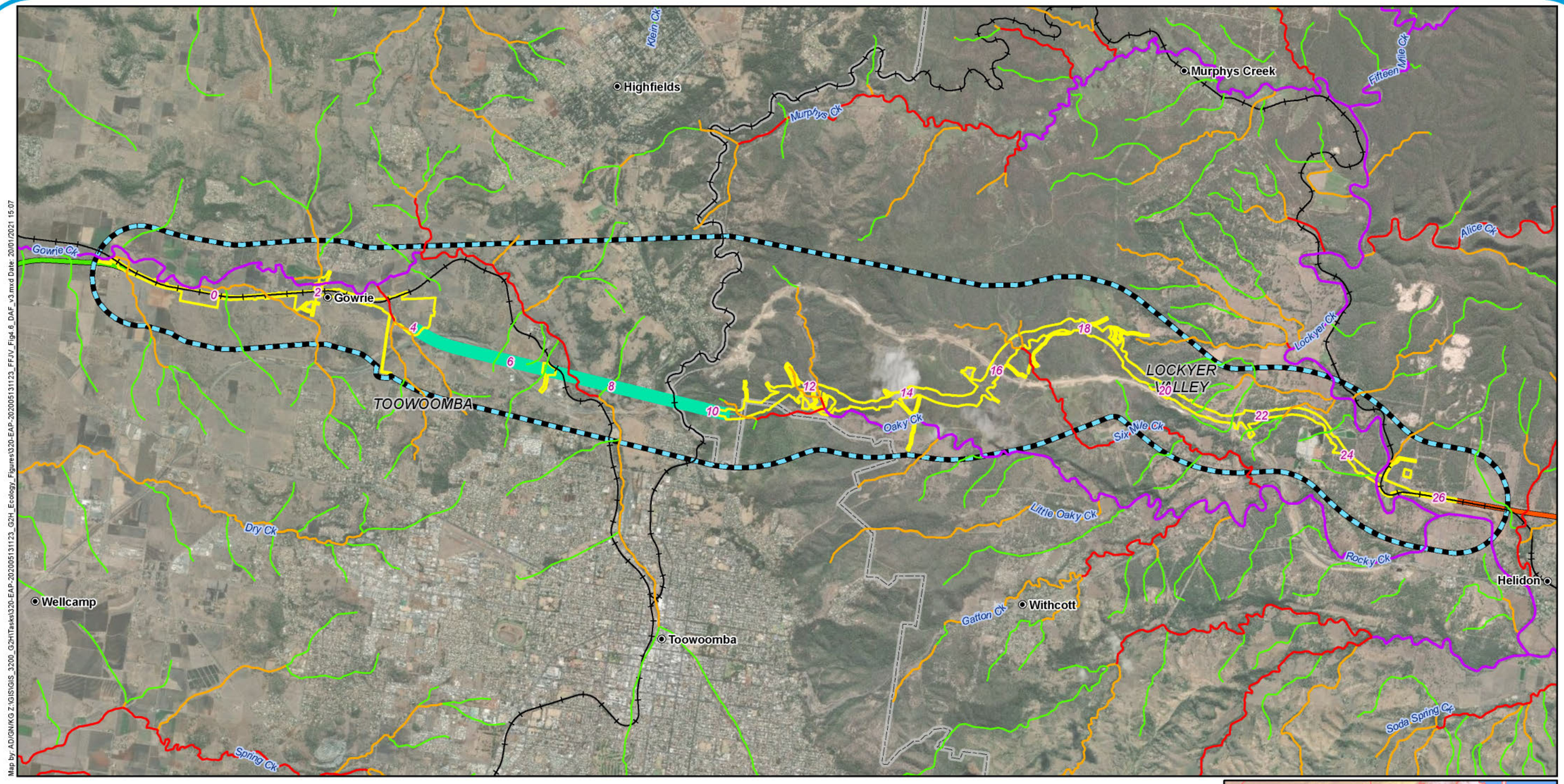
Table note:

Access = waterway barrier works corresponding with access road construction and/or maintenance during construction and operations

There are no known impoundments on these waterways, though there are some farm dams located within and downstream of the Project. There are also waterway barriers (e.g. culverts, rip rap) associated with the Toowoomba Bypass and the West Moreton System which influence this Project. Further consultation with DAF and DTMR is warranted to understand the relationship between the two projects, including requirements under the Fisheries Act and managing impacts on the waterways and fish passage.

As outlined in Section 4.2.5, there are potentially an additional 80 waterways impacted by the Project. Where the Project disturbance footprint will be located over these existing flow paths and other features not mapped as a waterway on the Queensland Waterways for Waterway Barrier Works mapping, further assessment and consultation with DAF will be undertaken to confirm whether they are considered to be a waterway providing for fish passage under the Fisheries Act, and if so, what colour they should be mapped as.

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



Map by: AD/GN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513112\3_G2H_Ecology_Figures\320-EAP-20200513112\3_FFJV_Fig4_6_DAF_v3.mxd Date: 20/01/2021 15:07

Legend

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

Risk of Impact

- 1 - Low
- 2 - Moderate
- 3 - High
- 4 - Major

A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.6: Department of Agriculture and Fisheries waterway barrier works waterways

At this stage of Project design, avoidance strategies incorporated into the design have resulted in the extensive use of viaducts and bridges to avoid significant interference with riparian vegetation and watercourses. Where the Project is co-located with the Western Line the works will likely involve the extension of the existing culverts under the Western Line and the Main Line under the Project alignment, with some changes to culvert numbers and design to maintained desired hydrologic objectives. Road access will also be required across these waterways.

To conform with the accepted development requirements for operational work that is constructing or raising waterway barrier works, fish passageway culverts have been upsized by 300 mm height for box culverts and 300 mm diameter for pipes from the calculated hydraulic sizes in order to submerge the culverts beneath the existing bed level by 300 mm at the upstream and downstream ends to comply with the fish passage requirements.

During detailed design the extent of the works within a waterway, including culvert design, viaducts and bridge structures footing, access roads, scour protection and whether the works is an upgrade of an existing waterway barrier (e.g. extending culverts under the existing QR rail corridor) will be confirmed. Designs will need to be in accordance with the DAF factsheet 'What is not a waterway barrier work?', or accepted development requirements for operational work that is constructing or raising waterway barrier works.

Where structures do not meet the accepted development requirements (including bridges that constitute waterway barrier works), development permits for operational work that is constructing or raising waterway barrier works (Planning Regulation, Schedule 10, Part 6, Division 4, Section 12) will need to be obtained.

As part of this process, ARTC will consult with DAF, DTMR, QR and DRDMW to confirm the approval processes and relevant management options.

4.2.8 Wetlands

There are no Wetlands of International Importance (Ramsar wetlands) within, or within 10 km of the ecology study area. The nearest Ramsar wetlands, which is also of national importance is Moreton Bay over 130 km downstream of the Project.

The Project intersects riverine wetlands associated with Lockyer Creek catchment, while there are no palustrine wetlands in the water quality study area. Lacustrine wetlands, including the dams associated with the Wetalla Wastewater Treatment Plant and Withcott Seedlings facility, along with Hoods Dam (Helidon Explosive Reserve).

These wetlands are not recognised as high ecological significance (HES) wetlands (under EPP (Water and Wetland Biodiversity) 2019) or are wetlands in a wetland protection area. Noting that HES wetlands and wetlands in a water protection area are identified as MSES under the Planning and Environmental Offsets legislation. There are also no HES wetlands or wetlands in a wetland protection area directly downstream (i.e. 5 km) of the Project.

High ecological value (HEV) waters (i.e. means waters in which the biological integrity of the water is effectively unmodified or highly valued), including watercourses and wetlands are present in the water quality study area. Some of these watercourses and wetlands are also recognised as MSES. The extent of HEV waters within the ecology study area and the Project disturbance footprint area is presented in Table 4.9 and illustrated in Figure 4.7. There are also no High ecological value waters directly downstream of the Project (i.e. 5 km) of the Project.

The watercourses and wetlands associated with Helidon Hills (i.e. large tracts of native vegetation north of Helidon and east of Lockyer Creek) are considered to be HEV waters under the EPP (Water and Wetland Biodiversity) 2019.

The Project disturbance footprint does not intersect HEV watercourses, though a drainage line of Lockyer Creek (Ch 26.0) directly upstream (within 50 m) of the Project is mapped as High ecological value waters (refer Table 5.13).

The Project disturbance footprint does not intersect any HEV wetlands, with the two closest HEV wetlands to the Project associated with regional ecosystem 12.3.7 (200 m to the north (Ch km) and 800 to the north east (Ch 26.0 km). The wetlands are located the Helidon Hills area immediately outside and hydraulically upstream of the Project disturbance footprint (refer Figure 4.7).

Lockyer Creek is recognised as a wetland of general ecological significance under the EPP (Water and Wetland Biodiversity).

Table 4.9 Wetlands present within the ecology study area

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
HES Wetlands (HES)	0.00	0.00
High ecological value Wetlands (HEV)	6.59	0.00

Anthropogenic wetlands in the form of farm dams or artificial constructed waterbodies were present within the ecology study area. Analysis of high-resolution aerial imagery indicates that a total of six artificial/constructed waterbodies are intersected by the project disturbance footprint (refer Table 4.10). These areas have the potential to act as important resources for local faunal species.

Table 4.10 Location of artificial/constructed waterbodies intercepted by the Project disturbance footprint

Location of artificial/constructed waterbody (approximate chainage)	Associated waterway
Ch -0.40 km	Unnamed drainage feature of Gowrie Creek
Ch 1.00 – 1.20 km	Within the channel of an unmapped watercourse of Gowrie Creek
Ch 6.80 km	Within the channel of an unmapped watercourse of Gowrie Creek
Ch 16.20 km	Structure associated with the Toowoomba Bypass
Ch 24.35 km	Farm dam on an unnamed drainage feature of Lockyer Creek

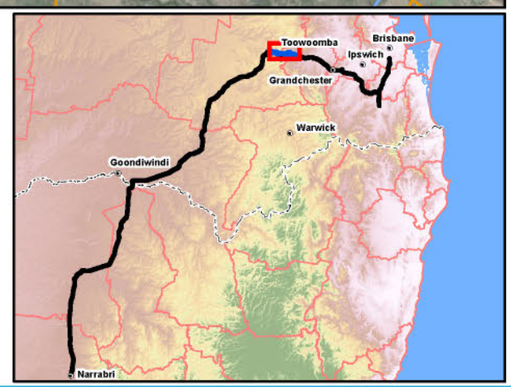
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Map by: AD/GN/KG/LTZ:\GIS\GIS_3200_G2H\Tasks\3320-EAP-20200513112 3_G2H_Ecology_Figures\3320-EAP-20200513112 3_FFJV_Fig4.7_HES_wetlands_v4.mxd Date: 24/03/2021 16:26

Highfields
TOOWOOMBA
Gowrie
Withcott
Helidon
Neringindan Ck
Klein Ck
Reedy Ck
New England Hwy
Gowrie Ck
Toowoomba Byp
Warrego Hwy
Toowoomba Conn Rd
Dry Ck
Ruthven St
Oaky Ck
Rocky Ck
Six Mile Ck
Little Oaky Ck
Gatton Ck
Lockyer Ck
Fifteen Mile Ck
Alice Ck
0
2
4
6
8
10
12
14
16
18
20
22
24
26
1 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)
- Ecology study area
- Local Government Areas
- High ecological value waters - watercourse
- High ecological significance wetlands
- High ecological value waters - wetlands



A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.7: High ecological significance (HES) and high ecological value (HEV) wetlands and watercourses

4.2.9 AquaBAMM

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).

Table 4.11 provides the assessment for the catchments relevant to the ecology study area (Condamine River Basin and Lockyer Creek catchment).

The catchment aquatic conservation assessment indicates a skew towards higher value wetlands (against the criteria indicated above) throughout both catchments, indicating the presence of wetland sensitive environmental receptors throughout both catchments. Noting this, aquatic ecology monitoring sites within the ecology study area were all classed as medium and high, reinforcing the catchment-wide assessment (refer Table 4.12). Aside from the potential hydrological changes associated with the diversions required for the Project (refer Section 5.1.2.11), no significant impact to overland flow regimes (and subsequent indirect impact to wetlands are considered).

Table 4.11 Aquascore for Lockyer Creek catchment and Condamine River Basin

Catchment	Aquascore (%)				
	Very low	Low	Medium	High	Very high
Riverine wetlands					
Lockyer Creek catchment	4% of the catchment had an Aquascore of very low	0% of the catchment had an Aquascore of low	50% of the catchment had an Aquascore of medium	6% of the catchment had an Aquascore of high	40% of the catchment had an Aquascore of very high
Condamine River Basin	8% of the catchment had an Aquascore of very low	10% of the catchment had an Aquascore of low	51% of the catchment had an Aquascore of medium	14% of the catchment had an Aquascore of high	17% of the catchment had an Aquascore of very high
Non-riverine wetlands					
Lockyer Creek (non-riverine wetland) *	0% of the catchment had an Aquascore of very low	0% of the catchment had an Aquascore of low	1% of the catchment had an Aquascore of medium	20% of the catchment had an Aquascore of high	78% of the catchment had an Aquascore of very high
Condamine River Basin	14% of the catchment had an Aquascore of very low	4% of the catchment had an Aquascore of low	43% of the catchment had an Aquascore of medium	25% of the catchment had an Aquascore of high	14% of the catchment had an Aquascore of very high

Table note:

* Rounding (<1%) within AquaBAMM *very low* and *low* categories resulted in 99 per cent overall score

Source: DEHP 2015; Fielder et al. (2011)

Gowrie Creek and the associated tributaries which intersect the Project footprint (excluding the tunnel) have a medium Aquascore, while the main channel above the tunnel has a high Aquascore. The upper reaches of Oaky Creek and Rocky Creek catchment, along with Six Mile Creek catchment have an Aquascore of very high, while the lower reaches are of medium value. The main channel of Lockyer Creek and the associated tributaries have a high Aquascore relative to the Project.

The results of the Aquascore riverine assessment against each aquatic ecology monitoring site are presented in Table 4.12. There was an equal split between medium and high Aquascores between the Project monitoring sites indicating a moderate-good condition across the ecology study area.

Table 4.12 Specific Riverine AquaBAMM score for water quality monitoring sites

Aquascore	Monitoring site	Associated watercourse
Very Low	Nil	-
Low	Nil	-
Medium	1A, 2A, 6A, 7A (alt), 10A (alt), H2C 11A	Gowrie Creek, Rocky Creek, Six Mile Creek, Lockyer Creek
High	3A, 4A, 5A, 8A, 9A	Gowrie Creek, Rocky Creek, Un-named tributary of Lockyer Creek, Lockyer Creek
Very High	Nil	-

Source: QLD Globe (2019)

Three non-riverine wetlands located within the ecology study area, two of the dams associated with the Withcott Seedlings Facility, along with Hoods Dam have a medium Aquascore.

4.2.10 Groundwater dependent ecosystems and springs

GDEs are ecosystems that require access to groundwater on a permanent or periodic basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services.

The GDE Atlas (BoM 2020) identifies three types of ecosystems:

- Aquatic ecosystems that rely on the surface expression of groundwater – this includes surface water ecosystems which may have a groundwater component (i.e. rivers, wetlands, springs)
- Terrestrial ecosystems that rely on the subsurface presence of groundwater – this includes all vegetation ecosystems
- Subterranean ecosystems – this includes cave and aquifer ecosystems.

As the assessment using the GDE Atlas is modelled at a large scale (i.e. typically at the 1:100,000 or 1:50,000 scale), the identification of potential GDEs in the Atlas therefore does not confirm that a particular ecosystem is groundwater dependent. Noting this, the Atlas has identified several potential aquatic and terrestrial groundwater dependent systems including wetland systems and watercourses (refer Figure 4.8).

A review of refined scale potential GDE mapping (DNRME 2020) has been undertaken and the following GDEs aquifer categories have the potential to occur within the ecology study area:

- Unconsolidated sedimentary aquifers
- Consolidated sedimentary aquifers
- Metamorphic rock aquifers.

Further it is noted that there are no GDEs listed under the water plans relevant to the Project, Lockyer Creek Spring, along with the section of Murphys Creek between Fifteen Mile Creek and Alice Creek and the section of Lockyer Creek downstream of the Murphys Creek and Alice Creek confluence to Lockyer Siding Road are recognised as GDEs under the GABORA water plan. The latter is recognised under the GABORA as Murphys Creek approximately 5 km update of the proposed Lockyer Creek crossing.

4.2.10.1 Aquatic groundwater dependent ecosystems

Numerous watercourses traversing the groundwater study area are designated as moderate potential GDEs from regional studies; including Gowrie Creek and Lockyer Creek. The potential GDEs are described as wetlands ‘supplied by alluvial aquifers with near-permanent flow’.

It is noted that several wetlands were identified as a component of the aquatic and terrestrial ecology field works; however, no wetland springs / spring-fed wetlands were identified. Generally, wetlands identified were dams, reservoirs, farm dams, and wetlands associated with floodplains.

4.2.10.2 Terrestrial groundwater dependent ecosystems

The terrestrial GDEs are generally associated with watercourses and drainage lines in the Lockyer Valley, and include:

- Vegetated (containing mature trees) regional ecosystems on alluvia with near-permanent flow.

Within the Toowoomba Plateau, such areas are located above the Toowoomba Range Tunnel. Springs were identified from the Groundwater Dependent Ecosystems Atlas (BoM 2020d) within the ecology study area. Noting this, several first order streams are intersected the Project alignment may be associated with natural springs.

As no field-truthing of these particular environments were undertaken, it has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs are accepted as true presence, and thus form a potentially sensitive receptor. However, mapping indicates that no surface area expressions (i.e. aquatic GDEs) are present within the disturbance footprint, with wetlands and springs being located proximate to the Project (refer Figure 4.8) (refer EIS Appendix L: Surface water quality technical reportfor further details) .

4.2.10.3 Springs

No springs were observed during field assessments associated with surface water or identified from the Groundwater Dependent Ecosystems Atlas (BoM 2020d) within the water quality study area. Noting this, several first order streams are intersected the Project alignment and may be associated with natural springs.

As no field-truthing of these particular environments were undertaken, it has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs are accepted as true presence, and thus form a potentially sensitive receptor. Therefore, GDEs and surface areas have been mapped as occurring within the water quality study area.

The location of terrestrial GDEs are provided in Figure 4.8, and quantified in Table 4.13.

Table 4.13 Extent of springs and ground water dependent ecosystems within the ecology study area

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
Springs	0.00	0.00
Terrestrial GDEs[1]	812.32	16.67
Surface area GDEs[2]	0.00	0.00
Total	**812.32**	**16.67**

Table notes:

1 Terrestrial ecosystems that rely on the subsurface presence of groundwater–this includes all vegetation ecosystems
2 Aquatic ecosystems that rely on the surface expression of groundwater–this includes surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs. Marine and estuarine ecosystems can also be groundwater dependent.

4.2.11 Declared fish habitat areas

A declared FHA is an area protected against physical disturbance from coastal development, while still allowing legal fishing. There are no declared FHAs mapped within the ecology study area. The nearest gazetted FHA is located on the QLD coastline, approximately 135 km downstream of the Project.

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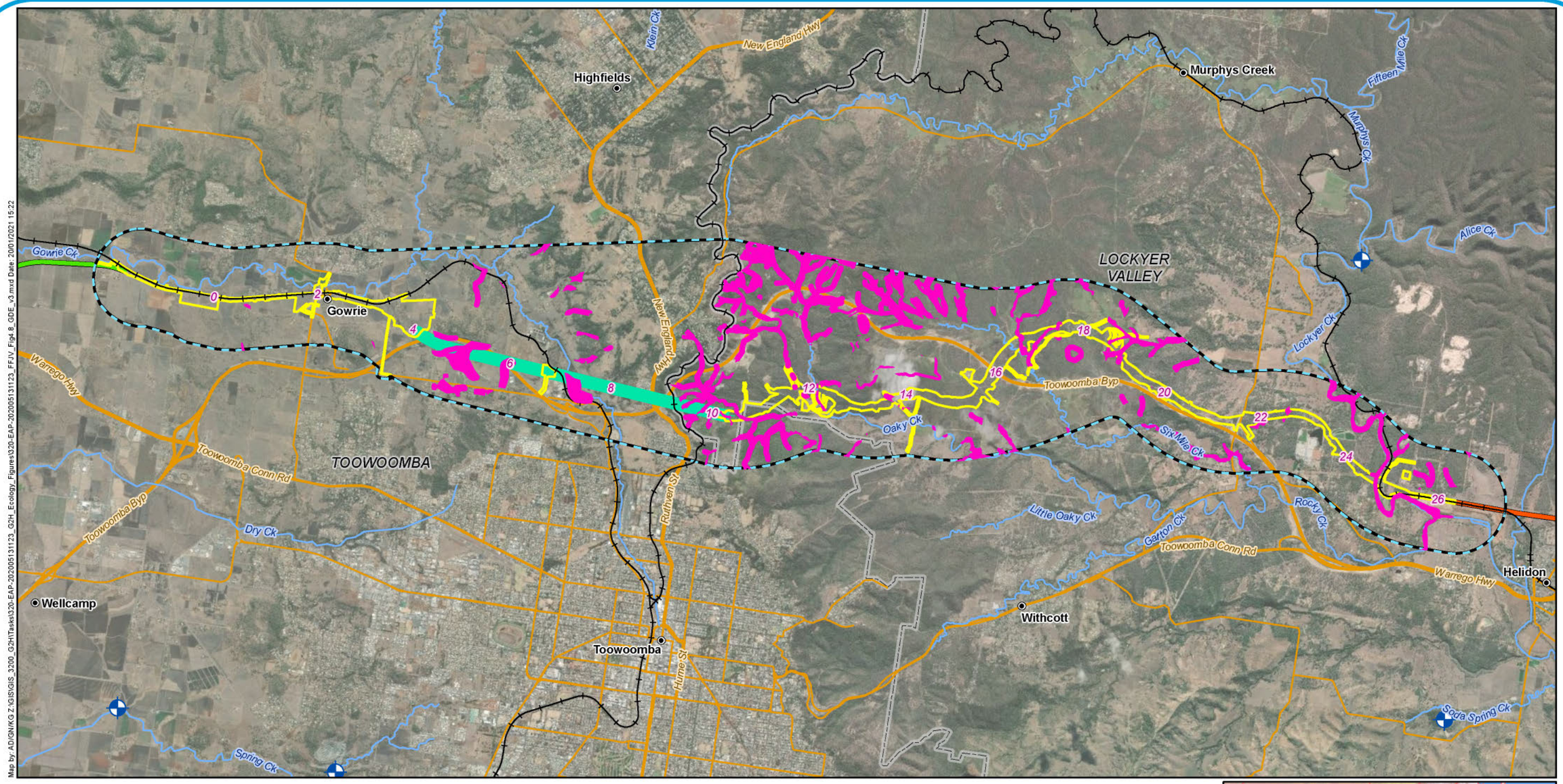

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Legend

- 5 Chainage (km)
- Localities
- Spring locations
- B2G project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Groundwater Dependant Ecosystems - Terrestrial

A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.8: Mapped terrestrial groundwater dependant ecosystems and surface areas present within the ecology study area

4.2.12 Local fisheries and fishing clubs

The Fisheries Act provides provisions for ecological sustainable development principles to be applied to developments which may have an impact on fishing clubs and stocking organisations which utilise water resources on an ongoing basis.

Whist there are no local fisheries of fishing clubs located within the ecology study area, the *Southern Cross Fishing Club Inc* is a Toowoomba based recreational fishing club that is located in proximity to the ecology study area. In addition to this club, there is the potential that smaller unofficial clubs exist in the area. Noting that recreational fishing is likely to be limited due to the local land uses and ephemeral nature of the watercourses intersected by the Project, along with recent issues with Per and poly-fluoroalkyl substances (PFAS) being detected in Gowrie Creek.

Oakey Freshwater Fish Restocking Association has been actively involved in restocking Gowrie Creek downstream of the Project, including Golden perch (*Macquaria ambigua*) and 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, lungfish, perch and crustacean species) may have historically occurred and may account for any records of such species within the local area.

4.2.13 Protected areas

No protected areas (including all classes of protected area except coordinated conservation areas) under the *Nature Conservation Act 1992* are located within the ecology study area (refer Figure 4.9). The nearest protected area, Lockyer National Park and Resource Reserve, is located approximately 2.3 km north of the eastern extent of the Project.

4.2.14 Koala habitat in SEQ

The Nature Conservation and Other Legislation (Koala Protection) Amendment Regulation 2020 amended a range of existing regulations to provide increased protection to koala habitat areas in South East Queensland, including the Koala Plan.

The South East Queensland Koala Conservation Strategy 2020–2025 (DES 2020) (Koala Strategy) was also established as part of the koala conservation reforms, with the strategy outlining the Queensland Government's direction in reversing the decline in koala populations across SEQ and, in doing so, safeguarding the future of this iconic species.

The ecology study area is predominately located within Koala district A which is defined as SEQ under the Planning Regulation 2017. Within this district, the density of the koala population is the highest compared to the rest of QLD with the threats associated with habitat destruction and human impacts are also the greatest, resulting in a reduction in the long-term viability of some koala populations.

The western extent of the ecology study area is located in District C (east of Lesson Road and Gowrie Creek rail bridge, Charlton and south of Kingsthorpe). A small area of the Project disturbance footprint, approximately 2,000 m^2 is located in District C. Works in this area relate to the provision of a RMAR off Lessons Road under the Western Line.

The ecology study area also intersects the following areas defined under the Koala Plan and the Koala Strategy, noting that Koala habitat areas (core and locally refined) are also recognised as MSES. The mapping is also relevant to SEQ with no associated mapping for District C.

Koala Priority Areas are large, connected areas where a focus will be on habitat protection, habitat restoration and threat mitigation to safeguard Koala populations in SEQ. The forested areas to the east of Lockyer Creek and northwest of Helidon, including Lockyer National Park are mapped as koala priority areas. The Project intersects this area between Lockyer Creek and Main Line, including a laydown area (located in a clearing) and proposed changes to Cattos Road.

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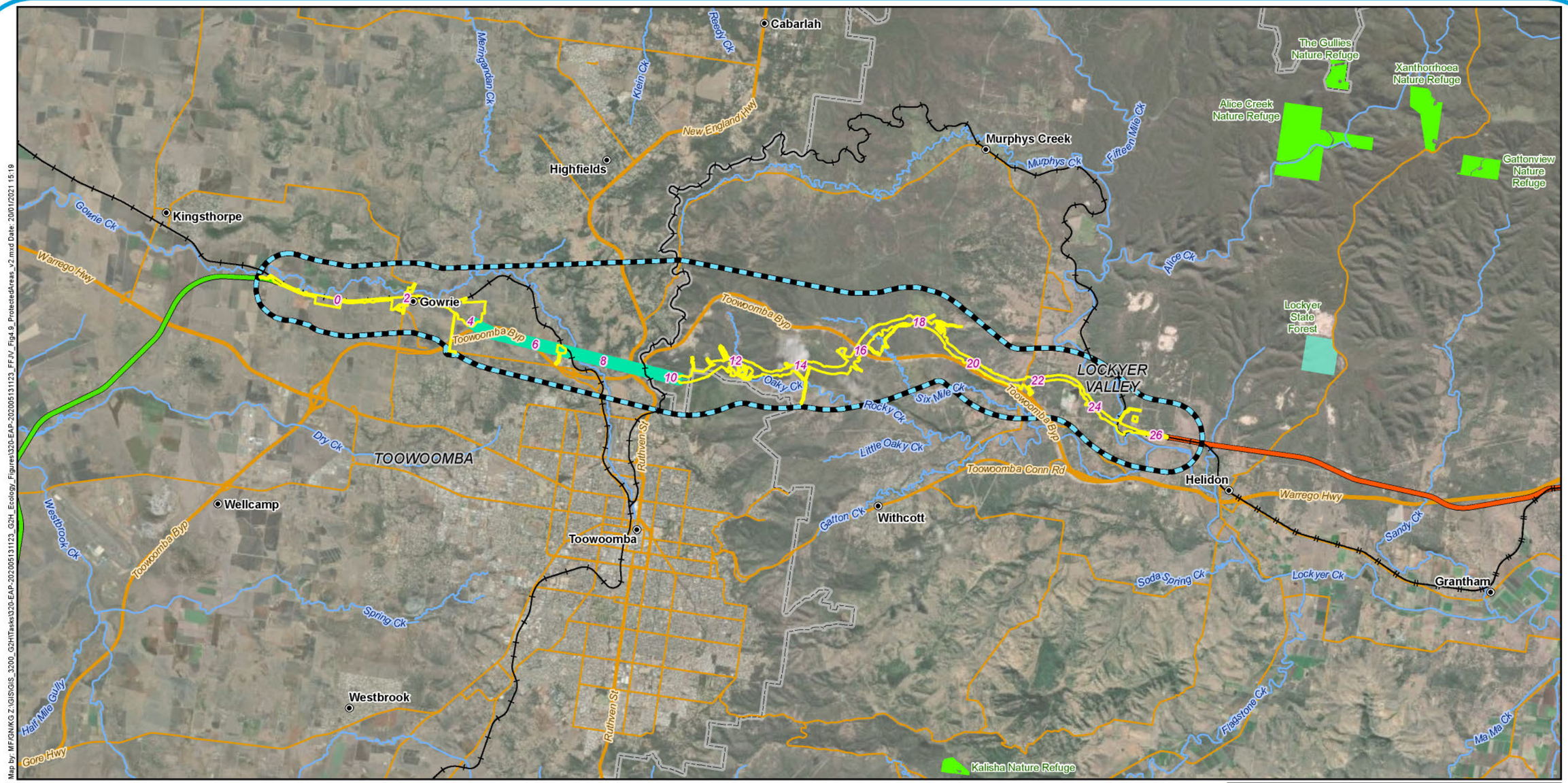

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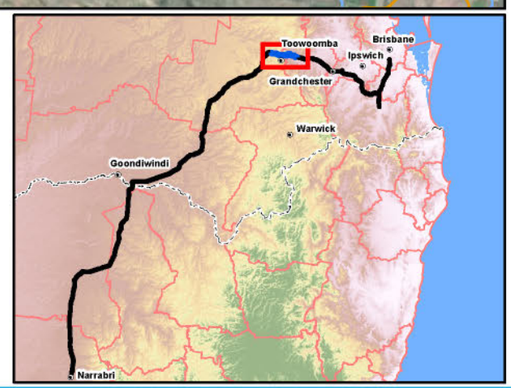
Legend

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



A3 scale: 1:120,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.9: Protected areas under the Nature Conservation (Protected Areas) Regulation 1994

Koala Habitat Areas (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. This mapping also generally aligns with the essential habitat mapping for Koalas. This habitat category constitutes the greatest area within the Project disturbance footprint.

West of the Great Dividing Range these areas are fragmented reflecting the level of anthropogenic activity in this area. The eucalypt woodlands associated with the Project west of western tunnel portal are not recognised as Koala habitat under this plan. Koala habitat area (core) is present adjacent the western tunnel portal east of Boundary Street, with this area recently fragmented by the Toowoomba Bypass. The tunnel will pass under the southern patch. While in the Lockyer Valley all remnant and regrowth vegetation, excluding the vine thicket around the eastern tunnel portal area is recognised as Koala habitat area (core).

Koala Habitat Restoration Areas is land that could be restored and established as Koala habitat. These areas feature low threats or constraints, and high conservation. This habitat category constitutes the second greatest area within the Project disturbance footprint. There are no restoration areas located west of the Great Dividing Range. East of the Great Dividing Range this area is associated with the cleared floodplains of Oaky, Six Mile, Rocky and Lockyer creeks, which have been cleared for rural residential and agricultural purposes. The mapping also includes parts of the Toowoomba Bypass and the Roma Brisbane Gas Pipeline.

Koala habitat areas (locally refined) are currently protected in SEQ and include areas of remnant (uncleared) or high-value regrowth vegetation previously protected by local governments. The area is a temporary protection (two years) with the areas to transition into Koala habitat area (core). A relatively small patch of Locally Refined Koala Habitat Area is present in the Project disturbance footprint, in association with the proposed Cattos Road realignment at Helidon.

The extent of these areas is shown in Figure 4.10 and defined in Table 4.14.

Table 4.14: The extent of Koala mapping within the ecology study area

Koala habitat	Extent (ha)	
	Ecology study area	Project disturbance footprint
Koala Priority Areas	232.53	10.18
Koala Habitat Areas	2,861.83	213.73
Koala Habitat Restoration Areas	1,281.30	79.42
Locally Refined Koala Habitat Areas	13.44	0.99

4.2.15 Biodiversity Planning Assessment

The DES attributes biodiversity significance on a bioregional scale through a BPA. A BPA involves the integration of ecological criteria using the BAMM.

BPAs assign three levels of overall biodiversity significance as identified below:

- **State significance** - areas assessed as being significant for biodiversity at the bioregional or state scales. They also include areas assessed by other studies/processes as being significant at national or international scales. In addition, areas flagged as being of State significance due to the presence of 'Endangered', 'Vulnerable' and/or 'Near threatened' taxa, are identified as "State Habitat for EVNT[4] taxa".
- **Regional significance** - areas assessed as being significant for biodiversity at the subregional scale. These areas have lower significance for biodiversity than areas assessed as being of State significance.
- **Local significance and/or other values** - areas assessed as not being significant for biodiversity at state or regional scales. Local values are of significance at the local government scale.

The results of the BPA assessment for habitat values and corridors are provided in Sections 4.2.15.2 and 4.2.15.3 respectively.

[4] Note that under the revised categories EVNT has been superseded. However for the purposes of the BPA, this term is still valid

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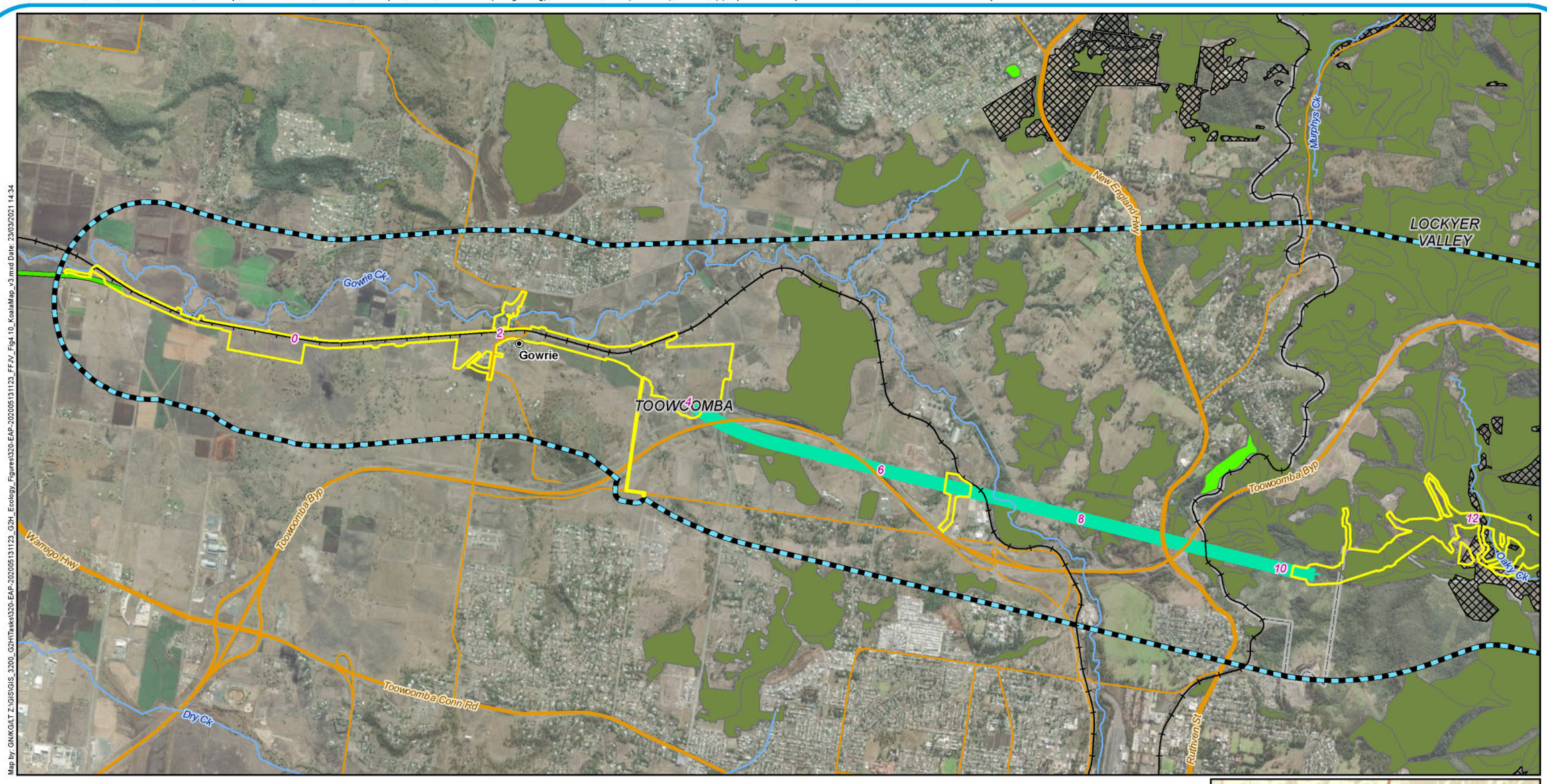
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Koala habitat restoration areas
- Locally refined koala habitat
- Koala habitat areas

A3 scale: 1:40,000
0 0.5 1 1.5 2 2.5km

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Gowrie to Helidon

Figure 4.10a: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

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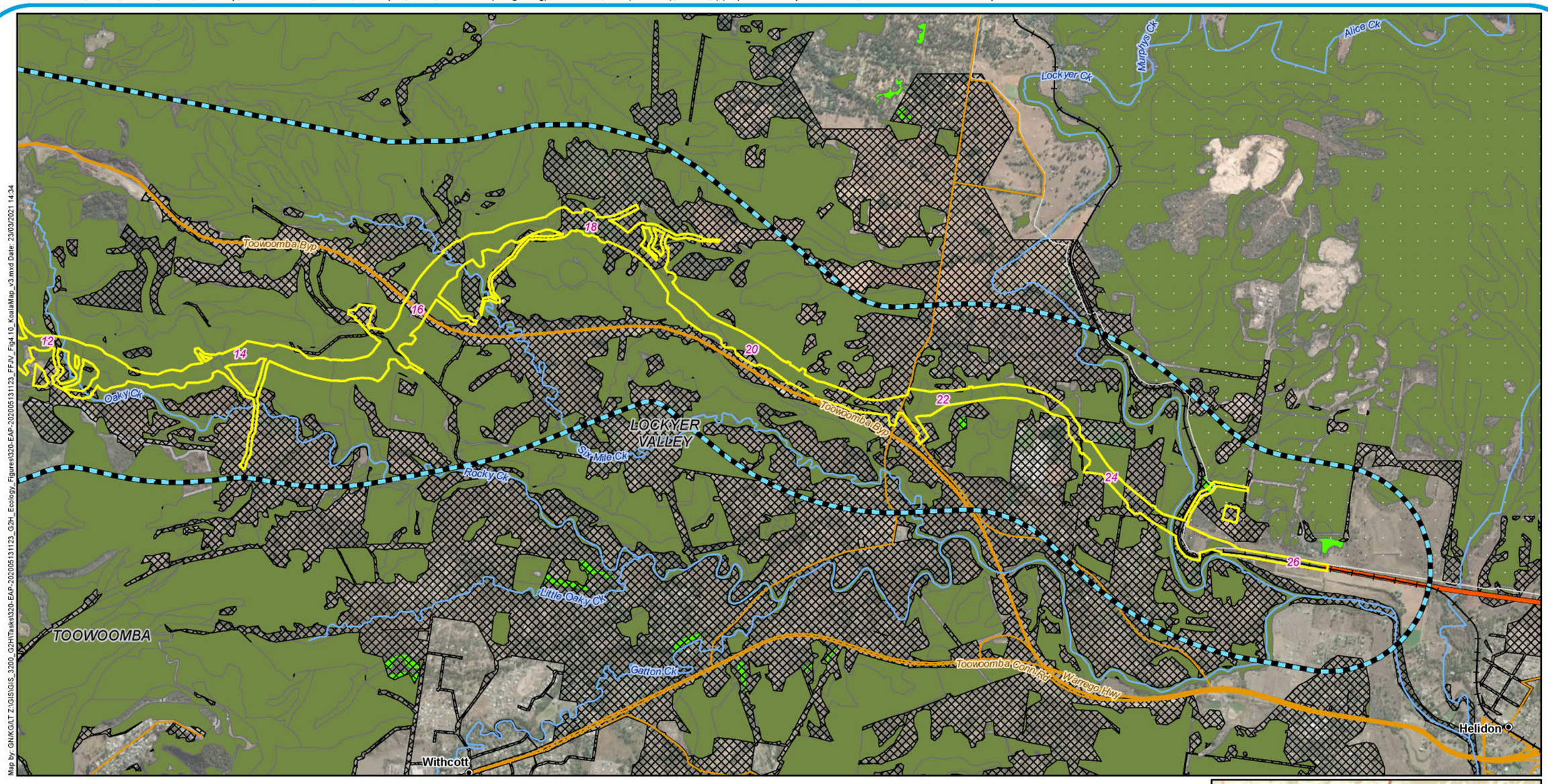
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



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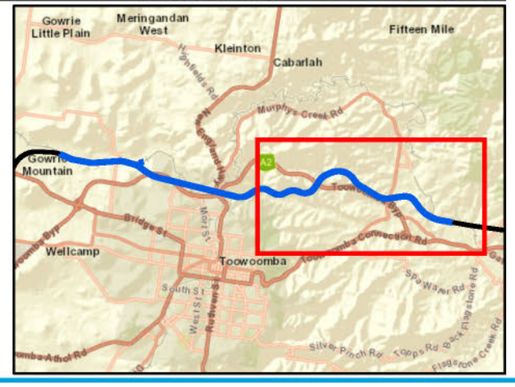
Legend

- 5 Chainage (km)
- Localities
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas
- Koala priority areas
- Koala habitat restoration areas
- Locally refined koala habitat
- Koala habitat areas



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Gowrie to Helidon

Figure 4.10b: Koala mapping as prescribed under the Nature Conservation (Koala) Conservation Plan 2017

4.2.15.1 Special area decisions

The BPA Expert panel derived "Special Area Decisions" are used to assign values to Other Essential Criteria. The specific decisions to the ecology study area include the following:

- **Relictual subregions (less than 30 per cent remnant vegetation) – remnant vegetation** (Regional significance) – The Project is located in the Eastern Darling Downs sub-bioregion there is less than 30% of remnant vegetation remaining. This vegetation provides a refuge from clearing in fragmented landscapes and should be retained to maintain biodiversity.
- **Mountain coolibah remnants, Eastern Darling Downs** (Regional significance) – The Eastern Darling Downs subregion contains the southern limits of Mountain coolibah (*Eucalyptus orgadophila*) woodlands on basalt hills (Regional Ecosystem 11.8.5). The community is considered to provide important habitat for several threatened plant species including: Finger panic (*Digitaria porrecta*), *Discaria pubescens*, Hawkweed (*Picris evae*) and Austral toadflax (*Thesium australe*). As outlined in Section 4.2.18, this community is present in the western extent of the Project.
- **Remnant grasslands, Eastern Darling Downs** (State significance) – Remnants of once more extensive grasslands (less than 2 per cent remains) dominated by Bluegrass (*Dichanthium* spp). or *Astrebla* spp. within the Eastern Darling Downs subregion provide a refuge for a variety of threatened flora, e.g. Finger panic (*Digitaria porrecta*), Austral cornflower (*Rhaponticum australe*), Austral toadflax (*Thesium australe*) and *Solanum papaverifolium*, many of which occur as disjunct populations or at the limit of their geographic range. These areas are also recognised as being of important for reptile fauna including *Carlia tetradactyla*, Shingle-back lizard (*Tiliqua rugosa*), Spotted black snake (*Pseudechis guttatus*), *Delma inornata*, Common delma (*Delma plebeia*) and the threatened Condamine earless dragon (*Tympanocryptis condaminensis*). Disjunct populations of the endangered Long-legged worm-skink (*Anomalopus mackayi*) are also found in similar habitat within the area. As outlined in Section 4.2.18, this community (RE 11.3.21) is present in Gowrie Creek floodplain but outside the Project disturbance footprint.
- Semi-evergreen vine thicket (State significance) - Patches of vine thicket are present within the SEQ Bioregion[5] on the escarpment in the vicinity of the eastern tunnel portal. The Project alignment has been designed to minimise impacts on this community.
- **Riparian lowland forest systems (other than riparian/gallery rainforests systems)** (State significance) – Riparian lowland forest ecosystems are important components of the lowland landscape, frequently exhibiting higher species richness and abundance than surrounding habitats. They act as movement pathways along riparian systems for a number of species, especially birds. They also often provide critical resources for many species in terms of food, shelter and nesting sites. For example, the seasonal flowering of melaleuca is important for species of honeyeaters, whilst narrow bands of flooded gum along watercourses are significant habitat for arboreal mammals, especially in times of drought. Large trees in these systems also act as a source of nest hollows for many species of birds, bats and arboreal mammals. Due to historical and preferential clearing in SEQ, remaining systems are often heavily fragmented and have undergone a substantial reduction in their extent. In many areas, condition is often poor and subject to considerable weed problems.
- **Permanent GDEs** (State significance) – This decision relates to all ecosystems that have a permanent groundwater connection. Such systems are very rare in the Australian landscape. Additionally, given the expected increase in frequency of droughts and higher temperatures, such areas may act as important drought refugia.
- **Helidon Hills** (State significance) – Collectively, the area delineated has very high flora and landscape values. It is an area of sedimentary geology in places capped by the remnants of an old duricrusted surface of Tertiary age. It has weathered surfaces throughout. Watercourses have cut gorges through the sandstone beds especially on the western side. This area includes the following:
- SEQ endemic taxa including narrow endemic taxa

[5] Semi-evergreen vine thicket within the SEQ bioregion is not considered to be a threatened ecological community under the EPBC Act

- Wildlife refugia
- Disjunct taxa
- Climate refugia
- There are no significant cave roosts for Microchiropteran bats identified within the ecology study area.

4.2.15.2 State and regional habitat values

Areas of state and regional BPA habitat values within the ecology study area are detailed in Table 4.15 and Figure 4.11. These areas overlap substantially with those mapped as essential habitat and MSES Wildlife habitat (refer Section 4.2.3).

Table 4.15 The extent of Biodiversity Planning Assessment habitat values within the ecology study area

Habitat values	Extent (ha)	
	Ecology study area	Project disturbance footprint
Local or other values	39.72	10.74
Non Bioregion Ecosystem	10.17	0.00
Regional	253.99	0.00
State	1,080.65	62.56
State habitat for EVNT taxa	874.64	39.70

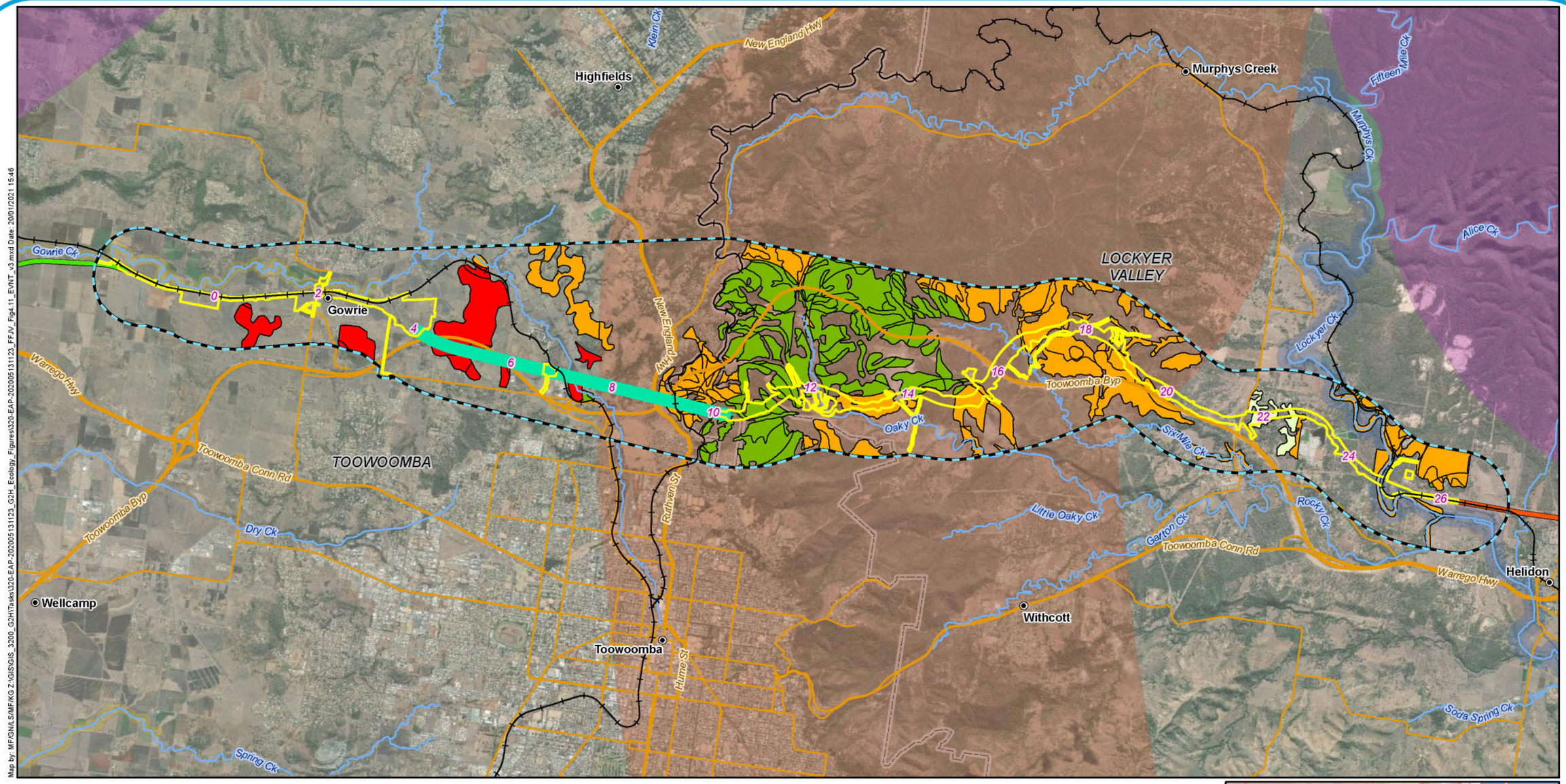
4.2.15.3 State and regionally significant corridors

Areas identified under the BPA as corridors qualify either because they are existing vegetated corridors important for contiguity including regrowth or cleared areas that could serve this purpose if revegetated. Some examples of corridors include riparian habitats, transport corridors and 'stepping-stones'. The function of terrestrial and riparian corridors is outlined below, with the corridors relevant to the Project illustrated in Figure 4.12:

- **Terrestrial Bioregional corridors**, in conjunction with large tracts of remnant vegetation, maintain ecological and evolutionary processes at a landscape scale, by:
  - Maintaining long term evolutionary/genetic processes that allow the natural change in distributions of species and connectivity between populations of species over long periods of time
  - Maintaining landscape/ecosystems processes associated with geological, altitudinal and climatic gradients, to allow for ecological responses to climate change
  - Maintaining large scale seasonal/migratory species processes and movement of fauna
  - Maximising connectivity between large tracts/patches of remnant vegetation
  - Identifying key areas for rehabilitation and offsets

  The Project intersects the Main Range National Park to Don River State Forest Terrestrial Corridor between the intermediate ventilation shaft and the crossing of Murphys Creek Road. This corridor forms part of a major north - south corridor (State corridors) which extends from NSW, meanders back and forth between SEQ and the Brigalow Belt and into northern SEQ Bioregion, generally following the Great Dividing Range.
- **Riparian Bioregional Corridors** also maintain and encourage connectivity of riparian and associated ecosystems. Gowrie Creek downstream of the Boundary Street, along with Lockyer Creek are recognised as riparian bioregional corridors.

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/LS/MF/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.11_EVNT_v3.mxd Date: 20/01/2021 15:46

Legend

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

Habitat values

- Local or Other Values
- Regional Habitat
- State Habitat
- State Habitat for EVNT taxa

Ecological corridors (BPA mapping)

- Riparian, Regional
- Riparian, State
- Riparian/Terrestrial, State
- Terrestrial, Regional
- Terrestrial, State

A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.11: State and regional EVNT taxa and habitats

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

Map by: LS/KG Z:\GIS\GIS_3200_G2H\Tasks\3320-EAP-20200513123_G2H_Ecology_Figures\3320-EAP-20200513123_FFJV_Fig4.12_EcoCorridors_v3.mxd Date: 20/01/2021 15:49

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
Oaky Ck
Rocky Ck
Warrego Hwy
Toowoomba Conn Rd
Dry Ck
Ruthven St
Little Oaky Ck
Carlton Ck
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)
- Ecology study area
- Local Government Areas

Ecological corridors (BPA mapping)

- Riparian, Regional
- Riparian, State
- Riparian/Terrestrial, Regional
- Riparian/Terrestrial, State
- Terrestrial, Regional
- Terrestrial, State

A3 scale: 1:80,000

0 1 2 3 4 5km

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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.12: Terrestrial and riparian ecological corridors

The location of the corridors is determined by the following principles:

- Terrestrial
  - Complement riparian landscape corridors (i.e. minimise overlap and maximise connectivity)
  - Follow major watershed/catchment and/or coastal boundaries
  - Incorporate major altitudinal/geological/climatic gradients
  - Include and maximise connectivity between large tracts/patches of remnant vegetation
  - Include and maximise connectivity between remnant vegetation in good condition
- Riparian
  - Located on the major river or creek systems within the bioregion in question.

The ecology study area is traversed by terrestrial and riparian ecological corridors as detailed in Table 4.16 and shown in Figure 4.12).

Table 4.16 The extent of BPA terrestrial and riparian ecological corridors within the ecology study area

Corridor type	Extent (ha)	
	Ecology study area	Project disturbance footprint
Riparian Corridor of Regional Significance	163.61	9.76
Riparian Corridor of State Significance	264.92	17.17
Terrestrial Corridor of State Significance	3,930.86	230.80

4.2.16 Register of critical habitats

No critical habitats as protected under the EPBC Act (i.e. included in the Register of Critical Habitat and identified as an MNES), occur within the ecology study area.

No critical habitats as protected under the provisions of the NC Act (i.e. identified as an MSES), occur within the ecology study area.

4.2.17 Regional Planning Interests Regulation 2014

No designated precincts, in a strategic environmental area under the *Regional Planning Interests Regulation 2014*, schedule 2, part 5, s15(3), are located within the ecology study area.

4.2.18 Regulated vegetation mapping

Vegetation regulated under the VM Act is categorised into five separate categories as follows:

- **Category A**: vegetation that is subject to compliance notices, offsets and voluntary declarations
- **Category B**: remnant vegetation shown on RE or remnant map as an 'Endangered' RE, an 'Of concern' RE or a 'Least concern' RE
- **Category C**: high-value regrowth vegetation
- **Category R**: regrowth watercourse area
- **Category X**: vegetation that is generally exempt from requirements under vegetation management laws except for State land tenures including Road, Trust land, Unallocated State Land where clearing is assessable development (unless prescribed as accepted development).

In addition to the five categories presented above, vegetation associated with Categories A, B, C and R have been assigned a specific three-digit RE code.

REs are vegetation communities that are consistently associated with a particular combination of geology, landform and soil in a bioregion. REs are shown on the vegetation management supporting map. Each RE has been assigned a vegetation management status based on its current remnant extent—that is, how much of it remains in a bioregion. The three vegetation management codes are as follows:

- **'Endangered'** status: the area of remnant vegetation is less than 10 per cent of the pre-clearing extent of the RE or the area of remnant vegetation is 10–30 per cent of the pre-clearing extent of the RE, and less than 10,000 ha remains.
- **'Of concern'** status: the area of remnant vegetation is 10–30 per cent of the pre-clearing extent of the RE or the area of remnant vegetation is more than 30 per cent of the pre-clearing extent of the RE, and less than 10,000 ha remains.
- **'Least concern'** status: the area of remnant vegetation is more than 30 per cent of the pre-clearing extent of the RE and more than 10,000 ha remains

Analysis of the State based Regulated vegetation mapping (DNRME 2019), indicates that the ecology study area contains Category A, B and C regulated vegetation. This vegetation is listed as 'Endangered', 'Of concern' or 'Least concern' REs. The ecology study area does not contain vegetation mapped as category R (refer Table 4.17 and Figure 4.13).

Regulated vegetation identified as an MSES includes that mapped as Category B, C, R, areas of 'Endangered' RE or 'Of concern' RE, and Category A, B, C, R areas intersecting a watercourse or wetland when they meet the following criteria:

- Category A, B, C and R areas that are located within a defined distance from the defining banks of a relevant watercourse identified on the vegetation management watercourse and drainage feature map
- Category A, B, C and R areas that are located within 100 m from the defining bank of a wetland identified on the vegetation management wetlands map.

Table 4.17 summarises the extent of category A, B, C, R and X areas of regulated vegetation contained within the ecology study area.

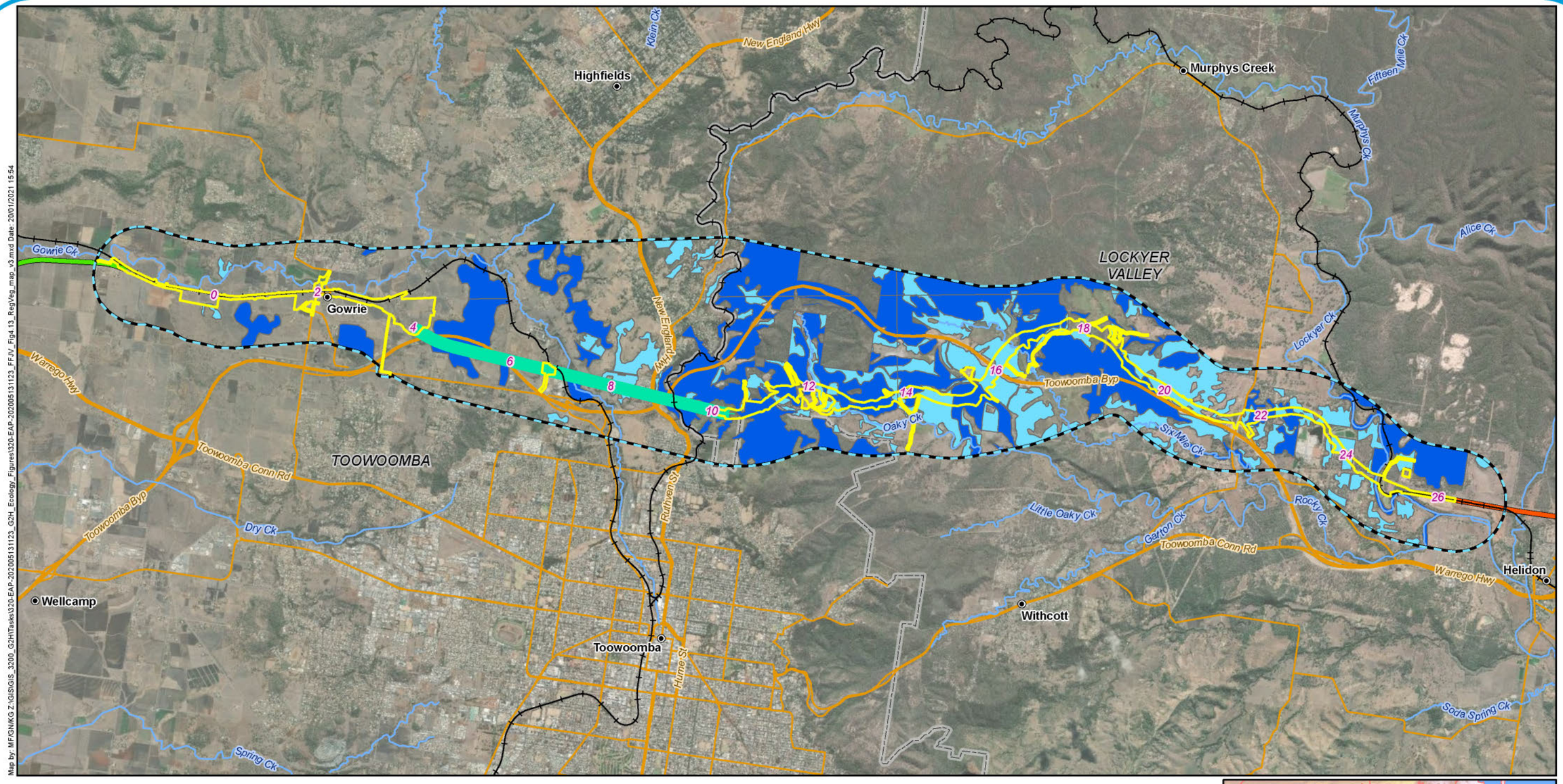
Table 4.17 Extent of category A, B, C, R and X areas of regulated vegetation within the ecology study area and Project disturbance footprint

Regulated vegetation category	Extent (ha)	
	Ecology study area	Project disturbance footprint
Category A – Assessable vegetation offset/compliance notices/Voluntary declaration (VDec)	264.27	0.00
Category B - Remnant vegetation	2,025.95	112.80
Category C - High value regrowth	1,030.74	106.48
Category R – Regrowth watercourse	0.00	0.00
Category X – non-remnant	4,379.27	237.53
Total area	**7,700.22**	**456.81**

Source: Regulated vegetation management map dataset

Category B and C regulated vegetation intersecting a watercourse/wetland occur within the ecology study area. Category R regulated vegetation intersecting a watercourse/wetland does not occur. Approximately 4.30 ha of Category B regulated vegetation (other than grassland) within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature is present within the disturbance footprint. The extent of regulated vegetation intersecting watercourses and wetlands is summarised in Table 4.18 and shown in Figure 4.14.

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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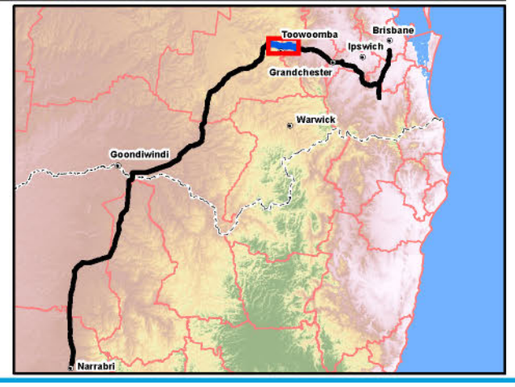
Legend

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

Regulated vegetation management category

- Category B – Remnant vegetation
- Category C – High value regrowth vegetation



A3 scale: 1:80,000

0 1 2 3 4 5km

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Figure 4.13: Regulated vegetation management mapping

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

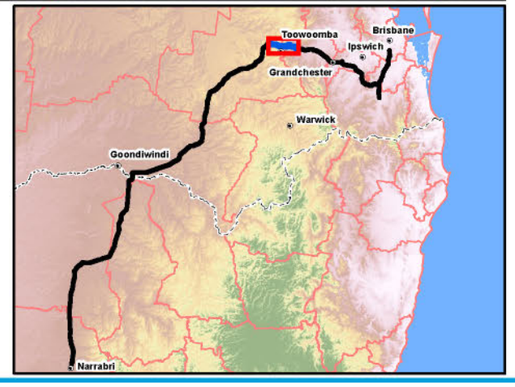
Map by: MFGN/LS/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.14_WetlandVeg_v3.mxd Date: 20/01/2021 15:53

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)
- Ecology study area
- Local Government Areas

Regulated vegetation management category

- Category B – Remnant vegetation
- Category C – High value regrowth vegetation



A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.14: Regulated vegetation intersecting watercourses and wetlands

Table 4.18 The extent of regulated vegetation within a defined distance to watercourses and wetlands within the ecology study area

Regulated vegetation category	Extent (ha)	
	Ecology study area	Project disturbance footprint
Category A – Assessable vegetation offset/compliance notices/VDec	6.45	0.00
Category B - Remnant vegetation	137.05	4.30
Category C - High value regrowth	68.42	5.58
Category X – Legally cleared areas that have not reached remnant status	393.64	15.59

Source: Regulated vegetation management map dataset

It is not possible to use the *Regulated vegetation management map* dataset to discern the quantum of individual RE types, as augmentation of this layer is likely to modify the state dataset to an unacceptable degree and potentially modify scheduled areas. To circumvent this issue, the *Vegetation management regional ecosystem map* was analysed to discern the quantum of each specific RE, which included a breakdown of heterogeneous polygons into their constituent components where they occurred throughout the landscape.

The *Regulated vegetation management map* is defined by Section 20A of the VM Act. The 2017 *Vegetation management regional ecosystem map* is a supplementary tool to the *Regulated vegetation management map*, providing supporting information for the VM Act. Total areas vary between the two mapping systems due to the presence of a category A polygon (located outside of the disturbance footprint) within the supporting *Vegetation management regional ecosystem map*, and as such, deviations in the calculated areas have been compounded by issue.

Table 4.19 provides a breakdown of the vegetation communities (i.e. REs) that constitute regulated vegetation (Category A, B and C) which were defined using the QLD Globe layer 'Vegetation management regional ecosystem map'. Figure 4.15 shows the distribution of these REs within the ecology study area. The extent (ha) of 'Endangered', 'Of concern', and 'Least concern' regulated vegetation (using the layer *Regulated vegetation management map*) contained within the ecology study area is provided in Table 4.20 and is used for the assessment of impact to MSES. A total of 3,155.01 ha of regulated vegetation REs is mapped in the ecology study area.

Table 4.19 Descriptions of Regional Ecosystems within the ecology study area

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11.1)*	Extent of Category B and C regulated vegetation (ha)#	
	VM Act	BD status		Ecology study area	Project disturbance footprint
11.3.21	E	E	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*.	4.50	0.00
11.3.25	LC	OC	*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.	46.40	0.00
11.8.11	OC	OC	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*.	7.92	0.67
11.8.2a	LC	NC	*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.	135.63	0.00
11.8.4	LC	NC	*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.	32.48	0.00
11.8.5	LC	NC	*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*.	218.59	0.00
11.8.5a	LC	NC	*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*.	3.52	0.00

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11.1)*	Extent of Category B and C regulated vegetation (ha)#	
	VM Act	BD status		Ecology study area	Project disturbance footprint
11.8.8	LC	NC	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.	58.00	0.00
12.3.3	E	E	*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).	74.78	3.40
12.3.7	LC	OC	Narrow fringing woodland of *Eucalyptus tereticornis*, *Casuarina cunninghamiana* subsp. *Cunninghamiana* +/- *Melaleuca viminalis*. Other species associated with this RE include *Melaleuca variegata*, *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	185.61	5.14
12.5.6	E	E	*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	1.72	0.00
12.5.6a	E	E	*Eucalyptus saligna* subsp. *saligna* or *E. grandis* open forest, often with vine forest understorey. Occurs on remnant Tertiary surfaces. Usually deep red soils.	1.15	0.00
12.8.9	LC	NC	*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.	106.61	0.00
12.8.14	LC	NC	*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	76.68	0.00
12.8.14a	LC	NC	*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.	49.79	0.00
12.8.17	LC	NC	*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.	126.99	0.00

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11.1)*	Extent of Category B and C regulated vegetation (ha)#	
	VM Act	BD status		Ecology study area	Project disturbance footprint
12.8.21	E	E	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.	112.75	2.36
12.8.24	E	E	*Corymbia citriodora* subsp. *variegata, Eucalyptus crebra* +/- *E. moluccana* open forest. Occurs on Cainozoic igneous rocks especially lower slopes of rhyolite and trachyte hill	12.44	0.00
12.9-10.2	LC	NC	*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.	633.11	89.09
12.9-10.3	OC	OC	*Eucalyptus moluccana* open forest. Other canopy species include *Eucalyptus siderophloia* or *E. crebra, E. tereticornis* and *Corymbia citriodora* subsp. *variegata*. Understorey generally sparse but can become shrubby in absence of fire. Occurs on Cainozoic and Mesozoic sediments, especially shales. Prefers lower slopes.	117.86	6.09
12.9-10.5a	LC	NC	*Eucalyptus helidonica*, *Corymbia citriodora* subsp. v*ariegata* 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.	41.78	0.19
12.9-10.7	OC	OC	*Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora leiocarpa*, *E. melanophloia* woodland. Occurs on Cainozoic and Mesozoic sediments.	1,172.84	104.56
12.9-10.15	E	E	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.	57.59	5.48
12.9-10.17a	LC	NC	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.	26.84	0.00

Regional ecosystems (REs)	Management status		Description (Regional Ecosystem Description Database Version 11.1)*	Extent of Category B and C regulated vegetation (ha)#	
	VM Act	BD status		Ecology study area	Project disturbance footprint
Non-remnant (Category X regulated vegetation)	-	-	*Not applicable*	4,394.65	239.83
Total area				**7,700.22**	**456.81**
Total area (excluding non-remnant vegetation)				3,305.57	216.98

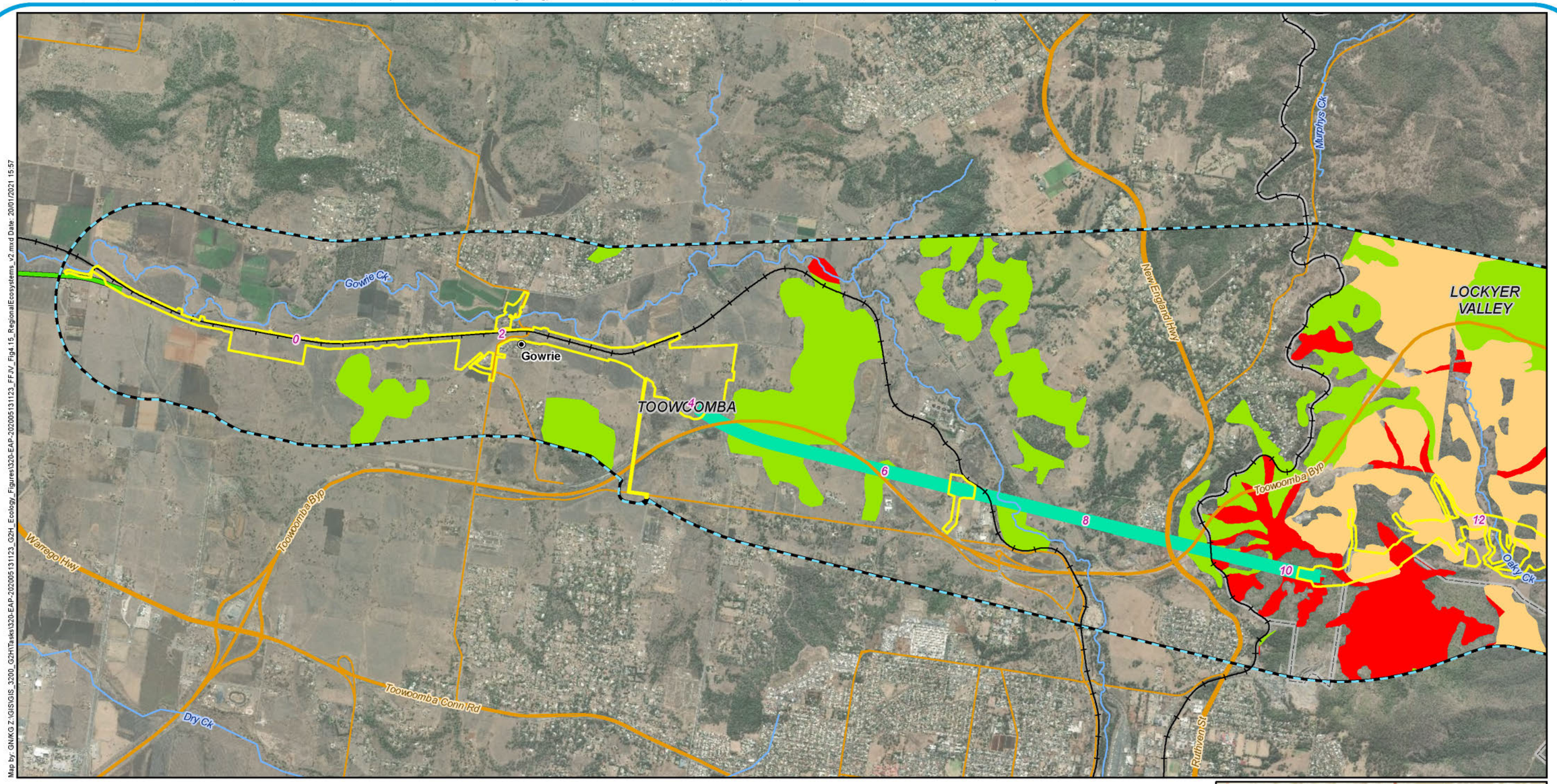
Table notes:

LC = Least concern NC = No concern at present OC = Of concern E = Endangered BD = Biodiversity

* Department of Science, Information Technology and Innovation (2019) # = Category A vegetation has been excluded from this table. Category A regulated vegetation approximates 264.27 ha and is located outside of the Project disturbance footprint (refer Table 4.17)

Source: Vegetation management regional ecosystem mapping dataset

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



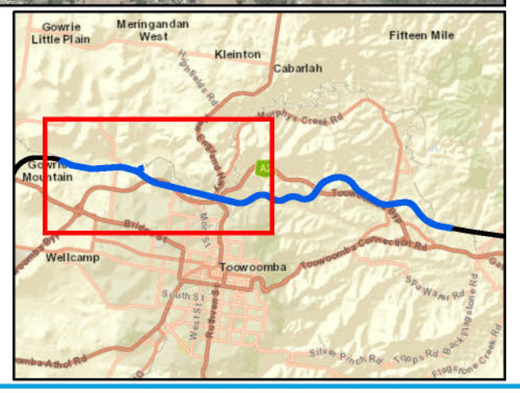
Map by: GN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.15_RegionalEcosystems_v2.mxd Date: 20/01/2021 15:57

Legend

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

Regional ecosystems

- Category A or B area containing endangered
- Category A or B area containing of concern
- Category A or B area that is least concern



A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

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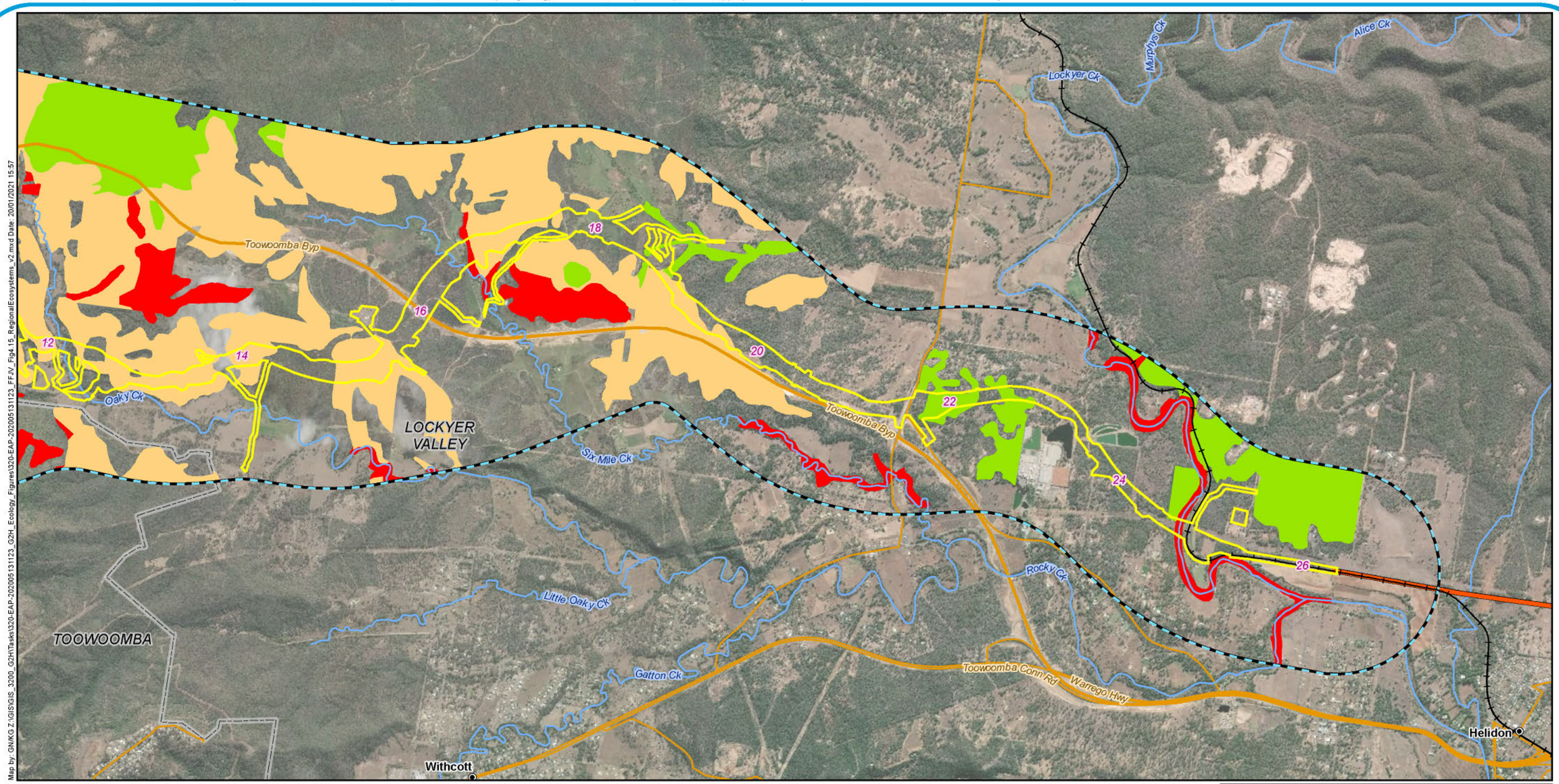
Gowrie to Helidon
Figure 4.15a:
Distribution of Regional Ecosystems

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: GN/KG Z:\GIS\GIS_3200_G2HTasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.15_RegionalEcosystems_v2.mxd Date: 20/01/2021 15:57

Legend

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

Regional ecosystems

- Category A or B area containing endangered
- Category A or B area containing of concern
- Category A or B area that is least concern

A3 scale: 1:40,000
0 0.5 1 1.5 2 2.5km

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Gowrie to Helidon
Figure 4.15b:
Distribution of Regional Ecosystems

Table 4.20 **Extent of remnant (Category B) 'Endangered', 'Of concern' and 'Least concern' regional ecosystems contained within the ecology study area and Project disturbance footprint**

RE VM Act category	Category B Extent (ha)		Category C Extent (ha)	
	Ecology study area	Project disturbance footprint	Ecology study area	Project disturbance footprint
'Endangered'	311.30	9.80	136.94	7.75
'Of concern'	971.40	89.62	748.58	98.74
'Least concern'	841.82	13.39	144.97	0.00
Total area	2,124.52	112.80	1,030.49	106.49

Table notes:

'Endangered' VM Act Category RE: 11.3.21, 12.3.3, 12.5.6, 12.5.6a, 12.8.21, 12.8.24, 12.9-10.15/
'Of concern' VM Act Category RE: 11.8.11, 12.9-10.3, 12.9-10.7/
'Least concern' VM Act Category RE: 11.3.25, 11.8.2a, 11.8.4, 11.8.5, 11.8.5a, 11.8.8, 12.3.7, 12.8.9, 2.8.14, 12.8.14a, 12.8.17, 12.9-10.2, 12.9-10.5a, 12.9-10.17a.

Source: Regulated vegetation management mapping dataset

4.2.19 Offset areas

There are no legally secured offset areas (offset register or vegetation offset), which are MSES, within the ecology study area.

A single offset area (Category A regulated vegetation), associated with the Toowoomba Second Range Crossing project, declared as a Voluntary declaration under the VM Act is located within the ecology study area approximately 500 m north of the Project alignment in the vicinity of Ch 12.0 km. The extent of this offset area is displayed in Figure 4.16 and Table 4.21.

Table 4.21 **Extent of Voluntary declaration (Category A - offset) areas contained within the ecology study area**

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
Voluntary declaration (VDec) area	264.27	0.00

4.2.20 Protected plants flora survey trigger map

The flora survey trigger map identifies high-risk areas where 'Endangered', 'Vulnerable' or 'Near threatened' native plants are present or are likely to be present. High risk areas are located within the ecology study area with some of these high risk areas associated with the findings of the EIS ecological investigations (refer Section 4.3.1). In the Gowrie Creek floodplain, the high risk areas are associated with remnant vegetation, though most of the protected plant records in this area are from non-remnant areas.

The extent of high risk areas are shown in Figure 4.17 and quantified in Table 4.22, noting that the mapping was updated in 2019 and the majority of the targeted surveys in accordance with the relevant protected plant flora survey guidelines were based on the older mapping. These surveys have targeted a number areas along the Project alignment including non-remnant areas and in some instances an area has been surveyed multiple times (e.g. the vegetation communities within the vicinity of the eastern tunnel portal have been surveyed a number of times between 2016 and 2019, resulting in the majority of the footprint, including above the tunnel being surveyed).

Table 4.22 **Extent of high-risk areas contained within the ecology study area**

Feature	Extent (ha)	
	Ecology study area	Project disturbance footprint
High risk area	1,393.20	72.28

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

Map by: MFit,S/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.16_OffsetAreasVMA_v3.mxd Date: 20/01/2021 15:58

Highfields
Murphys Creek
Gowrie
TOOWOOMBA
LOCKYER VALLEY
Wellcamp
Toowoomba
Withcott
Helidon
Klein Ck
New England Hwy
Fifteen Mile Ck
Murphys Ck
Alice Ck
Gowrie Ck
Warrego Hwy
Toowoomba Conn Rd
Toowoomba Byp
Dry Ck
Ruthven St
Six Mile Ck
Lockyer Ck
Oaky Ck
Rocky Ck
Little Oaky Ck
Carton Ck
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)
- Ecology study area
- Local Government Areas
- Regulated vegetation - Category A

A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

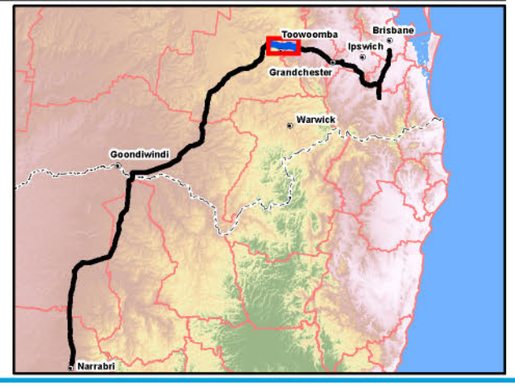
Figure 4.16: Offset areas under the Vegetation Management Act 1999 within the ecology study area

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

Map by: MFGN/LS/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.17_HighRiskFlora_v3.mxd Date: 20/01/2021 16:04

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)
- Ecology study area
- Local Government Areas
- High risk flora area



A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon
Figure 4.17: High risk flora areas

4.3 Results of field assessments

This section provides a description of the existing environmental values of the ecology 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 and vegetation communities, aquatic values and predicted habitat mapping for conservation significant species as listed under the provisions of the NC Act.

4.3.1 Flora

4.3.1.1 Species richness

A total of 274 plant species were identified within the ecology 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 and Appendix I).

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.

4.3.1.2 Conservation significant and 'Special least concern' flora species

Excluding MNES species, three NC Act threatened flora species were recorded within the ecology study area:

- 30 individuals of Finger panic grass (*Digitaria porrecta*) were recorded from a tributary of Gowrie Creek at the western tunnel portal in March 2018 (refer Photograph 4.3). Subsequent surveys within the area failed to identify this species, which may be attributed to the ephemeral nature of the species. This species has also been previously recorded from the Draper Road area west of Gowrie and appears to be well represented within road reserves containing well developed native grass assemblages on black soil throughout the Toowoomba region.
- 15 individuals of *Cyperus clarus* were recorded from attenuated grasslands above the Toowoomba Range Tunnel in March 2018 (refer Photograph 4.4). Subsequent surveys within the area failed to identify this species, which may be attributed to the ephemeral nature of the species and the dry conditions.
- 12 individuals of Slender milk vine (*Marsdenia coronata*) were recorded from eucalypt woodlands near the eastern tunnel portal (refer Photograph 4.5). Within the region this species had not been previously recorded west of Ipswich, with the records a substantial range extension.

Additionally, four SLC flora species were recorded in the ecology study area. All NC Act conservation significant and SLC flora species are summarised in Table 4.23. NC Act conservation significant flora species observed in the ecology study area are shown in Figure 4.18, with the exclusion of MNES species. Information related to the occurrence of MNES flora species (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix J: Matters of National Environmental Significance.

Field investigations also confirmed the presence of habitat, including:

- Slender Milkvine (*Marsdenia coronata*) – presence of moist areas of open forest, especially in eucalypt forest associated with the Toowoomba Range
- *Cyperus clarus* and Finger panic grass (*Digitaria porrecta*) – the presence of black soils associated with the Gowrie section of the Project area.

The availability of habitat types and their relevance to MSES flora is discussed further in Section 4.3.4.

This information was used to inform the predictive habitat modelling and mapping for each of the threatened flora species (refer Appendix G for species habitat maps).

Table 4.23 NC Act conservation significant and 'Special least concern' flora species observed within the ecology study area

Family	Species name	Common name	NC Act status
Adiantaceae	*Cheilanthes distans*	Bristly cloak fern	SLC
Apocynaceae	*Marsdenia coronata*	Slender milkvine	V
Campanulaceae	*Wahlenbergia communis*	Tufted bluebell	SLC
Campanulaceae	*Wahlenbergia gracilis*	Sprawling bluebell	SLC
Cyperaceae	*Cyperus clarus*	(A sedge)	V
Poaceae	*Digitaria porrecta*	Finger panic grass	NT
Sterculiaceae	*Brachychiton populneus*	Kurrajong	SLC

Table notes:

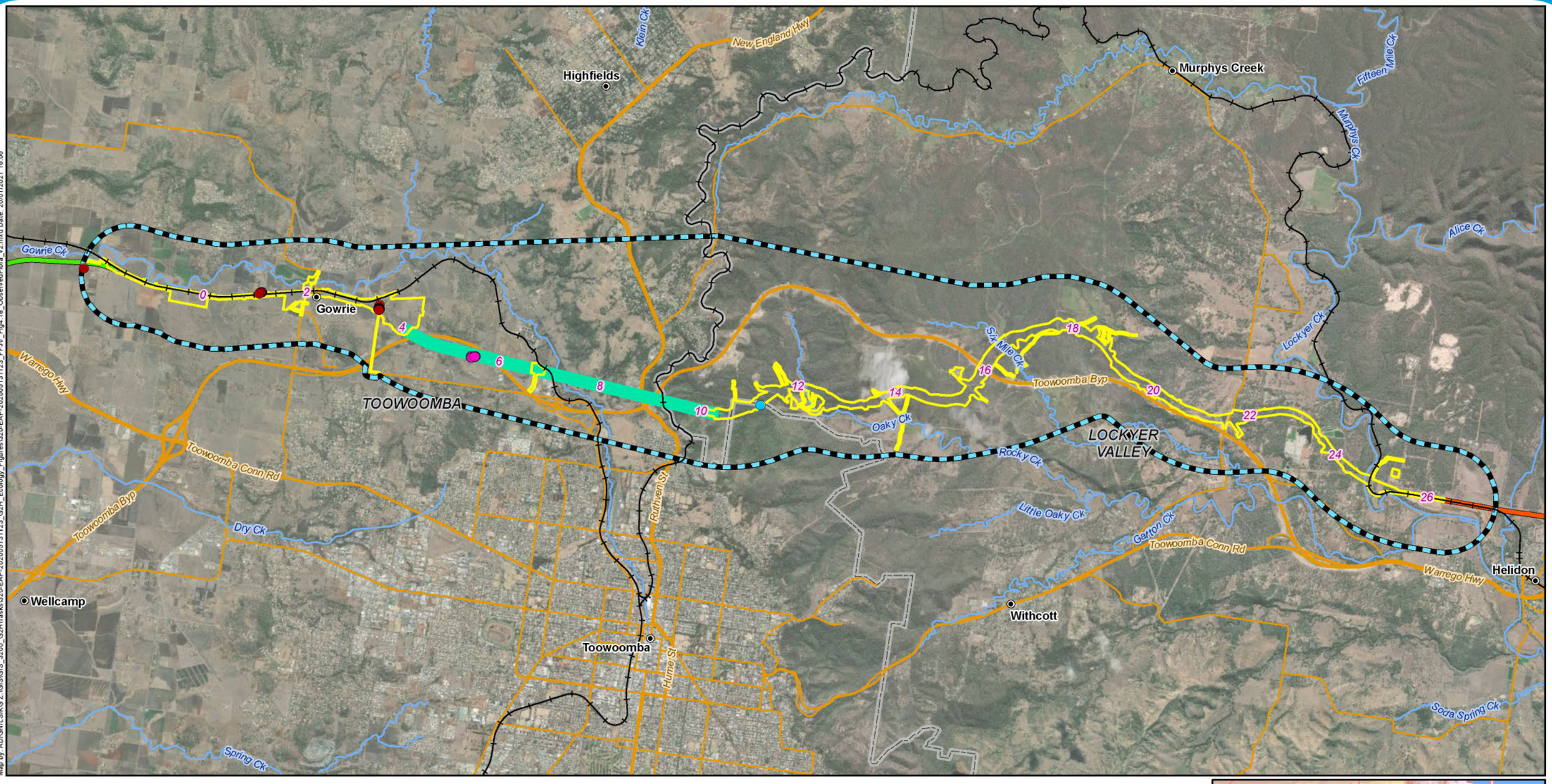
SLC = Special least concern V = Vulnerable NT = Near threatened

Photograph 4.3 Finger panic (*Digitaria porrecta*) amongst bluegrass and Mayne's pest (left) and typical habitat (right) within the vicinity of Gowrie within the ecology study area (FFJV 2018)

Photograph 4.4 *Cyperus clarus* (left) and typical habitat (right) within the vicinity of Gowrie within the ecology study area (FFJV 2018)

Photograph 4.5 Slender milkvine (*Marsdenia coronata*) identified within eucalypt woodland on the Toowoomba range, in ecology study area (EMM 2019)

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



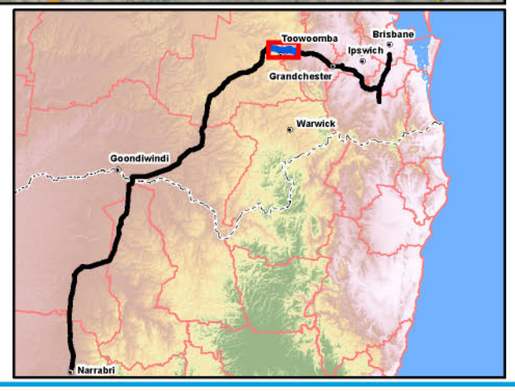
Map by: AD/GN/LS/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.18_ObservedFlora_v2.mxd Date: 20/01/2021 16:06

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)
- Ecology study area
- Local Government Areas

Significant flora

- Cyperus Clarus (*Cyperus clarus*)
- Finger Panic Grass (*Digitaria porrecta*)
- Slender Milkvine (*Marsdenia coronata*)



A3 scale: 1:80,000

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.18: Observed conservation significant flora species (excluding threatened MNES)

4.3.1.3 Aquatic flora

Aquatic flora species were relatively poorly represented (i.e. low diversity) within the ecology study area (refer Photograph 4.6, Photograph 4.7, Photograph 4.8 and Photograph 4.9).

The Project EIS field investigations identified five aquatic flora species from the ecology study area (refer Table 4.24).

All aquatic species identified were generally common and widespread where suitable conditions for their colonisation were available (i.e. permanent water).

Photograph 4.6 **Gowrie Creek, upstream of the Project alignment showing poor representation of aquatic macrophytes within the area (FFJV 2017)**

Photograph 4.7 **Lockyer Creek, upstream of the Project alignment showing reduced levels of aquatic flora species (FFJV 2017)**

Photograph 4.8 **Rocky Creek, upstream of the Project alignment showing a well-developed stratum of aquatic plant with very low diversity (FFJV 2017)**

Photograph 4.9 **Six Mile Creek, downstream of the Project alignment show no aquatic flora species and ephemeral nature (FFJV 2017)**

Table 4.24 **Aquatic flora identified within the ecology study area**

Family	Species name	Common name	NC Act status	Native/non-native
Cyperaceae	*Cyperus spp*	Sedge	LC	Native
Juncaceae	*Juncus usitatus*	Common rush	LC	Native
Nymphaeaceae	*Nymphaea gigantea*	Giant waterlily	LC	Native
Poaceae	*Paspalum distichum*	Water couch	LC	Native
Typhaceae	*Typha orientalis*	Broadleaf cumbungi	LC	Native

Table note:

LC = Least concern

4.3.1.4 Weed species

In total, 72 non-native flora species were identified during the Project EIS field investigations (refer Appendix E). Of the 72 non-native species, 17 are listed as restricted matters flora species (under the Biosecurity Act) and 10 are Weeds of National Significance (WoNS). Restricted matters and WoNS recorded in the ecology study area are summarised in Table 4.25. Weeds were prevalent across the entire ecology study area but were most abundant in areas subject to anthropogenic disturbance such as roadsides and areas subject to cattle grazing.

Whist the Toowoomba Regional Biosecurity Plan for invasive animals and plants (Toowoomba Regional Council (TRC)) and Lockyer Regional Council (LVRC) prioritises species listed under the Biosecurity Act, particular focus is placed on the following species which have been identified as prevalent within the Toowoomba and Lockyer Valley Regions:

- Bridal creeper (*Asparagus asparagoides*)
- Honey locust (*Gleditsia triacanthos*)
- Chilean needle grass (*Nassella neesiana*)
- African boxthorn (*Lycium ferocissimum*)
- Annual ragweed (*Ambrosia artemisiifolia*)
- Blackberry (*Rubus anglocandicans*)
- Fireweed (*Scenecio madagascariensis*)
- Groundsel bush (*Baccharis halimifolia*)
- Harrisia cactus (*Harrisia martinii*)
- Mother of millions (*Bryophyllum delagoense*)
- Parthenium weed (*Parthenium hysterophorus*)
- Prickly pears (*Opuntia* spp.)
- Giant rats-tail grasses (*Sporobolus* spp.)
- Madeira vine (*Anredera cordifolia*)
- Cat's claw creeper (*Dolichandra unguis-cati*)
- Water weeds (including Water hyacinth - *Eichhornia crassipes*).

Of these species, eight have been identified within the ecology study area are identified in Table 4.25.

Table 4.25 Restricted matters identified within the ecology study area

Family	Species name	Common name	Schedule 2 of the Biosecurity Act	Weed of National Significance	LVRC - Active Species/ Weed of Alert	TRC - Weed of particular Interest	Relative abundance within ecology study area	Areas containing greatest densities within ecology study area
Asparagaceae	*Asparagus plumosus*	Feathered asparagus fern	Category 3	Yes			Uncommon	Riparian forests and bushland
Asteraceae	*Baccharis halimifolia*#	Groundsel bush	Category 3	No	Yes	Yes	Uncommon	Bushland and disturbed areas including grazing land
Asteraceae	*Parthenium hysterophorus*#	Parthenium weed	Category 3	Yes	Yes	Yes	Uncommon	Bushland and disturbed areas including grazing land
Asteraceae	*Senecio madagascariensis*#	Fireweed	Category 3	Yes	Yes	Yes	Common	Disturbed areas including grazing land
Basellaceae	*Anredera cordifolia*	Madeira vine	Category 3	Yes	Yes		Common	Riparian forest and bushland
Bignoniaceae	*Dolichandra unguis-cati*	Cat's claw creeper	Category 3	Yes	Yes		Common	Riparian forest and bushland
Cactaceae	*Opuntia stricta* #	Common pest pear	Category 3	Yes	Yes	Yes	Common	Bushland and disturbed areas including grazing land
Cactaceae	*Opuntia tomentosa*#	Velvety tree pear	Category 3	Yes	Yes	Yes	Very common	Bushland and disturbed areas including grazing land
Caesalpiniaceae	*Gleditsia triacanthos*#	Honey locust	Category 3	No	Yes	Yes	Uncommon	Bushland and disturbed areas including grazing land
Lauraceae	*Cinnamomum camphora*	Camphor laurel	Category 3	No			Common	Riparian forest and bushland
Oleaceae	*Ligustrum lucidum*	Large-leaved privet	Category 3	No			Very common	Riparian forest and bushland
Oleaceae	*Ligustrum sinense*	Small-leaved privet	Category 3	No			Common	Riparian forest and bushland
Rosaceae	*Rubus anglocandicans*#	Blackberry	Category 3	Yes		Yes	Uncommon	Disturbed areas including grazing land
Solanaceae	*Lycium ferocissimum*#	African boxthorn	Category 3	Yes	Yes	Yes	Uncommon	Disturbed areas including grazing land
Ulmaceae	*Celtis sinensis*	Chinese celtis	Category 3	No			Common	Riparian forest and bushland
Verbenaceae	*Lantana camara*	Lantana	Category 3	Yes			Very common	Bushland and disturbed areas including grazing land

Family	Species name	Common name	Schedule 2 of the Biosecurity Act	Weed of National Significance	LVRC - Active Species/ Weed of Alert	TRC - Weed of particular Interest	Relative abundance within ecology study area	Areas containing greatest densities within ecology study area
Verbenaceae	*Lantana montevidensis*	Creeping lantana	Category 3	No			Very common	Bushland and disturbed areas including grazing land

Table note:

Category 3 = includes noxious fish, weeds and pest animals. You must not distribute this restricted matter. This means it must not be given as a gift, sold, traded or released into the environment unless the distribution or disposal is authorised in a regulation or under permit.

4.3.2 Fauna

This section outlines the fauna species richness observed within the ecology study area. This section also provides the conservation significant species listed under the provisions of the NC Act and/or EPBC Act (non-threatened migratory species) and the pest species declared under the Biosecurity Act that were recorded within the ecology study area.

4.3.2.1 Species richness

Project EIS field investigations 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, two of which are restricted matters (refer Section 4.3.2.3). Recorded species consisted of 75 birds, 21 mammals, eight reptiles and one frog (refer Appendix F).

Given the nature of bushland areas within the ecology 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.

4.3.2.2 Conservation significant and 'Special least concern' fauna species

Excluding MNES, no threatened fauna species were identified within the ecology study area from Project EIS field investigations (refer Appendix F). However, four SLC fauna species were recorded within the ecology study area:

The Satin flycatcher (*Myiagra cyanoleuca*) and the Spectacled monarch (*Symposiachrus trivirgatus*) were observed from site T17. In addition, the Black-faced monarch (*Monarcha melanopsis*) was observed within the Lockyer Valley within the eastern portion of the Ecology study area. These species are also listed as Migratory under the EPBC Act.

The Platypus (*Ornithorhynchus anatinus*) was observed in Gowrie Creek neat Gowrie Creek site 3A

The Short-beaked echidna (*Tachyglossus aculeatus*) was observed from within bushland associated with the Toowoomba Range, in proximity to the Toowoomba Second Range Crossing. This species is known to be relatively abundant within this area.

The location of NC Act conservation significant fauna species identified during project EIS field investigations is provided in Figure 4.19.

Information related to the occurrence MNES fauna species (excluding migratory species) (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix J: Matters of National Environmental Significance.

Whilst not observed as part of the Project EIS investigations, two NC Act threatened species (i.e. Powerful owl (*Ninox strenua*) and Glossy black-cockatoo (*Calyptorhynchus lathami*)) are known to occur in area. The Glossy-black cockatoo has been record from Lockyer Creek, approximately 800 metres east of the Withcott Seedling Viaduct Both species have also been record from the Jubilee Park area approximately 3 km south of the eastern tunnel portal, with the Glossy-black cockatoo also known from Cotswold Hills, approximately 1.8 km south of the western tunnel portal. These species were also recorded from areas associated with the TSRC project.

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

Map by: AD/GK/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.19_ObservedFauna_v4.mxd Date: 20/01/2021 16:08

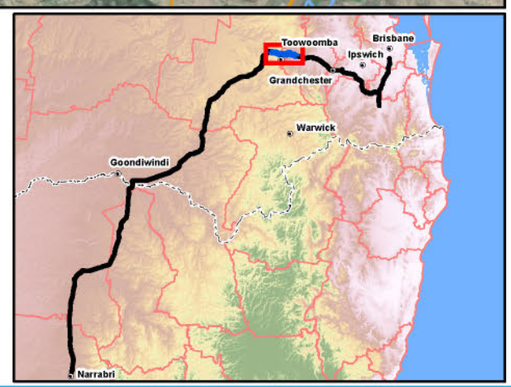
Kingsthorpe
Highfields
Murphys Creek
Gowrie
TOOWOOMBA
LOCKYER VALLEY
Helidon
Withcott
Oaky Creek
Gowrie Ck
Klein Ck
New England Hwy
Fifteen Mile Ck
Murphys Ck
Alice Ck
Lockyer Ck
Warrego Hwy
Toowoomba Conn Rd
Toowoomba Byp
Oaky Ck
Rocky Ck
Six Mile Ck
Little Oaky Ck
Gatton Ck
Soda Spring Ck
Flagstone Ck
0
2
4
6
8
10
12
14
16
18
20
22
24
26
1 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)
- Ecology study area
- Local Government Areas

Fauna species

- Short-beaked echidna (*Tachyglossus aculeatus*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Black-faced monarch *Monarcha melanopsis*)
- Platypus (*Ornithorhynchus anatinus*)
- Spectacled monarch (*Symposiachrus trivirgatus*)



A3 scale: 1:98,053

0 1 2 3 4 5km

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Gowrie to Helidon

Figure 4.19: Observed NC Act conservation significant and EPBC Act listed migratory fauna species (excluding threatened MNES)

Field investigations also confirmed the presence of habitat (foraging and breeding), including:

- Suitable habitat for forest/woodland migratory species such as the Oriental cuckoo (*Cuculus optatus*), Satin flycatcher (*Myiagra cyanoleuca*) ,Rufous fantail (*Rhipidura rufifrons*), Black-faced monarch (*Monarcha melanopsis*) and Spectacled monarch (*Symposiachrus trivirgatus*) in the form of riparian forests and woodlands, larger open forest to woodland remnants associated with the Toowoomba Range
- Suitable habitat for wetland/wader migratory species such as the Glossy ibis (*Plegadis falcinellus*) in the form or farm dams and larger drainage lines
- Glossy black-cockatoo (*Calyptorhynchus lathami*) – presence of large hollows and foraging trees (i.e. *Allocasuarina torulosa* and *Allocasuarina littoralis*) within Toowoomba Range
- Powerful owl (*Ninox strenua*) – large tracts of forest or woodland within the Toowoomba Range, and large hollows and foraging habitat within more fragmented landscapes
- Echidna (*Tachyglossus aculeatus*) – occurrence of forests, woodlands and grasslands with areas suitable for breeding burrows
- Platypus (*Ornithorhynchus anatinus*) – occurrence of perennial watercourses with well-formed banks to allow the construction of breeding burrows (e.g. Gowrie Creek).

The availability of habitat types and their relevance to fauna is discussed further in Section 4.3.4.

This information was used, in addition to that contained within relevant recovery plans and conservation listing advice, to inform the predictive habitat modelling and mapping for each of the threatened and migratory fauna species (refer Appendix G for species habitat maps). Potential habitat for threatened fauna species, special least concern species and migratory species is spread throughout the Project alignment but is typically focused on the Toowoomba Range.

It is noted that whilst all areas of the ecology study area were not accessible, information derived from historic and concurrent surveys (refer Table 3.3) was used to inform the predictive mapping where applicable.

Information related to the occurrence MNES fauna species (excluding migratory species) (i.e. controlling provisions under the EPBC Act) is provided within EIS Appendix J: Matters of National Environmental Significance.

4.3.2.3 Invasive animals

Six non-native fauna species, including two declared as restricted matter under the Biosecurity Act, were identified within ecology study area during Project EIS field investigations (Appendix F). Non-native species identified within the ecology study area are identified in Table 4.26. Whist the Toowoomba and Lockyer Valley Regional Councils prioritise species listed under the Biosecurity Act, particular focus is place on the following species which have been identified as prevalent within the Toowoomba and Lockyer Valley Regions:

- Feral pig (*Sus scrofa*)
- Wild dogs (*Canis familiaris, C. familiaris dingo, C. lupus familiaris, C. lupus dingo*)
- Foxes (*Vulpes vulpes*)
- Rabbits (*Oryctolagus cuniculus*)
- Feral Deer (*Axis axis, Cervus elaphus, Dama dama, Rusa timorensis, Cervus timorensis*)
- Feral cats (*Felis catus*)
- Feral goats (*Capra hicus*)

Of these species, two have been identified within the ecology study area are identified in Table 4.26.

Table 4.26 Non-native fauna species identified within the ecology study area

Family name	Species name	Common name	Schedule 2 of the Biosecurity Act	Relative abundance within the ecology study area
Bufonidae	*Rhinella marina*	Cane toad	-	Very common
Cervidae	*Cervus elaphus*#^	Red deer	Category 3,4,6	Rare
Equidae	*Equus caballus*	Horse	-	Common
Leporidae	*Lepus europaeus*	European hare	-	Common
Leporidae	*Oryctolagus cuniculus*#^	European rabbit	Category 3,4,5,6	Common
Sturnidae	*Acridotheres tristis*	Common myna	-	Common

Table notes:

\# Priority pest animal within the Toowoomba Regional Council area as identified by Toowoomba Regional Council

^ Locker Valley Regional Council pest animals as listed by Lockyer Valley Regional Council

Biosecurity category 3: A person must not distribute the invasive plant either by sale or gift, release it into the environment.

Biosecurity category 4: A person must not move the invasive plant.

Biosecurity category 5: A person must not keep the invasive plant.

Biosecurity category 6: Includes certain invasive animals such as foxes, rabbits, wild dogs, feral deer and noxious fish such as carp, gambusia and tilapia. A person must not feed this category of restricted matter.

4.3.2.4 Aquatic fauna

The Project EIS field assessments identified three fish species from the ecology study area (refer Table 4.27).

Table 4.27 Aquatic fauna identified within the ecology study area

Family name	Species name	Common name
Ambassidae	*Ambassis agassizii*	Agassiz's glassfish
Chelidae	*Emydura macquarii macquarii*	Murray turtle
Eleotridae	*Gobiomorphus australis*	Striped gudgeon

4.3.3 Predicted habitat for NC Act conservation significant and EPBC Act migratory flora and fauna species

Predictive habitat mapping for NC Act threatened fauna and flora species, two special least concern fauna species and migratory species (refer Section 3.3.4 and Appendix A) indicates that potential habitat for 11 conservation significant species (including two SLC mammal species), and 18 EPBC Act listed migratory species occurs within the ecology study area (refer Table 4.28 and Table 4.29 respectively).

Predicted habitat mapping for NC Act conservation significant and EPBC Act listed migratory species is presented in Appendix G. No habitat critical to the survival of the EPBC Act listed migratory species has been identified within the ecology study area.

Table 4.28 Predicted habitat for NC Act conservation significant flora and fauna species (excluding MNES) within the ecology study area

Species name	Common name	NC Act status	Predicted habitat within the ecology study area (ha) (7,700.22 ha)				Predicted habitat within the Project disturbance footprint (ha)* (456.81 ha)			
			General	Essential	Core	Total habitat*	General	Essential	Core	Total habitat*
NC Act conservation significant flora										
Callitris baileyi	Bailey's cypress	NT	2,665.50	0.00	0.00	**2,665.50**	213.09	0.00	0.00	**213.09**
Caustis blakei subsp. *macrantha*	Caustis	V	210.64	11.49	0.00	**222.13**	10.41	0.00	0.00	**10.41**
Cyperus clarus	A sedge	V	356.42	59.23	0.00	**415.66**	0.00	0.00	0.00	**0.00**
Digitaria porrecta	*Finger panic grass*	NT	709.06	36.90	0.00	**745.97**	43.25	5.27	0.00	**48.52**
Marsdenia coronata	Slender milkvine	V	313.95	0.00	0.00	**313.95**	51.02	0.00	0.00	**51.02**
NC Act conservation significant fauna										
Calyptorhynchus lathami lathami	Glossy black-cockatoo (eastern)	V	473.64	0.00	0.00	**473.64**	21.58	0.00	0.00	**21.58**
Ninox strenua	Powerful owl	V	1305.07	0.00	0.00	**1305.07**	99.05	0.00	0.00	**99.05**
Hemiaspis damelii	Grey snake	E	181.88	0.00	0.00	**181.88**	0.00	0.00	0.00	**0.00**
NC Act 'Special least concern' animals										
Ornithorhynchus anatinus	Platypus	SLC	763.54	58.02	0.00	**821.56**	46.83	0.00	0.00	**46.83**
Tachyglossus aculeatus	Short-beaked echidna	SLC	2,823.36	0.00	0.00	**2,823.36**	161.69	0.00	0.00	**161.69**

Table notes:

E = Endangered V = Vulnerable NT = Near threatened SLC = Special least concern

* Total habitat is the sum of the general, essential and core habitat categories

Table 4.29 Predicted habitat for EPBC Act listed migratory species within the ecology study area

Species name	Common name	NC Act status	EPBC Act status	Predicted habitat within the ecology study area (ha) (7,700.22 ha)			Predicted habitat within the Project disturbance footprint (ha) (456.81 ha)		
				Potential habitat	Important habitat	Total habitat*	Potential habitat	Important habitat	Total habitat*
Actitis hypoleucos	Common sandpiper	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Apus pacificus	Fork-tailed swift	SLC	M	4,362.80	2,790.48	**7,153.28**	226.16	201.19	**427.35**
Calidris acuminata	Sharp-tailed sandpiper	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Calidris melanotos	Pectoral sandpiper	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Calidris ruficollis	Red-necked stint	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Cuculus optatus	Oriental cuckoo	SLC	M	44.58	74.45	**119.03**	1.93	1.53	**3.46**
Gallinago hardwickii	Latham's snipe	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Hydroprogne caspia	Caspian tern	SLC	M	441.73	6.58	**448.32**	13.25	0.00	**13.25**
Monarcha melanopsis	Black-faced monarch	SLC	M	595.54	91.64	**687.17**	66.06	1.53	**67.59**
Motacilla flava	Yellow wagtail	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Myiagra cyanoleuca	Satin flycatcher	SLC	M	44.58	74.45	**119.03**	1.93	1.53	**3.46**
Pandion haliaetus	Osprey	SLC	M	269.94	2.38	**272.32**	8.90	0.00	**8.90**
Plegadis falcinellus	Glossy ibis	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Pluvialis fulva	Pacific golden plover	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Rhipidura rufifrons	Rufous fantail	SLC	M	350.36	81.14	**431.50**	15.71	1.53	**17.24**
Symposiachrus trivirgatus	Spectacled monarch	SLC	M	44.58	74.45	**119.03**	1.93	1.53	**3.46**
Tringa nebularia	Common greenshank	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**
Tringa stagnatilis	Marsh sandpiper	SLC	M	272.32	690.50	**962.82**	8.90	56.85	**65.75**

Table notes:

M = Migratory SLC = Special least concern

* Total habitat is the sum of the general, essential and core habitat categories

4.3.4 Flora and fauna habitat located within the ecology study area

A total of eight broad fauna habitat types have been identified within the ecology 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 ecology study area.

The ecology 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 ecology 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 Main Range, 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.

Each broad habitat type is discussed in further detail below and shown in Figure 4.20. An analysis of the quantity of fauna habitat contained within the ecology study area and within the Project disturbance footprint is presented in Table 4.30.

Table 4.30 Extent of flora and fauna habitat located within the ecology study area

Fauna habitat type (refer Figure 4.20)	Analogous Regional Ecosystems (REs)	Extent (ha)	
		Ecology study area	Project disturbance
Mature eucalypt open forest and woodland	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	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 including 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)
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 (ha)		**7,700.22**	**456.81**

Table note:

Numbers do not align exactly with numbers in Table 4.18 as they are generated from different government datasets.

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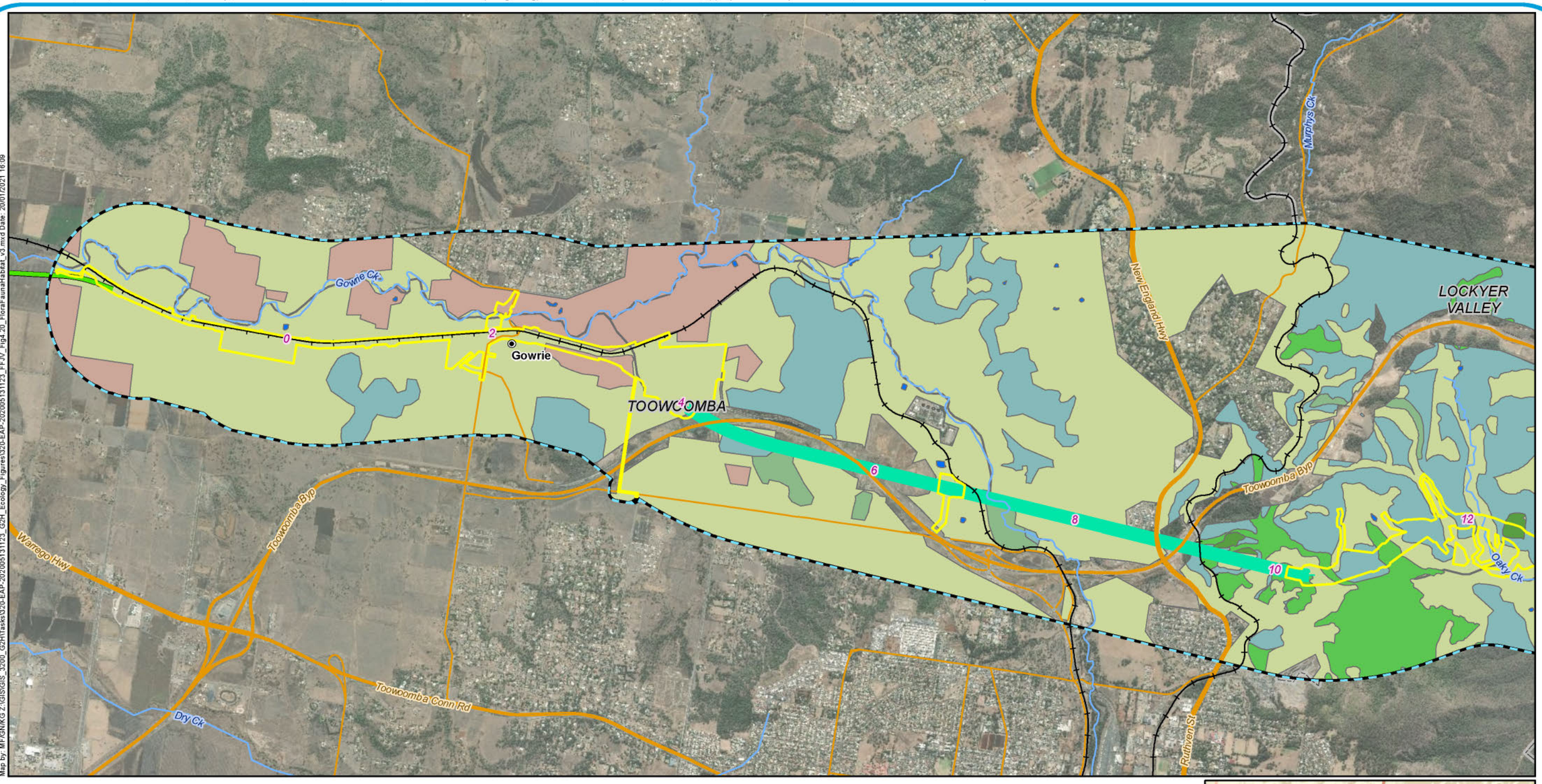
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community



Map by: MFGN/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513\123_G2H_Ecology_Figures\320-EAP-20200513\123_FFJV_Fig4.20_FloraFaunaHabitat_v3.mxd Date: 20/01/2021 16:09

Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology 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
- No habitat value present
- Regrowth
- Waterways
- Wetlands

A3 scale: 1:40,000
0 0.5 1 1.5 2 2.5km

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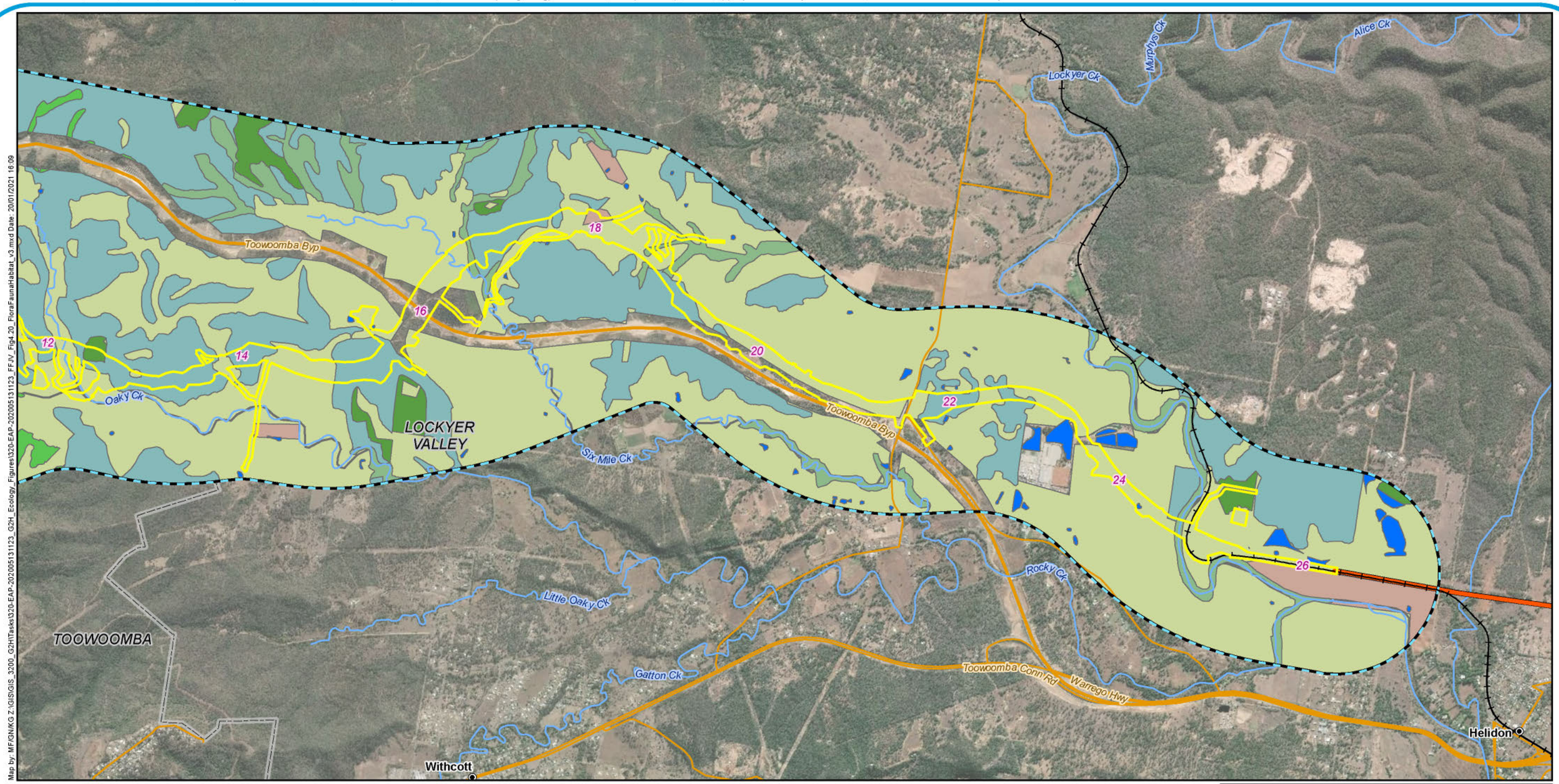
Gowrie to Helidon
Figure 4.20a: Location of fauna habitat types contained within the ecology study area

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/KG Z:\GIS\GIS_3200_G2H\Tasks\320-EAP-20200513123_G2H_Ecology_Figures\320-EAP-20200513123_FFJV_Fig4.20_FloraFaunaHabitat_v3.mxd Date: 20/01/2021 16:09

Legend

- 5 Chainage (km)
- Localities
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- EIS disturbance footprint (surface disturbance only)
- Ecology 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
- No habitat value present
- Regrowth
- Waterways
- Wetlands

A3 scale: 1:40,000

0 0.5 1 1.5 2 2.5km

Future Freight
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Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 4.20b: Location of fauna habitat types contained within the ecology study area

4.3.4.1 Mature Eucalypt open forest and woodland

On sedimentary and igneous rocks

Areas of mature eucalypt open forest and woodland on sedimentary and igneous rocks within the ecology study area include areas dominated by Narrow-leaved ironbark (*Eucalyptus crebra*), Grey gum (*Eucalyptus major*), White mahogany (*Eucalyptus acmenoides*), Grey ironbark (*Eucalyptus siderophloia*), Spotted gum (*Corymbia citriodora*), Brush box (*Lophostemon confertus*) and Swamp box (*Lophostemon suaveolens*). While in the Gowrie Creek are Mountain coolibah (*Eucalyptus orgadophila*) is also a common feature.

Areas of remnant, mature eucalypt open forest and woodland (on sedimentary and igneous rocks) within the ecology study area are represented by REs 11.8.2a, 11.8.4, 11.8.5, 11.8.5a, 11.8.8, 12.5.6, 12.8.14, 12.8.14a, 12.8.17, 12.9-10.2, 12.9-10.5a, 12.9-10.17 and 12.9-10.17a. The condition and structure of these habitats varies greatly across the ecology 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. Examples of this habitat are shown in Photograph 4.10 and Photograph 4.11.

Important microhabitat refugia provided by this habitat type includes rocky escarpments and outcrops, boulder piles, hollow logs, and termitaria (arboreal and terrestrial termite nests).

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.

Threatened flora species that may occur within this habitat include Bailey's cypress (*Callitris baileyi*), *Caustis blakei macrantha*, and Slender milk vine (*Marsdenia coronata*), while threatened fauna species that may utilise these areas include Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) and Powerful owl (*Ninox strenua*).

Photograph 4.10 Eucalypt forest on sedimentary rock in the ecology study area

Photograph 4.11 Eucalypt forest on sedimentary rock in the ecology study area

On basalt derived and alluvial plains

Areas of mature eucalypt open forest and woodland on basalt derived and alluvial plains within the ecology study area (refer Photograph 4.12 and Photograph 4.13) include areas dominated by Queensland bluegum (*Eucalyptus tereticornis*). Areas of remnant eucalypt open forest and woodland (on alluvial plains) within the ecology study area are represented by REs 11.8.2a, 11.8.4, 11.8.5, 11.8.8 and 12.3.3. This habitat type exists on floodplains and creek flats within the ecology 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*). 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 *Cyperus clarus* and Finger panic (*Digitaria porrecta*).

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.

Photograph 4.12 Mature eucalypt forest on alluvial plain in ecology study area

Photograph 4.13 Mature eucalypt forest on basalt derived plain in ecology study area

4.3.4.2 Mature eucalypt riparian woodland

Eucalypt riparian open forest and woodlands within the ecology 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*), Native apple (*Angophora* spp.), and River she-oak (*Casuarina cunninghamiana*). Areas of remnant Eucalypt riparian open forest and woodland within the ecology study area are represented by RE 12.3.7 and 11.3.25. This habitat type occurs exclusively along the edge of rivers, creeks and vegetated drainage lines within the ecology study area (refer Photograph 4.14 and Photograph 4.15). Mature eucalypt riparian open forest and woodlands within the ecology study area is often structurally complex at all strata levels and potentially supports the greatest diversity of wildlife taxa per hectare.

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 *Cyperus clarus* and Finger panic (*Digitaria porrecta*).

Photograph 4.14 Mature eucalypt riparian woodland in the ecology study area

Photograph 4.15 Mature eucalypt riparian woodland in the ecology study area

4.3.4.3 Lowland rainforest/Semi-evergreen vine thicket

Areas of semi-evergreen vine thicket within the ecology study area include low microphyll vine forest and semi-evergreen vine thicket (refer Photograph 4.16) with these areas associated with the escarpment within the SEQ Bioregion. Noting that the Gowrie to Grandchester future State transport corridor was realigned in part to minimise impacts on this community.

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 east of Toowoomba. Characteristic species include Brush box (*Lophostemon confertus)*, Bottle tree (*Brachychiton rupestris*), Leopard wood (*Flindersia collina*), Crow's ash (*Flindersia australis*), *Alectryon diversifolius*, *Alectryon subdentatus*, *Elattostachys xylocarpa*, *Erythroxylum* sp., *Psydrax odorata forma buxifolia*, Ebony (*Diospyros geminata*), *Planchonella cotinifolia*, Croton (*Croton insularis*), *Bridelia exaltata* and Wallaby apple (*Bursaria incana*).

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, rock crevices, and dense vine thickets. Lowland rainforest/Semi-evergreen vine thickets within the ecology 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.

Photograph 4.16 Lowland rainforest in the ecology study area

4.3.4.4 Regrowth communities

Areas of regrowth vegetation are present throughout the ecology study area (refer Photograph 4.17 and Photograph 4.18). Extant patches of regrowth vegetation within the ecology study area are typically in poor ecological condition, suffering from extensive weed invasion and disturbance from cattle grazing practices. 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, including cracking clay soils for reptile species. In addition, where large, isolated hollow bearing trees are present, these features may provide forage, nesting and denning sites for arboreal mammals and birds.

Threatened flora species that may occur in this habitat type include *Cyperus clarus* and Finger panic (*Digitaria porrecta*), particularly where these areas are located on basalt derived soils.

Photograph 4.17 Regrowth vegetation in the ecology study area

Photograph 4.18 Regrowth vegetation in the ecology study area

4.3.4.5 Grassland

Grassland habitats within the ecology 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 threatened ecological community. 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 sphacelata*), Green panic (*Megathyrsus maximus*), and Sabi grass (*Urochloa mosambicensis*). However, native grass species that may also occur 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*), Blue grass (*Dichanthium sericeum*), Digitaria (*Digitaria divaricatissima*), and Pitted bluegrass (*Bothriochloa decipiens*). However, exotic pasture grasses sometimes occur, such as Rhodes grass (*Chloris gayana*). In some areas woody vegetation is also present including Mountain coolibah (*Eucalyptus orgadophila*) and Queensland bluegum (*Eucalyptus tereticornis*).

Non-native and native derived grasslands are considered as one fauna habitat type due to similarities in structure and floristics. Grassland are typically located on alluvial floodplains and creek flats. These grassland habitats are commonly utilised for agricultural purposes including livestock grazing and fodder harvesting.

Remnant grassland within the ecology study area is represented by RE11.3.21 and RE11.8.11. RE11.3.21 occurs on alluvial plains and is dominated by Blue grass (*Dichanthium sericeum*) and *Astrebla* spp. A relic remnant patch is present on the Gowrie Creek floodplain approximately 3.5 km upstream of the Project. RE11.8.11 is a *Dichanthium sericeum* grassland on Cainozoic igneous rocks which is also present with ecology study area, with a small patch of HVR located in the Project footprint.

Representatives of grassland habitat in the ecology study area are provided in Photograph 4.19 and Photograph 4.20.

Threatened flora species that may occur in this habitat type include *Cyperus clarus* and Finger panic (*Digitaria porrecta*), particularly where grasslands are located on basalt derived (black) soils. With both species recorded from the grasslands habitats within or near the Project footprint (refer Section 4.3.1.2).

Grassland within the ecology 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 ecology study area include Squatter pigeon (southern subspecies) (*Geophaps scripta scripta*) and Five-clawed worm-skink (*Anomalopus mackayi*). Furthermore, grassland may provide important habitat or refuge for migratory bird species when flooded.

Photograph 4.19 Grassland habitat in the ecology study area

Photograph 4.20 Grassland habitat in the ecology study area

4.3.4.6 Wetlands

Wetland habitats within the ecology study area include dams and reservoirs (lacustrine), and wetlands associated with the floodplains of watercourses (riverine). 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 (refer Photograph 4.21 and Photograph 4.22). 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*).

Wetland habitats within the ecology study area are considered to provide suitable habitat for a variety of amphibian, reptile and bird species.

No springs are identified on the QLD wetland mapping (QLD Government 2019c) within the ecology study area.

Photograph 4.21 Wetland habitat in the ecology study area

Photograph 4.22 Wetland habitat in the ecology study area

4.3.4.7 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 ecology 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.

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.

As noted in Section 4.2.5, there is over 13.5 lineal km of watercourses within the Project disturbance footprint, with the riparian zone high variable and reflective of local anthropogenic activities and natural processes. For example the watercourses in Gowrie Creek catchment are generally poor near within the Project footprint and have limited riparian structure, while the watercourses in Lockyer Creek catchment are intact and diverse. In the upper catchments there may be no obvious riparian zone associated with these watercourses.

Examples of riparian habitat/waterways in the ecology study area are provided in Photograph 4.23 and Photograph 4.24.

Photograph 4.23 Riparian habitat at Gowrie Creek, at the proposed Project waterway crossing location

Photograph 4.24 Riparian habitat at Rocky Creek, downstream of the Project

4.3.4.8 Cultivated land

Small areas of cultivated land exist within the ecology 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 orru*), 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*).

Areas of cultivated land within the Project disturbance footprint are associated with the Gowrie Creek floodplain and Lockyer Creek.

4.3.5 Aquatic physical habitat values and species diversity

The ecological site values at the ten aquatic ecology survey locations were assessed using the AUSRIVAS Physical Assessment Protocol. The ecological site values were recorded across a 100 m assessment reach and have been summarised for each survey location in the sections below (refer Table 4.31). The habitat assessment scores noted that most of the aquatic habitat across the ecology study area was typically poor to fair. A photographic record was taken at each sample location and are provided in Appendix H. The location of aquatic sampling locations is displayed in Figure 3.3.

Table 4.31 Habitat assessment score summary

Location (refer Figure 3.3)	Watercourse	Relation of site to alignment waterway crossing	Habitat assessment score (%)	Category
G2H 1A	Gowrie Creek	Located ~1,600 km downstream of the Project (where in tunnel)	47	Poor
G2H 2A	Gowrie Creek	Located proximal to the tunnel intermediate	56.5	Fair
G2H 3A	Gowrie Creek	Located ~720 m upstream of the Project (where in tunnel)	45.5	Poor
G2H 4A	Rocky Creek	Located at Project alignment intersection	55.5	Fair
G2H 5A	Rocky Creek	Located ~1.3 km downstream of the Project	50.5	Fair
G2H 6A	Rocky Creek	Located ~3.4 km downstream of the Project	57.5	Fair
G2H 7A alt	Six Mile Creek	Located ~3.5 km downstream of the Project	48	Fair

Location (refer Figure 3.3)	Watercourse	Relation of site to alignment waterway crossing	Habitat assessment score (%)	Category
G2H 8A	Un-named tributary of Lockyer Creek	Located ~1.3 km downstream of the Project	53.5	Fair
G2H 9A	Lockyer Creek	Located ~5 km upstream of the Project alignment	65	Fair
G2H 10A	Rocky Creek	Located ~9.1 km downstream of the Project	57	Fair
H2C 11A	Lockyer Creek	Located 4.5 km downstream of the Project alignment	41.5	Fair

4.3.5.1 G2H 1A

Overview

Site G2H 1A is located at Gowrie Creek, approximately 1,600 m downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 1A, the site habitat assessment scored 47 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 1A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone.

Table 4.32 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 1A.

Table 4.32 G2H 1A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: Mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	10
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	8
Pool variability	Poor: Majority of pools small-shallow or pools absent	2
Sediment deposition	Good: Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pods.	13
Channel flow status	Excellent: Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	18
Channel alteration	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelization, i.e. dredging (greater than 20 years) may be present, but recent channelization is not present	13
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	10
Bank stability	Left bank: Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods Right bank: Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods	Left bank: 5 Right bank: 5
Vegetation protection	Fair: 50 to 70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining	Left bank: 5 Right bank: 5
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities	Left bank: 0 Right bank:0
Total Low Gradient Stream Habitat Score		**94/200 Poor (47%)**

Site characteristics

The G2H 1A assessment reach bedform features were defined by;

- A run for 80 per cent of the site, with a gradient of 1 to 3˚ and a small but distinct uniform current with an unbroken surface
- A riffle for 10 per cent of the site, with a gradient of 1 to 3˚ and moderate currents with an unbroken but smooth surface
- A pool area where the stream widened
- An artificial waterfall created from a culvert on 1 per cent of the site.

The assessment reach was characterised by a widened, infilled shaped channel which had channel modifications present, associated with a reinforced retaining wall. The left bank had a wide lower bank shape with a moderate bank slope (i.e. between 30° to 60˚). The right bank had a concave shape with a steep bank slope (i.e. between 60° to 80˚). Bank stability was potentially affected by cleared vegetation, stock access and an associated culvert. A rock layer was present along the bank and metal fencing at the base of the rock layer as a bank protection measure.

The creek bed within the assessment reach was considered to have moderate compaction with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment was defined by a matrix filled contact framework, with 5 to 32 per cent fine sediment present with a moderate availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, the water level was at baseflow. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach had slight turbidity, with water clarity reduced by suspended material.

The assessment reach was considered to have a partially restricted fish passage. Barriers to fish movement included gravel deposition, falling rocks and the rock retaining wall. There were mid-channel vegetated bars and high flow deposits present within the assessment reach.

Approximately 20 per cent of the assessment reach supported macrophytes. Macrophyte vegetation included Rush *(Juncus* sp.), Water Couch *(Paspalum* sp.) and Cumbungi *(Typha orientalis*). There was no large woody debris with visibility clear.

The riparian zone of the assessment reach had a vegetation disturbance rating of ‘extreme disturbance’. The riparian vegetation (excluding grass cover) consisted of isolated and scattered vegetation. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m were non-existent in the riparian zone. Trees less than 10 m in height had a vegetative cover of approximately 1 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 5 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 20 per cent native vegetation and 80 per cent exotic vegetation. Riparian shading of the assessment reach was less than 5 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included grazing on non-native pastures. Local impacts noted at the assessment site included a present road, culvert, discharge and intake pipe and also grazing further downstream.

4.3.5.2 G2H 2A

Overview

Site G2H 2A is located on Gowrie Creek, proximal to the proposed intermediate tunnel ventilation shaft disturbance area.

Following assessment of the condition and extent of habitat variables present at G2H 2A, the site habitat assessment scored 56.5 percent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 2A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.33 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 2A.

Table 4.33 G2H 2A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	10
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	7
Pool variability	Poor: Majority of pools small-shallow or pools absent	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	18
Channel flow status	Excellent: Water reaches base of both lower banks, and minimal amount of channel substrate is exposed	20
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	10
Bank stability	Left bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 7 Right bank: 7
Vegetation protection	Good: 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining.	Left bank: 6 Right bank: 6
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		**113/200 Fair (56.5%)**

Site characteristics

G2H 2A is situated within Gowrie Creek.

The G2H 2A assessment reach bedform features were defined by a run, with a gradient of 1 to 3˚ for 90 per cent of the site, and a small but distinct uniform current with an unbroken surface. A further 10 per cent of the site was riffle has a gradient of 1 to 3˚ with moderate currents and surface unbroken but smooth.

The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a concave shape with a moderate bank slope (i.e. between 30˚ and 60˚). Bank stability was potentially affected by cleared vegetation and stock access. There were no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have a packed, unarmoured compaction, with an array of overlapping, tightly packed, sediment sizes present. The sediment was defined by a matrix filled contact framework, with 5 to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, the water level was at baseflow or near baseflow. There were no sediment oils, water oils or sediment odours present, but an organic water odour was present within the assessment reach. Water within the assessment reach was slightly turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have a partially restricted fish passage, but at high flow there was an expected good passage. Barriers to fish movement included side/point bars that were unvegetated. There were no channel modifications present.

Approximately 15 per cent of the assessment reach supported macrophytes. Macrophyte vegetation was dominated by Cumbungi *(Typha orientalis*). There was no large woody debris present.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'moderate disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 20 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 10 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 5 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 50 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 70 per cent native vegetation and 30 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 and 25 per cent.

The right bank of the assessment reach was not covered by bedrock outcrops whereas the left bank was covered by 15 per cent.

Local land use along the assessment reach included a recreation area and grazing on non-native pastures. A horse riding company was present during the time of assessment. Local impacts noted at the assessment site included grazing by horses and litter from flood debris including sheet metal.

4.3.5.3 G2H 3A

Overview

Site G2H 3A is located on Gowrie Creek, approximately 720 m upstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 3A, the site habitat assessment scored 45.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 3A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.34 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 3A.

Table 4.34 G2H 3A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	6
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	7
Pool variability	Poor: Majority of pools small-shallow or pools absent	2
Sediment deposition	Good: Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pods	11
Channel flow status	Good: Water fills >75% of the available channel; or <25% of channel substrate is exposed	15
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20

Habitat variable	Condition category	Score
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	6
Bank stability	Left bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 7 Right bank: 7
Vegetation protection	Fair: 50 to 70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining	Left bank: 4 Right bank: 4
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		**91/200 Poor (45.5%)**

Site characteristics

The G2H 3A assessment reach bedform features were defined by 90 per cent of the site consisting of a run with a gradient of 1 to 3˚ and a small but distinct uniform current with an unbroken surface. The remainder 10 per cent of the site was a riffle with a gradient of 1 to 3˚ with moderate currents and surface unbroken but unsmooth.

The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a concave shape with the left bank comprised of a moderate bank slope (i.e. between 30° and 60°), and the right bank consisting of a steep slope (i.e. between 60° and 80°). Bank stability was potentially affected by cleared vegetation and there was no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have low compaction with a limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easy. The sediment was defined by dilated framework, with 32 to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, the water level was low. There were no sediment oils, water oils or sediment odours present but there were organic water odours. Water within the assessment reach was slightly turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have a partially restricted fish passage. Barriers to fish movement included rocks at a height of approximately 0.2 m. There were unvegetated side/point bars present within the assessment reach.

None of the assessment reach supported macrophytes and no species were present. There was no large woody debris present.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'extreme disturbance'. The riparian vegetation (excluding grass cover) occurred as isolated and scattered vegetation on the banks of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 5 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 20 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 15 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 and 25 per cent.

The right bank of the assessment reach was not covered by bedrock outcrops whilst the left bank comprised of 15 per cent.

Local land use along the assessment consisted primarily of exotic grassland. Local impacts noted at the assessment site included an adjacent road and overhead pipeline and easement adjacent to the rail corridor.

4.3.5.4 G2H 4A

Overview

Site G2H 4A is located on Rocky Creek, on the intersection with the Project disturbance footprint.

Following assessment of the condition and extent of habitat variables present at G2H 4A, the site habitat assessment scored 55.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 4A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.35 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 4A.

Table 4.35 G2H 4A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Excellent: Greater than 50% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at a stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient)	19
Pool substrate characterisation	Good: Mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present	13
Pool variability	Poor: Majority of pools small-shallow or pools absent	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	0
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	8
Bank stability	Left bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 8 Right bank: 8
Vegetation protection	Fair: 50 to 70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining	Left bank: 5 Right bank: 5
Riparian zone score	Left bank: Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities Right bank: Fair: Width of riparian zone 6-12 m; human activities have impacted the riparian zone a great deal	Left bank: 2 Right bank: 3
Total Low Gradient Stream Habitat Score		**111/200 Fair (55.5%)**

Site characteristics

There was no bedform features at site G2H 4A with the total percent composition being dry.

The assessment reach was characterised by a two-stage shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a stepped shape with the left bank having a steep slope of 60° to 80˚, and the right bank had a moderate slope of 30˚ and 60˚. At the time of assessment, the left and right banks of the assessment reach were demonstrating erosion affects from a flood event, creating bank stability. Other factors affecting bank stability included stock and human access to the creek. There were no artificial features at the site.

The creek bed within the assessment reach was considered to have moderate compaction, with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment was defined by a matrix filled contact framework, with 5 to 32 per cent fine sediment present with moderate availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, there was no water level and the creek was dry. The assessment reach was considered to have good fish passage. There were no identified barriers to fish movement when the creek had normal flows. There were no macrophytes present at the site and no large woody debris present.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'moderate disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 25 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 20 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 60 per cent within the riparian zone of the assessment reach. There was also approximately 30 per cent leaf litter within the riparian zone. The riparian zone was defined by approximately 80 per cent native vegetation and 20 per cent exotic vegetation, dominated by (D) Lantana (*Lantana camara*). Riparian shading of the assessment reach was between 6 and 25 per cent.

The left and right banks of the assessment reach had 10 per cent coverage by bedrock outcrops.

Local land use along the assessment reach included grazing along the left and right banks. Local impacts noted at the assessment site included bank instability caused by stock access and visible barbed wire fencing as a bank protection measure.

4.3.5.5 G2H 5A

Overview

Site G2H 5A is located on Rocky Creek, approximately 1.3 km downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 5A, the site habitat assessment scored 50.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 5A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.36 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 5A.

Table 4.36 G2H 5A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Excellent: Greater than 50% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at a stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient)	20
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	10
Pool variability	Poor: Majority of pools small-shallow or pools absent	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	0
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	6
Bank stability	Left bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 7 Right bank: 7
Vegetation protection	Left bank: Poor: less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimetres of less in average stubble height Right bank: Fair: 50 to 70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining	Left bank: 2 Right bank: 3
Riparian zone score	Left bank: Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities Right bank: Fair: Width of riparian zone 6-12 m; human activities have impacted the riparian zone a great deal	Left bank: 2 Right bank: 4
Total Low Gradient Stream Habitat Score		**101/200 Fair (50.5%)**

Site characteristics

The bedform features at G2H 5A was comprised of a dry creek bed.

The assessment reach was characterised by a two-stage shape with the left bank depicting a concave shape and the right bank a stepped shape. The left bank was characterised by a vertical slope (i.e. 80˚ to 90˚), and the right bank characterised by a moderate slope (30˚ to 60˚). Bank stability was affected by stock access and no artificial bank protection measures were present.

The creek bed within the assessment reach was considered to have a packed, unarmoured compaction, with an array of overlapping, tightly packed, sediment sizes present. The sediment was defined by framework dilated, with 32 to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, the creek bed was dry, therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have a partially restricted fish passage but was considered good when high flows are present. Barriers to fish movement included logs at an approximate height of 1 m. There were no bars present within the assessment reach.

Since the creek bed was dry, there was no presence of macrophytes. Approximately 20 per cent of the assessment reach was covered by logs and branches greater than 10 centimetres (cm) in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'moderate disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was present in the riparian zone. Trees with a height greater than 10 m had approximately 15 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 20 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 50 percent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 90 per cent native vegetation and 10 per cent exotic vegetation. Species included Blue Gum *(Eucalyptus tereticornis),* River she-oak (*Casuarina cunninghamiana*), Lantana (*Lantana camara*) and Red natal grass *(Melinis repens)*. Riparian shading of the assessment reach was between 26 and 50 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops and the primary local land use along the assessment reach included grazing along the left and right banks.

4.3.5.6 G2H 6A –Rocky Creek

Overview

Site G2H 6A is located on Rocky Creek, approximately 3.4 km downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 6A, the site habitat assessment scored 57.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 6A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.37 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 6A.

Table 4.37 G2H 6A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: Mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonisation (may rate at high end of scale)	13
Pool substrate characterisation	Good: Mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present	13
Pool variability	Poor: Majority of pools small-shallow or pools absent	2
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	1
Channel alteration (road present)	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	18
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	10
Bank stability	Left bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 8 Right bank: 6

Habitat variable	Condition category	Score
Vegetation protection	Good: 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 8 Right bank: 8
Riparian zone score	Fair: Width of riparian zone 6-12 m; human activities have impacted the riparian zone a great deal	Left bank: 3 Right bank: 5
Total Low Gradient Stream Habitat Score		**115/200** **Fair** **(57.5%)**

Site characteristics

The G2H 6A assessment reach bedform features were defined by a dry area with 10 per cent of the reach comprised of a pool area where stream widens or deepens and current declines.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present including a bed level crossing. The left bank had a convex shape with a low slope (i.e. 10° to 30°). The right bank had an undercut bank shape with a steep slope (i.e. 60° to 80°). Bank stability was potentially affected by cleared vegetation and a bridge level crossing with a culvert. There were no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have a moderate compaction, with an array of sediment sizes, little overlapping, some packing but can be dislodged with moderate. The sediment was defined by a framework dilated matrix, with 32 to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was rounded.

At the time of assessment, the water level had no flow. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have a very restricted fish passage at high flows and no fish passage at base and low flows. Barriers to fish movement included the bed level crossing and culvert and. There were no bars present within the assessment reach.

Approximately 90 per cent of the assessment reach supported macrophytes. Approximately 90 per cent of the Macrophyte vegetation was comprised of Cumbungi *(Typha orientalis*). There was no large woody debris present.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'high disturbance'. The riparian vegetation (excluding grass cover) occurred as occasional clumps on the left bank and as semi-continuous on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 25 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 20 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 60 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 80 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 40 per cent native vegetation and 60 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 and 25 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach comprised of exotic grassland and local impacts on the creek included the bed level crossing and culvert which was approximately 30 cm in diameter.

4.3.5.7 G2H 7A alt

Overview

Site G2H 7A alt is located at Six Mile Creek, approximately 3.5 km downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 7A alt, the site habitat assessment scored 48 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 7A alt was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.38 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 7A alt.

Table 4.38 G2H 7A alt habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Poor: Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking	5
Pool substrate characterisation	Poor: Hard-pan clay or bedrock; no root mat or vegetation	3
Pool variability	Poor: Majority of pools small-shallow or pools absent	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	0
Channel alteration (Bed level crossing)	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	16
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	8
Bank stability	Excellent: Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Left bank: 9 Right bank: 9
Vegetation protection	Good: 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 8 Right bank: 8
Riparian zone score	Fair: Width of riparian zone 6-12 m; human activities have impacted the riparian zone a great deal	Left bank: 5 Right bank: 5
Total Low Gradient Stream Habitat Score		**96/200 Fair (48%)**

Site characteristics

The G2H 7A alt site bedform features were defined by a dry creek bed.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with a slightly straightened stretch consisting of the bed level crossing. The left and right banks of the assessment reach had a convex shape with a moderate bank slope (i.e. between 30˚ and 60˚). Bank stability was potentially affected by stock access and the bed level crossing and associated culverts. The bed level crossing was located on Six Mile road and was comprised of two 1 m in diameter culverts.

The creek bed within the assessment reach was considered to have a packed, unarmoured compaction, with an array of overlapping, tightly packed, sediment sizes present. The sediment was defined by a framework dilated matrix, with 32 to 60 per cent fine sediment present with low availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, the creek bed was dry therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have a very restricted fish passage which would be partially restricted with high flows. Barriers to fish movement included the Six Mile Road bridge culverts, which included two box culverts, approximately 1 m in diameter. There were no bars present within the assessment reach. There was also a fence present along the creek which had debris entangled upon the wire.

No macrophyte vegetation was present on site. Approximately 10 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'high disturbance'. The riparian vegetation (excluding grass cover) occurred as occasional clumps of vegetation on the left bank and the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 10 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 5 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 25 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 15 per cent native vegetation and 85 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 and 25 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included grazing along the right bank and cropped irrigation on the left bank. Local impacts noted at the assessment site included camp facilities and presence of two culverts associated with the bed level crossing. The wire fencing across the creek had also accumulated litter and debris.

4.3.5.8 G2H 8A

Overview

Site G2H 8A is located on an un-named tributary of Lockyer Creek, approximately 1.3 km downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 8A, the site habitat assessment scored 53.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 8A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and limited variability in instream habitat types (i.e. pools, riffles, runs).

Table 4.39 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 8A.

Table 4.39 G2H 8A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	10
Pool substrate characterisation	Fair: All mud or clay or sand bottom; little or no root mat; no submerged vegetation	8
Pool variability	Poor: Majority of pools small-shallow or pools absent	0
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	0
Channel alteration	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20

Habitat variable	Condition category	Score
Channel sinuosity	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	20
Bank stability	Left bank: Fair: Moderately unstable; 30 to 60% of bank in reach has areas of erosion; high erosion potential during floods Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 5 Right bank: 6
Vegetation protection	Good: 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 8 Right bank: 8
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		**107/200 Fair (53.5%)**

Site characteristics

G2H 8A is situated within the Rocky Creek system.

The G2H 8A assessment reach bedform features were not present as the creek was dry.

The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a concave shape with the left bank having a steep slope (i.e. 60˚ and 80˚) and the right bank being comprised of a moderate slope (i.e. 30˚ and 60˚). Bank stability was potentially affected by cleared vegetation and stock access. There were no artificial bank measures present.

The creek bed within the assessment reach was considered to have low compaction, with limited range of sediment sizes, little overlapping, some packing and structure but can be dislodged very easily. The sediment was matrix dominated and sediment angularity for cobble, pebble and gravel fractions within the assessment reach was well rounded.

At the time of assessment, the creek bed was dry, therefore there were no sediment oils, water oils, sediment odours or water odours present within the assessment reach.

The assessment reach was considered to have moderately restricted fish passage that would only be partially restricted at high flow. Barriers to fish movement included a build-up of debris in the creek to approximately 1 m as a result of a fence, and sheet metal fencing at the creek crossing to approximately 2 m. There were no bars present within the assessment reach.

There were no macrophyte species present at the location. Approximately 30 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'very high disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 30 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height were not present and shrubs had a vegetative cover of approximately 20 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 70 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 80 per cent native vegetation and 20 per cent exotic vegetation. Riparian shading of the assessment reach was between 51 and 75 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included grazing along the left and right banks. Local impacts noted at the assessment site included a clear barrier across the creek due to fencing and sheet metal.

4.3.5.9 G2H 9A

Overview

Site G2H 9A is located at Lockyer Creek, approximately 5 km upstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 9A, the site habitat assessment scored 65 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 9A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone.

Table 4.40 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 9A.

Table 4.40 G2H 9A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Good: Mix of stable habitat; well-suited for full colonisation potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of new fall, but not yet prepared for colonisation (may rate at high end of scale)	11
Pool substrate characterisation	Good: Mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present	13
Pool variability	Good: Majority of pools large-deep; very few shallow	15
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	18
Channel flow status	Good: Water fills >75% of the available channel; or <25% of channel substrate is exposed	15
Channel alteration **(Bridge present)**	Excellent: Channelisation or dredging absent or minimal; stream with normal pattern	16
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	6
Bank stability	Left bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion Right bank: Good: Moderately stable; infrequent, small areas of erosion mostly healed over. 5 to 30% of bank in reach has areas of erosion	Left bank: 8 Right bank: 8
Vegetation protection	Good: 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining.	Left bank: 8 Right bank: 8
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		**130/200 Fair (65%)**

Site characteristics

The G2H 9A assessment reach bedform features were defined by a run, with a gradient of 1 to 3˚ and a small but distinct uniform current with an unbroken surface.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with the bridge abutments. The left and right banks of the assessment reach had a convex shape with a moderate left bank slope (i.e. between 30˚ and 60˚) and a low right bank slope (i.e. between 10˚ and 30˚). Bank stability was potentially affected by cleared vegetation and a present bridge. A rock wall was present which was associated with the bridge, this provided artificial bank protection.

The creek bed within the assessment reach was considered to have a moderate compaction, with an array of overlapping, some packing and structure but can be very easily dislodged. The sediment was defined by a matrix filled contact framework, with 5 to 32 per cent fine sediment present with moderate availability of interstitial spaces. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was sub-angular.

At the time of assessment, the water level was at baseflow. There were no sediment oils, water oils, sediment odours or water odours present within the assessment reach. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have good fish passage. There were no barriers to fish movement are bars were absent within the assessment reach.

Approximately 40 per cent of the assessment reach supported macrophytes. Macrophyte vegetation included Rush (*Juncus* sp.) and Sedge *(Cyperus* sp.). There was no large woody debris present.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'extreme disturbance'. The riparian vegetation (excluding grass cover) occurred as isolated and scattered vegetation on the banks of the assessment reach. Regeneration of native canopy species was abundant in the riparian zone with more than 5 per cent cover present and considered healthy. Trees with a height greater than 10 m and Trees less than 10 m in height were not existent at the site. Shrubs had a vegetative cover of approximately 5 per cent and Ground cover vegetation, including grass species, had a vegetative cover of approximately 95 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 5 per cent native vegetation and 95 per cent exotic vegetation. Riparian shading of the assessment reach was less than 5 per cent.

The left and right banks of the assessment reach were not covered by bedrock outcrops.

Local land use along the assessment reach included cleared landscapes for grazing along the left and right banks. Local impacts noted at the assessment site included an adjacent road and bridge, grazing and litter.

4.3.5.10 G2H 10A

Overview

Site G2H 10A alt is located on Rocky Creek, approximately 9.1 km downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at G2H 10A alt, the site habitat assessment scored 57 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of G2H 10A alt was compromised by disturbances to the integrity and cover of vegetation within the riparian zone.

Table 4.41 presents the results of the AUSRIVAS habitat assessment (low gradient stream) for assessment site G2H 10A alt.

Table 4.41 G2H 10A alt habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Excellent: Greater than 50% of substrate favourable for epifaunal colonisation and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at a stage to allow full colonisation potential (i.e. logs/snags that are not new fall and not transient)	16
Pool substrate characterisation	Good: Mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present	11
Pool variability	Fair: Swallow pools much more prevalent than deep pools	6
Sediment deposition	Excellent: Little or no enlargement of point bars and less than 20% of the bottom affected by sediment deposition	20
Channel flow status	Poor: Very little water in channel and mostly present as standing pools	3

Habitat variable	Condition category	Score
Channel alteration (Bridge)	Good: Some channelisation present, usually in areas of bridge abutments, evidence of past channelization, i.e. dredging (greater than 20 years) may be present, but recent channelization is not present	16
Channel sinuosity	Fair: The bends in the stream increase the stream 1 to 2 times longer than if it was in a straight line	6
Bank stability	Excellent: Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected	Left bank: 9 Right bank: 9
Vegetation protection	Good: 70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one half of the potential plant stubble height remaining	Left bank: 8 Right bank: 8
Riparian zone score	Poor: Width of riparian zone less than 6 m; little or no riparian vegetation is present because of human activities	Left bank: 1 Right bank: 1
Total Low Gradient Stream Habitat Score		**114/200 Fair (57%)**

Site characteristics

The G2H 10A alt assessment reach bedform features were defined by a pool, with an area where the steam widens or deepens and the current declines.

The assessment reach was characterised by a flat 'U' shaped channel which had channel modifications present, associated with a bridge abutment. The left and right banks of the assessment reach had a concave shape with the left bank having a moderate bank slope (i.e. between 30˚ and 60˚) and the right bank having a low bank slope (i.e. between 10˚ and 30˚). Bank stability was affected by human access and a present bridge. There were artificial bank protection measures including a wall layer associated with the bridge.

The creek bed within the assessment reach was considered to have a tightly packed, armoured array of overlapping, tightly packed and very hard to dislodge. The sediment was defined by bedrock and therefore the sediment angularity was not present.

At the time of assessment, the creek was dry and therefore there were no sediment oils or water oils present, but sediment odours and water odours were present in the stagnant pool. Water within the assessment reach was turbid, with water clarity reduced by suspended material.

The assessment reach was considered to have a very restricted fish passage with a moderately restricted passage at high flow. Barriers to fish movement included the Postmans Ridge Road bridge. There were no bars present within the assessment reach but a large amount of bedrock and *Typha* clumps were present. The bedrock areas were considered to be basking habitat for turtles.

Approximately 70 per cent of the assessment reach supported macrophytes including Rush *(Juncus)* and Cumbungi *(Typha).* Approximately 2 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'very high disturbance'. The riparian vegetation (excluding grass cover) occurred as occasional clumps of vegetation on the left bank and right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 5 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 10 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 5 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 70 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 90 per cent native vegetation and 10 per cent exotic vegetation. Riparian shading of the assessment reach was between 6 and 25 per cent.

The left bank of the assessment reach had 40 per cent coverage by bedrock outcrops and the right bank 10 per cent.

Local land use along the assessment reach included rural residential along the left and right banks. Local impacts noted at the assessment site included a road and postman's ridge road bridge. The site also had a considerable amount of litter.

4.3.5.11 H2C 11A

Overview

The H2C 11A sampling location is located on the Lockyer Creek, approximately 4.5 km downstream of the Project alignment.

Following assessment of the condition and extent of habitat variables present at H2C 11A, the site habitat assessment scored 41.5 per cent when assessed using the AUSRIVAS habitat assessment approach. The habitat condition of H2C 11A was compromised by disturbances to the integrity and cover of vegetation within the riparian zone and subsequent bank erosion and poor variability in instream habitat types (i.e. pools, riffles and runs).

Table 4.32 presents the results of the AUSRIVAS habitat assessment for assessment site H2C 11A.

Table 4.42 H2C 11A habitat assessment (low gradient stream)

Habitat variable	Condition category	Score
Epifaunal substrate/ available cover	Fair: 10-30 per cent mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	8
Pool substrate characterisation	Good: mixture of soft sand, mud or clay; mud may be dominant; some root mats and submerged vegetation present.	13
Pool variability	Poor: Majority of pools small-shallow or pools absent.	3
Sediment deposition	Fair: Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80 per cent of the bottom affected; sediment deposits at obstructions, constructions and bends; moderate deposition in pools prevalent.	8
Channel flow status	Poor: Very little water in channel and mostly present as standing pools.	3
Channel alteration	Excellent: Artificial channelisation or dredging absent or minimal; stream with normal pattern.	20
Channel sinuosity	Poor: Channel straight; waterway has been channelised for a long distance.	5
Bank stability	Left bank: Fair: Moderately unstable; 30-60 per cent of bank in reach has areas of erosion; high erosion potential during floods Right bank: Poor: Unstable; many eroded areas; 'raw' areas frequent along straight sections and bends; obvious bank sloughing; 60-100 per cent of bank has erosional scars.	Left bank: 5 Right bank: 2
Vegetation protection	Fair: 50-70 per cent of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Left bank: 5 Right bank: 3
Riparian zone score	Left bank: Good: width or riparian zone 12-18 m; human activities have impacted the riparian zone only minimally. Right bank: Fair: Width or riparian zone 6-12 m; human activities have impacted the riparian zone a great deal.	Left bank: 5 Right bank: 3
Total Low Gradient Stream Habitat Score		83/200 Fair (41.5%)

Site characteristics

The H2C 11A assessment reach bedform features were defined by a pool area where the stream widens or deepens and the current declines.

The assessment reach was characterised by a flat 'U' shaped channel which had no channel modifications present. The left and right banks of the assessment reach had a concave shape with the left bank having a moderate bank slope (i.e. between 30˚ to 60˚) and the right bank having a steep slope (i.e. between 60° to 80˚). Bank stability was potentially affected by cleared vegetation and a bed level crossing. There were no artificial bank protection measures present.

The creek bed within the assessment reach was considered to have low compaction with a loose array of fine sediments, no overlapping, no packing and structure and could be dislodged very easily. The sediment was defined by matrix dominated with less than 60 per cent fine sediment, interstitial spaces virtually absent. The sediment angularity for cobble, pebble and gravel fractions within the assessment reach was well-rounded.

At the time of assessment, no flow or pooled water was present.

The assessment reach was considered to have no fish passage at low and base flow with the exemption of being moderately restricted at high flow. Barriers to fish movement include rocks, earth material and a bed level road crossing. There were side/point bars that were vegetated present within the assessment reach.

Approximately 95 per cent of the assessment reach supported macrophytes. Macrophyte vegetation included Rush *(Juncus* sp.), Cumbungi *(Typha* sp.) and Princes feathers (*Persicaria* sp.) Approximately 5 per cent of the assessment reach was covered by logs and branches greater than 10 cm in diameter.

The riparian zone of the assessment reach had a vegetation disturbance rating of 'high disturbance'. The riparian vegetation (excluding grass cover) occurred as semi-continuous vegetation on the left bank and as occasional clumps on the right bank of the assessment reach. Regeneration of native canopy species was very limited in the riparian zone. Trees with a height greater than 10 m had approximately 15 per cent vegetative cover within the riparian zone along the assessment reach. Trees less than 10 m in height had a vegetative cover of approximately 25 per cent within the riparian zone of the assessment reach and shrubs had a vegetative cover of approximately 10 per cent. Ground cover vegetation, including grass species, had a vegetative cover of approximately 60 per cent within the riparian zone of the assessment reach. The riparian zone was defined by approximately 60 per cent native vegetation and 40 per cent exotic vegetation. Riparian shading of the assessment reach was less than 5 per cent.

Local land use along the assessment reach included cleared and modified landscapes along the left and right banks including rural residential and recreation areas. Local impacts noted at the assessment site included litter, bed level road crossing and recreational activities including an adjacent campground.

4.3.6 Field assessment surface water quality results

The baseline water quality results for the assessment are provided in Table 4.43.

Table 4.43 Surface water quality results for the Project aquatic ecology monitoring sites

Site	Date	pH	Electrical conductivity (µS/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen[1] (%)
Lockyer Creek catchment								
WQO		**6.5-8.0**	**< 520**	**-**	**< 6**	**-**	**-**	**85 - 110**
G2H 10A (Alt) Rocky Creek	22/09/2017	8.50	2014	20.2	49.8	1.14	6.26	70.1
	01/03/2018	7.96	575	23.3	656	0.29	1.71	19.4
	11/03/2019	Dry at the time of sampling						

Site	Date	pH	Electrical conductivity (µS/cm)	Temperature (°C)	Turbidity (NTU)	Salinity (ppt)	Dissolved oxygen (mg/L)	Dissolved oxygen[1] (%)
H2C 11A Lockyer Creek	09/10/2017	9.32	1,400	26.7	46.1	1.24	9.61	120.8
	01/03/2018	8.44	1,100	24.7	53.5	0.65	5.1	61.4
	11/03/2019	Dry at the time of sampling						
G2H 9A Lockyer Creek	20/09/2017	7.87	871	19.0	20.1	0.48	3.86	41.5
	01/03/2018	7.63	907	26.3	3.4	0.43	2.78	24.9
	11/03/2019	7.60	2085	28.3	16.7	0.99	8.02	103.2
G2H 8A Un-named tributary of Lockyer Creek	20/09/2017	Dry at the time of sampling						
	01/03/2018	Dry at the time of sampling						
	11/03/2019	Dry at the time of sampling						
G2H 7A (Alt) Six Mile Creek	20/09/2017	Dry at the time of sampling						
	01/03/2018	7.75	626	23.5	390	0.32	3.37	39.5
	11/03/2019	Dry at the time of sampling						
G2H 6A Rocky Creek	20/09/2017	7.90	1182	19.3	9.2	0.66	8.08	87.5
	01/03/2018	7.87	917	26.2	35.4	0.44	4.98	62
	11/03/2019	Dry at the time of sampling						
G2H 5A Rocky Creek	20/09/2017	Dry at the time of sampling						
	01/03/2018	8.52	1098	27.4	14	0.52	6.8	83.2
	12/03/2019	Dry at time of sampling						
G2H 4A Rocky Creek	20/09/2017	Dry at time of sampling						
	01/03/2018	8.02	1297	29.9	52	0.58	4.98	65
	12/03/2019	Dry at time of sampling						
Condamine River Basin								
WQO		**7.7-8.3**	**< 510**	**-**	**< 13**	**-**	**-**	**60 - 110**
G2H 3A Gowrie Creek	19/09/2017	8.28	628	20.4	1.0	0.34	8.84	98
	01/03/2018	8.00	486.4	26.2	4.3	0.23	5.94	74.2
	11/03/2019	7.99	706	16.1	7.7	0.37	11.16	137.9
G2H 2A Gowrie Creek	19/09/2017	7.93	1350	21.2	32.8	0.72	19.76	220
	01/03/2018	8.34	512	28.3	4.5	0.23	7.7	96
	11/03/2019	8.51	769	26.1	4.0	0.37	12.97	160.8
G2H 1A Gowrie Creek	19/09/2017	7.77	895	22.8	-	0.46	8.16	95
	01/03/2018	7.88	898	28.3	3.2	0.41	7.18	89.9
	11/03/2019	7.78	1144	28.7	5.1	0.53	9.3	120.2

Source WQO: DERM (2010) and DES (2019b)

Table notes:

Highlighted colour where value is above WQO or outside WQO range where applicable

1	Over-saturation of dissolved oxygen *in situ*.		
°C	Degrees Celsius	ppt	parts per thousand
NTU	Nephelometric Turbidity Units	µS/cm	microsiemens per centimetre
mg/L	milligrams per litre		

4.3.7 Laboratory assessed surface water quality results

The laboratory results for the baseline water quality assessments for the ecology study area are provided Table 4.44 and Table 4.45.

Table 4.44 Key laboratory results for water quality monitoring sites

Site	Date	pH	Conductivity (µS/cm) (at 25°C)	Chlorophyll *a* (µg/L)	Total P (mg/L)[1]	Filterable reactive P (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.05** **0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
Lockyer Creek catchment														
WQO		**6.5 – 8.0**	**< 520**	**< 5**	**< 0.05**	**< 0.02**	**< 6**	**< 6**	**< 0.02**	**-**	**-**	**< 0.42**	**-**	**< 0.5**
G2H 10A (Alt) Rocky Creek	22/09/2017	8.7	2300	12	0.05	<0.05	4.8	4.2	<0.01	<0.02	<0.02	1.1	1.1	1.10
	01/03/2018	7.8	510	12	0.25	0.06	170	420	0.19	0.21	0.02	0.6	0.8	1.00
	11/03/2019	Dry at the time of sampling												
H2C 11A Lockyer Creek	09/10/2017	9.3	1400	< 10	0.10		47	36	0.11	< 0.02	< 0.02	0.49	0.6	0.6
	01/03/2018	8.5	1100	29	0.19		53	32	< 0.01	< 0.02	< 0.02	0.7	0.7	0.7
	11/03/2019	Dry at the time of sampling												
G2H 9A Lockyer Creek	19/07/2017	8.4	590	<5	<0.05	0.1	4.5	1.7	0.17	<0.02	<0.02	0.4	0.6	1.70
	01/03/2018	8.0	810	<5	0.09	<0.05	4.0	2.8	<0.01	<0.02	<0.02	0.3	0.3	0.30
	11/03/2019	8.4	1800	7.5	0.01	0.01	13	7.1	0.04	<0.02	<0.02	0.42	0.5	0.46
G2H 8A Un-named tributary of Lockyer Creek	19/09/2017	Dry at the time of sampling												
	01/03/2018	Dry at the time of sampling												
	11/03/2019	Dry at the time of sampling												
G2H 7A (alt) Six Mile Creek	19/09/2017	Dry at the time of sampling												
	01/03/2018	7.6	570	<5	0.09	<0.05	89	210	0.02	0.41	0.05	1.2	1.2	1.70
	11/03/2019	Dry at the time of sampling												
G2H 6A Rocky Creek	19/09/2017	7.8	1200	16	<0.05	<0.05	7.6	3.7	0.08	<0.02	<0.02	0.2	0.3	1.70
	01/03/2018	8.1	800	<5	0.12	<0.05	18	28	0.03	0.30	<0.02	0.4	0.4	0.70
	11/03/2019	Dry at the time of sampling												

Site	Date	pH	Conductivity (µS/cm) (at 25°C)	Chlorophyll *a* (µg/L)	Total P (mg/L)[1]	Filterable reactive P (mg/L)	Suspended solids (mg/L)	Turbidity (NTU)	Ammonia (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Organic nitrogen (mg/L)	Total Kjeldahl nitrogen (mg/L)	Total N (mg/L)
LOR	**-**	**0.1**	**1**	**5**	**0.05** **0.01**	**0.05** **0.01**	**1**	**1**	**0.01**	**0.02**	**0.02**	**0.2**	**0.2**	**0.2**
G2H 5A Rocky Creek	19/09/2017	Dry at the time of sampling												
	01/03/2018	8.6	950	<5	0.17	0.06	18	11	0.11	0.17	<0.02	0.3	0.4	0.58
	11/03/2019	Dry at the time of sampling												
G2H 4A Rocky Creek	19/09/2017	Dry at the time of sampling												
	01/03/2018	8.4	1000	<5	0.25	0.08	30	19	<0.01	0.12	<0.02	0.3	0.3	0.43
	11/03/2019	Dry at the time of sampling												
Condamine River Basin														
WQO		**7.7 – 8.3**	**< 510**	**< 5**	**< 0.11**	**< 0.045**	**< 14**	**< 13**	**< 0.01**	**-**	**-**	**-**	**-**	**< 1.005**
G2H 3A Gowrie Creek	19/09/2017	7.8	900	<5	0.13	<0.05	5.3	5.0	<0.01	<0.02	<0.02	0.6	0.6	0.6
	01/03/2018	8.1	410	<5	0.24	<0.05	5.9	2.8	<0.01	1.4	<0.02	0.8	0.8	2.2
	11/03/2019	8.3	380	<5	0.06	0.03	4.9	2.1	<0.01	1.0	<0.02	1.2	1.2	1.3
G2H 2A Gowrie Creek	19/09/2017	8.9	600	5.3	<0.05	0.08	4.0	1.8	0.03	0.67	0.07	0.47	0.5	1.2
	01/03/2018	8.3	430	<5	0.11	<0.05	2.6	2.8	0.04	1.2	0.02	0.7	0.7	2.0
	11/03/2019	8.5	440	<5	0.12	0.02	3.8	1.8	<0.01	0.7	<0.02	<0.2	<0.2	0.71
G2H 1A Gowrie Creek	19/09/2017	8.9	620	<5	0.15	0.11	<1	1.1	0.03	2.1	<0.02	1.6	1.6	3.7
	01/03/2018	8.0	760	<5	1.2	0.92	2.0	2.8	0.04	1.9	<0.02	1.3	1.3	2.2
	11/03/2019	8.3	920	<5	0.12	0.1	13	2.5	<0.01	2.1	<0.02	1.1	1.1	3.2

Source WQO: DERM (2010) and DES (2019)

Table notes:

µg/L = micrograms per litre
Highlighted colour where value is above WQO or outside WQO range where applicable
1 LOR changes for total phosphorus occurred between field assessments 2 (March 2018) and 3 (March 2019)

Table 4.45 Dissolved metal and indicative polycyclic aromatic hydrocarbons laboratory results for Project water quality monitoring sites

Site	Date	Arsenic (III) (mgL^{-1})	Cadmium (mgL^{-1})	Chromium (VI) (mgL^{-1})	Copper (mgL^{-1})	Lead (mgL^{-1})	Mercury (mgL^{-1})	Nickel (mgL^{-1})	Zinc (mgL^{-1})	Naphthalene (mgL^{-1}) (PAH)
LOR	**-**	**0.001**	**0.0002**	**0.001**	**0.001**	**0.001**	**0.0001**	**0.001**	**0.005**	**0.001**
Lockyer Creek catchment										
WQO		**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
G2H 10A (Alt) Rocky Creek	22/09/2017	0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	01/03/2018	0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.009	0.005	<0.001
	11/03/2019	Dry at the time of sampling								
H2C 11A Lockyer Creek	09/10/2017	0.002	<0.0002	<0.001	0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	01/03/2018	0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.002	<0.005	<0.001
	11/03/2019	Dry at the time of sampling								
G2H 9A Lockyer Creek	19/09/2017	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.002	<0.005	<0.001
	01/03/2018	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	11/03/2019	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
G2H 8A Un-named tributary of Lockyer Creek	19/092017	Dry at the time of sampling								
	01/03/2018	Dry at the time of sampling								
	11/03/2019	Dry at the time of sampling								
G2H 7A (Alt) Six Mile Creek	19/092017	Dry at the time of sampling								
	01/03/2018	0.002	<0.0002	<0.001	0.006	<0.001	<0.0001	0.006	<0.005	<0.001
	11/03/2019	Dry at the time of sampling								
G2H 6A Rocky Creek	19/09/2017	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.002	0.006	<0.001
	01/03/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.003	0.011	<0.001
	11/03/2019	Dry at the time of sampling								
G2H 5A Rocky Creek	19/09/2017	Dry at the time of sampling								
	01/03/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.003	0.011	<0.001
	11/03/2019	Dry at the time of sampling								

Site	Date	Arsenic (III) (mgL^{-1})	Cadmium (mgL^{-1})	Chromium (VI) (mgL^{-1})	Copper (mgL^{-1})	Lead (mgL^{-1})	Mercury (mgL^{-1})	Nickel (mgL^{-1})	Zinc (mgL^{-1})	Naphthalene (mgL^{-1}) (PAH)
LOR	**-**	**0.001**	**0.0002**	**0.001**	**0.001**	**0.001**	**0.0001**	**0.001**	**0.005**	**0.001**
G2H 4A Rocky Creek	19/09/2017	Dry at the time of sampling								
	01/03/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.003	<0.005	<0.001
	11/03/2019	Dry at the time of sampling								
Condamine River Basin										
WQO		**0.024**	**0.0055**	**0.0004**	**0.0014**	**0.0034**	**0.0006**	**0.011**	**0.008**	**0.016**
G2H 3A Gowrie Creek	19/09/2017	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.005	<0.001
	01/03/2018	<0.001	<0.0002	<0.001	0.001	<0.001	<0.0001	0.002	0.006	<0.001
	11/03/2019	0.002	<0.0002	<0.001	<0.001	<0.001	<0.0001	0.001	<0.005	<0.001
G2H 2A Gowrie Creek	19/09/2017	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.003	<0.005	<0.001
	01/03/2018	<0.001	<0.0002	<0.001	0.002	<0.001	<0.0001	0.001	<0.005	<0.001
	11/03/2019	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.0001	<0.001	0.025	<0.001
G2H 1A Gowrie Creek	19/09/2017	<0.001	<0.0002	<0.001	0.003	<0.001	<0.0001	0.003	<0.005	<0.001
	01/03/2018	<0.001	<0.0002	<0.001	0.008	<0.001	<0.0001	0.003	0.052	<0.001
	11/03/2019	<0.001	<0.0002	<0.001	<.001	<0.001	<0.0001	<0.001	0.025	<0.001

Source WQO: ANZECC/ARMCANZ (2000/2018)

Table note:

Highlighted colour where value is above WQO or outside WQO range where applicable
mgL^{-1} = Milligrams per litre

4.3.8 Springs and groundwater dependent ecosystems

No springs were observed during field assessments including geotechnical investigations which may be in part due to the dry conditions prior and during field investigations. The surveys were also not able to verify the GDE mapping (BoM 2018) including potential GDEs above the tunnel and several first order streams which intersect the Project disturbance footprint also mapped as potential GDE.

It has been assumed for the purposes of the EIS, that the modelled extent of the aquatic and terrestrial GDEs as identified in Section 4.2.10, are accepted as true presence, and thus form a potentially sensitive environmental receptor for the purpose of impact assessment.

4.4 Environmental values and receptors

4.4.1 Environmental values

Consistent with the relevant legislation as stated in Section 2, the overarching ecological values adopted for the ecology study area include:

- QLD'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.

4.4.2 Sensitive environmental receptors

A sensitive environmental receptor is a feature, area or structure that may be affected by direct or indirect changes to the environment.

For conservation significant flora and fauna species, predictive habitat mapping has been used to assess the species potential to occur within the ecology study area (refer Appendix A). Mapping associated with this process is presented in Appendix G and the area of predicted habitat contained within the ecology study area is provided in Table 4.28. In instances where species did not have potential habitat contained within the ecology study area, these species were not subject to impact assessment and were no longer considered to constitute sensitive environmental receptors as the risk of impacts to any these species are considered low.

The sensitive environmental receptors identified for terrestrial and aquatic ecology within the ecology study area are identified in Table 4.46 along with their assigned sensitivity value as determined by Table 3.7.

Table 4.46 Sensitive environmental receptors identified within the ecology study area

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
■ QLD's natural environment and native flora and fauna ■ Land conducive to the maintenance of existing landforms, ecological health,	Protected areas: ■ Regulated vegetation Category A – VDec areas	High	■ Protected by State legislation ■ Important for biodiversity ■ Moderate sensitivity, high exposure to impacts.

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
connectivity, riverine and wetland areas ▪ Biodiversity. ▪	Category B regulated vegetation ('Endangered' REs): ▪ 11.3.21 ▪ 12.3.3 ▪ 12.5.6 ▪ 12.5.6a ▪ 12.8.21 ▪ 12.8.24 ▪ 12.9-10.15	High	▪ Protected by State legislation ▪ Important for biodiversity ▪ Rare ▪ High sensitivity, high exposure to impacts
	Category B regulated vegetation ('Of concern' REs): ▪ 11.8.11 ▪ 12.9-10.3 ▪ 12.9-10.7	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact
	Category B regulated vegetation ('Least concern' REs): ▪ 11.3.25 ▪ 11.8.2a ▪ 11.8.4 ▪ 11.8.5 ▪ 11.8.5a ▪ 11.8.8 ▪ 12.3.7 ▪ 12.8.9 ▪ 12.8.14 ▪ 12.8.14a ▪ 12.8.17 ▪ 12.9-10.2 ▪ 12.9-10.5a ▪ 12.9-10.17a	Low	▪ Protected by State legislation ▪ Important for biodiversity ▪ Low sensitivity, high exposure to impact
	Category C regulated (High Value Regrowth vegetation - HVR)	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact
	Regulated vegetation within a defined distance to watercourses and wetlands	Moderate	▪ Protected by State legislation ▪ Important for biodiversity ▪ Moderate sensitivity, high exposure to impact
	Migratory fauna species listed under the provisions of the EPBC Act[1] (including habitat): ▪ Common sandpiper (*Actitis hypoleucos*) ▪ Fork-tailed swift (*Apus pacificus*) ▪ Sharp-tailed sandpiper (*Calidris acuminata*) ▪ Pectoral sandpiper (*Calidris melanotos*)	High	▪ Protected by Commonwealth legislation ▪ Uncommon ▪ High sensitivity, high vulnerability

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
	■ Red-necked stint (*Calidris ruficollis*) ■ Oriental cuckoo (*Cuculus optatus*) ■ Latham's snipe (*Gallinago hardwickii*) ■ Caspian tern (*Hydroprogne caspia*) ■ Black-faced monarch (*Monarcha melanopsis*) ■ Yellow wagtail (*Motacilla flava*) ■ Satin flycatcher (*Myiagra cyanoleuca*) ■ Osprey (*Pandion haliaetus*) ■ Glossy ibis (*Plegadis falcinellus*) ■ Pacific golden plover (*Pluvialis fulva*) ■ Rufous fantail (*Rhipidura rufifrons*) Spectacled monarch (*Symposiachrus trivirgatus*) ■ Common greenshank (*Tringa nebularia*) ■ Marsh sandpiper (*Tringa stagnatilis*)		
	Conservation significant terrestrial flora and fauna species listed under the provisions of the NC Act (including habitat): **Flora** ■ Bailey's cypress (*Callitris bailey*) ■ Caustis (*Caustis blakei macrantha*) ■ A sedge (*Cyperus clarus*) ■ Finger panic grass (*Digitaria porrecta*) ■ Slender milkvine (*Marsdenia coronata*) **Fauna** ■ Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) ■ Powerful owl (*Ninox strenua*) ■ Grey snake (*Hemiaspis damelii*)	High	■ Protected by State legislation ■ Rare ■ High sensitivity, high vulnerability
	Priority Back on Track flora and fauna species (that are not listed as threatened under the provisions of the EPBC Act or NC Act)	Low	■ Protected by State legislation ■ A common feature of the landscape, not facing endangerment, not rare, low extinction risk ■ Low sensitivity, high exposure to impact
	Flora and fauna species not listed under the EPBC Act but listed as 'Least concern' under the provisions of the NC Act and flora that is listed as 'Special least concern' under the provisions of the NC Act (e.g. Echidna and Platypus)	Low	■ Protected by State legislation ■ A common feature of the landscape, not facing endangerment, not rare, low extinction risk ■ Low sensitivity, high exposure to impact
■ QLD's natural environment and native flora and fauna ■ Land conducive to the maintenance of	MSES wildlife habitat, State significant vegetation, bioregional corridors and Koala habitat mapping	High	■ Important for biodiversity ■ High sensitivity, high exposure to impact

Associated ecological value	Identified sensitive environmental receptors	Assigned sensitivity (refer Table 3.7)	Justification
existing landforms, ecological health, connectivity, riverine and wetland areas ■ Biodiversity	Regionally significant vegetation, bioregional corridors and wildlife refugia	Moderate	■ Identified as sensitive by State policy ■ Important for biodiversity ■ High exposure to impact
	Natural wetlands and watercourses, including: ■ State significant waters (HEV) ■ MSES Watercourses ■ Groundwater dependent ecosystems ■ Waterway barriers for fish passage	High	■ Protected by State legislation ■ Important for biodiversity ■ High sensitivity, high exposure to impacts

Table note:

1 These receptors may also be listed as Special Least Concern under the provisions of the NC Act.

5 Potential impacts and impact mitigation

Potential Project related impacts are described in the sections below. These impacts have been assessed against the identified sensitive environmental receptors, with initial design mitigation considered. Project mitigation measures have then been used to re-assess the significance of impact to determine residual impacts with all mitigation measures in place.

In instances where preliminary assessment indicates potential for a significant residual impact to an MNES (i.e. migratory species listed under the EPBC Act) or to an MSES (no matter how slight), these sensitive environmental receptors have been assessed under the relevant State or Commonwealth significant impact guidelines (refer Sections 5.3.3 and 5.3.4).

Through information gathered during the Project EIS process, sensitive environmental receptors 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.

5.1 Description of potential impacts

5.1.1 Project activities

Infrastructure activities proposed as part of the Project have been categorised into four phases; construction; commissioning and reinstatement; operation; and decommissioning. 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 construction, commissioning and reinstatement, operation and decommissioning phases

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 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	Temporary
		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	Excavation	Temporary
		Trenching	Short term
		Modification, diversion and realignment of utilities and associated infrastructure	Short term/Medium term
	Drainage	Culvert installation	Permanent
	Structures	Construction of bridges over main waterways	Medium term
		Road/rail bridge construction	Medium term

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 for definitions)
	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
	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
		Tunnel boring machine	Medium term
		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/ Decommissioning	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

Phase	Infrastructure activity	Description of activities	Duration of disturbance (refer Table 3.6 for definitions)
Operation	Train operations	Train movement along rail	Permanent
	Operational maintenance	Ongoing vehicle movement within rail corridor	Permanent
Decommissioning	Lines decommissioned	Increased vehicle movement within rail corridor	Short term

5.1.2 Potential impacts to terrestrial and aquatic ecology

5.1.2.1 Habitat loss and degradation from vegetation clearing/removal

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. 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 species listed under the provisions of the NC Act, as well as migratory species listed under the EPBC Act (including their associated habitats) identified in this assessment.

Whist it is acknowledged that the SEQ and Brigalow Belt bioregions exists 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.

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 Powerful owl (*Ninox strenua*), Glossy black-cockatoo (*Calyptorhynchus lathami*) and Short-beaked echidna (*Tachyglossus aculeatus*) (i.e. K-selected species) and is less pronounces in those that are R-selected (e.g. those species with high fecundity and shorter lifespans) (Oli, 2004).

Physical trauma to 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 area (through the movement of vehicles, which for some activities may occur at any time of the day (e.g. tunnelling operations are 24 hours a day, seven days a week). Species most at risk of injuries and mortality are those that are cryptic, difficult to detect and with poorly developed dispersal mechanisms (e.g. Grey snake (*Hemiaspis damelii)*). However, larger species with defined territories and movement patters may also be ‘Vulnerable’, particularly during vegetation clearing activities.

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 sensitive environmental receptors, including conservation significant fauna species listed under the provisions of the NC Act, ‘Special least concern’ fauna species listed under the provisions of the NC Act and migratory species listed under the EPBC Act.

Some diurnal (active during the day) and mobile species, such as birds, including migratory species, 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. Powerful owl (*Ninox strenua)*), 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 (i.e. vehicle movement to facilitate construction) 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 construction of tracks, as well as the general use of 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 development of the Project are ground dwelling species that are capable of moving across modified areas including Grey snake (*Hemiaspis damelii)* and Short-beaked echidna *(Tachyglossus aculeatus*) and arboreal species which ascend to the ground to disperse.

Aquatic fauna may be injured or killed during construction within waterways, such as the construction of culverts and bridges. Species most susceptible to death or injury include smaller and/or sessile species such as freshwater invertebrates.

The unmitigated potential occurrence of fauna species injuries or mortalities resulting from the Project can be short term and permanent, where mortality to the species occurs, or temporary where the species is rehabilitated and re-released (refer Table 3.6 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 Bailey's cypress (*Callitris baileyi*), Caustis (*Caustis blakei subsp. macrantha*), *Cyperus clarus* and Finger panic (*Digitaria porrecta*) and Slender milkvine (*Marsdenia coronata*). Impacts to soil may also have flow on effects to other threatened fauna species though 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 2004). This will act directly upon recruitment processes and may impact upon a species/community's 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. 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.

Larger non-burrowing soil animals such as mites, springtails, and fly larvae may also be affected by soil compaction. Burrowing animals such as earthworms, termites, ants, and beetles can defend themselves better but may still suffer negative effects.

The unmitigated potential impacts of soil compaction resulting from the Project are generally short term and temporary (refer Table 3.6 for definitions associated with timeframes).

5.1.2.4 Displacement of 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 2001; 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 during the operation phase of the Project.

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 sensitive environmental receptors. These potential impacts are likely to be long term and affect all sensitive environmental receptors in the Project disturbance footprint, including affecting the quality and integrity of remnant vegetation, habitat for threatened species, wetlands and waterways.

Numerous non-native species have been recorded in the ecology study area. Of these, two fauna species and 17 flora species were restricted matters, listed under the provisions of the Biosecurity Act, were recorded. 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 have high specific habitat requirements where weed encroachment has been identified as a threatening process.

Project activities also have the potential to introduce new weed species into the ecology 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.

Large areas of the ecology 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 Project disturbance footprint into the surrounding landscape, due to habitat removal, noise disturbance, and human presence during the construction and operational 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. Therefore, unmitigated potential impacts of the displacement of native species through the invasion of non-native may be temporary or irreversible (refer Table 3.6 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 many threatened species including the Powerful owl (*Ninox strenua*) and Glossy black-cockatoo (*Calyptorhynchus lathami*).

The Queensland corridor mapping for SEQ and the Brigalow Belt bioregions (QLD Government 2019a) depicts regional and State corridors within the ecology study area (refer Figure 4.12), which portrays vegetation that is significant for the spread and movement of flora and fauna. Connectivity is present north and south of the ecology study area, and this is particularly evident in areas associated with steep topography and drainage lines such as Main Range. The Project intersects the corridor between Ch 7.5 km and Ch 20.5 km. Within this area there is the proposed Toowoomba Range Tunnel (~2.5 km) and approximately 3.3 km of viaducts.

Lockyer Creek is also recognised as a state corridor, with the Project proposing to cross the creek via viaduct (Lockyer Creek Viaduct). There is limited connectivity in the Gowrie Creek area with further barriers to movement as a result of the Toowoomba Bypass. Gowrie Creek downstream from the western tunnel portal area is recognised as a regional corridor with the proposed Gowrie Junction Road bridge intersecting the corridor.

However, areas within the west and east of the ecology study area exists in a generally fragmented environment. Despite this, 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 mobile species such as birds and bats.

The potential impacts of linear infrastructure traversing these biodiversity corridors include 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. Sensitive environmental receptors involving threatened species, bioregional corridors and wildlife refugia are likely to be impacted the most from these potential impacts due to the importance of habitat quality and linkages for species at a local scale and the cumulative impacts at a regional landscape scale.

The unmitigated potential impacts to biodiversity corridors resulting from the Project are likely to be long term and irreversible (refer Table 3.6 for definitions associated with timeframes).

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).

Within the ecology study area, many patches of vegetation are small, irregularly shaped, and fragmented, and as such are already subject to considerable edge effects. Therefore, it is unlikely that the Project would increase the overall extent of edge effects in these areas. However, in large habitat patches with low edge to area ratios, 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 ecology study area, especially upon the species with specific micro-habitat requirements that are less tolerant to disturbance. Conversely, some threatened plant species appear to respond positively to edge effects, particularly ground disturbance, and colonise these edge areas reasonably quickly including Finger panic (*Digitaria porrecta*).

It is anticipated that threatened species and other sensitive environmental receptors may be impacted the 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 3.6 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 1990), or, is generally only used by adaptive and aggressive generalist species (i.e. Noisy miners) (Loyn et al 1983) which further decreases population levels of other species remaining in the fragments.

The landscape in which 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. Sensitive environmental receptors involving conservation significant species, regionally significant vegetation, bioregional corridors and wildlife refugia may be impacted upon the most from habitat fragmentation. 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.

Habitat fragmentation has been identified as an important threatening process to several threatened species. This is due to the importance of connectivity, dispersal opportunities and habitat quality for 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, given the capacity of the species to disperse widely across the landscape and vagile species such as birds and bats).

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 vine thickets, wet sclerophyll and Lowland rainforest.

The unmitigated potential impacts of habitat fragmentation resulting from the Project are considered to be long term and irreversible (refer Table 3.6 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. Sensitive environmental receptors that are most vulnerable to barrier effects include the Short-beaked echidna (*Tachyglossus aculeatus*) and small, insectivorous migratory birds that depend on interconnect tracts of vegetation to facilitate migratory movements.

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). Mobile species such as larger mammals, birds (e.g. Powerful owl (*Ninox strenua*)), and bats may not be affected to the same extent.

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 is 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.

Waterway barrier works have the potential to impair movement of fish species across the works area, decreasing connectivity of habitat and overall ecological service.

- Although waterway barrier works for the Project are expected to be restricted to bridge infrastructure works within the construction phase, these works will occur along major watercourses and therefore have the potential to cause major (although temporary during the construction period) impacts to waterways. However, it is proposed that bridge construction activities will incorporate locating piers for the bridge structures outside the low-flow areas of the watercourses thereby avoiding further unmitigated impacts to instream habitat.
- Crossings of Gowrie Creek, Oakey Creek, Rocky Creek, Six Mile Creek are all proposed and depending on the nature of the works waterway barriers may be required. This include temporary structures
- A number of existing and new access roads are required, including across Rocky Creek, a purple waterway
- Where the Project is co-located with the existing rail line, the existing culverts are likely to be extended and/or upgraded
- There are three unmapped watercourses, including a red waterway where diversion works are proposed.

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.

The unmitigated potential impacts of barrier effects resulting from the Project are considered to be long term and irreversible (refer Table 3.6 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. 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.

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).

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.

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.

Sensitive environmental receptors affected from these potential impacts include all threatened flora (impact associated with dust) and terrestrial fauna species (impact associated with noise and vibration). 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. Littered objects may also provide suitable habitat for disease-spreading insects, such as flies and mosquitoes (Healthy Land and Water 2019) and as such negatively impact particular fish species.

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).

Sensitive environmental receptors affected from this potential impact include 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

There are over 13.5 lineal km of watercourses within the Project disturbance, through there are no mapped wetlands present. Without mitigation, activities related to the construction and operation of the Project are likely to impact water quality, thereby degrading habitats for aquatic fauna and flora. Erosion and sedimentation, 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 watercourse diversions and waterway crossings during construction and operation.

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. This in turn 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 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.

EIS Chapter 9: Land resources identifies potential existing contamination sources and associated potential receptors and indicates where there is a potential for bioaccumulation of contaminants due to direct contact or consumption of contaminants by terrestrial and aquatic receptors. Potential sources of existing contamination are associated with:

- Agricultural use and storage of chemicals and hydrocarbons
- Activities in the existing rail corridor
- Unexploded ordnance (although this is considered unlikely).

Potential land contamination sources associated with proposed Project activities both during construction and operation. Potential sources of impacts on terrestrial and aquatic receptors include hydrocarbon and hazardous materials use and storage, biosecurity management and waste storage (including storage of sewage tanks). A low post-mitigation risk of potential for mobilisation of sediment-bound metals and other substances, acting as contaminants from standard construction and operational phase activities. These potential sources are considered to be derived from physical land and stream disturbances, clearing activities, accidental spills, dewatering activities and standard rail maintenance and operating procedures.

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.

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 course 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 the secondary impact of erosion and sedimentation on aquatic habitats, the primary impact of erosion on terrestrial habitat has 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 a localised direct impact on terrestrial habitats. 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).

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 Main Range Volcanics (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 Chapter 9 of the EIS: Land Resources for further detail).

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 (approximately 100 mbgl at this point) a patch of Queensland blue gum (*E. tereticornis*) woodland along Gowrie Creek. 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.

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 ecology 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 ecology 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 ecology 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 ecology 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.

The main long-term impact from the tunnel activities is associated with the management of groundwater inflow at the western tunnel portal and potentially at the eastern tunnel portal. Groundwater inflow at the western tunnel portal will be diverted into an ephemeral watercourse (Gowrie Creek UT1) during operations, and may also be released into the same watercourse during construction. Groundwater inflow from the tunnel will be released into an ephemeral watercourse, potentially after treatment, at the eastern tunnel portal. The change from an ephemeral watercourse to a perennial system (assuming constant flows) will impact the flora and fauna assemblages, noting that both systems may be influenced by natural groundwater inflows.

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 in the absence of mitigation. 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 (in an unmitigated scenario) 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 manner, 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 and as such the criteria for human comfort has been used as a default. Vibration impacts are very likely to be similar to those described for noise (refer Chapter 15: Noise and Vibration). In addition, vibration impacts will be restricted to the construction period.

The assessment found that during construction the following is likely:

- Within an approximate distance of 260 m from the works which will exceed guideline ground-borne noise criteria for daytime hours
- Within an approximate distance of 390 m from the works which will exceed guideline ground-borne noise criteria for night-time hours.

These impacts will be temporary in nature lasting up to 80 days, based on a tunnel rate of 10 m per day.

The majority of this area has been developed with limited areas of habitat above the tunnel, with the exception of the Gowrie Creek and the vegetation communities along the escarpment. As such, any potential There are no guidelines and little research information regarding the potential impacts of ground-borne noise and vibration on fauna. Vibration impacts are very likely to be similar to those described for noise (refer Section 5.1.2.9).

Further any impact upon fauna during construction is likely to be minor at worst and temporary in duration. No ground-borne noise or vibration impacts are anticipated during operations based on the Project achieving the criteria for railway operations (refer EIS Appendix P: Operational railway noise).

5.2 Impact mitigation

This section outlines both the flora and fauna impact mitigation measures included as part of the Project design and the additional mitigation measures that are proposed for the Project to manage predicted environmental impacts. The impacts are initially assessed with consideration of the 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 collocated with the existing QR West Moreton System rail corridor for 5.6 km and generally follows the protected Gowrie to Grandchester future State transport corridor. The Gowrie to Grandchester future State transport corridor was assessed in detail in 2003, 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 62.5 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.
- 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 in-stream connectivity and riparian fauna conduits. For example fish passageway culverts have been upsized by 300 mm height for box culverts and 300 mm diameter for pipes from the calculated hydraulic sizes in order to submerge the culverts beneath the existing bed level by 300 mm at the upstream and downstream ends to comply with the fish passage requirements.
- Thirteen new bridge and viaduct structures, totalling over 6 km in length, are to be constructed to minimise disturbance of aquatic habitats during operations and facilitate terrestrial fauna passage during construction and operations (refer Figure 5.1).
- 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 RMAR's. Habitat for threatened species has been avoided wherever possible.
- The Toowoomba Range is 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 during and following construction. This includes a number of viaducts in the floodplains and gully areas and the inclusion of the rail tunnel (6.24 km long) in the more elevated section of the range. Fauna will be 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 Glossy black-cockatoo, Powerful owl, Short-beaked echidna and any other fauna species 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 to safe movement opportunities including the proposed fauna crossing locations. 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 5.2. 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 where 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 5.2). It is acknowledged the effectiveness of these measures may not be subject to rigorous peer-reviewed analysis.

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. Noting that DTMR are current assessing the effectiveness of the measures adopted on the Toowoomba Bypass and these lessons learnt may inform the measures being considered by ARTC.

A review has been undertaken of 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 passes are complementary, with the ability to avoid animal collisions and maintain infrastructure permeability (VicRoads 2012; Carlvalho 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 (Offburg and Blank 2015).
- Use of planting native species to the region was validated by Milton, et al. (2015).

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

Map by: LT Z:\GIS\GIS_3200_G2H\Tasks\3200-EAP-20200513112 3_G2H_Ecology_Figures\3200-EAP-20200513112 3_FFJV_Fig5.1_Location_viaductsand_bridges_that_will_provide_fauna_movement_v1.mxd Date: 24/03/2021 16:43

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Nerimgandan Ck
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Highfields
Murphys Creek
Fifteen Mile Ck
Murphys Ck
Alice Ck
LOCKYER VALLEY
TOOWOOMBA
Gowrie Ck
Gowrie
Toowoomba Byp
Warrego Hwy
Toowoomba Conn Rd
Dry Ck
Ruthven St
Oaky Ck
Rocky Ck
Six Mile Ck
Lockyer Ck
Little Oaky Ck
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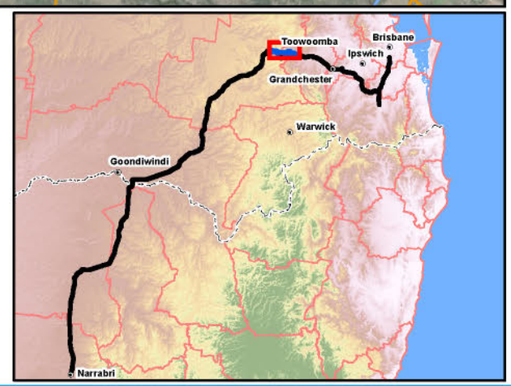
Legend

- 5 Chainage (km)
- Localities
- B2G project alignment
- G2H project alignment
- H2C project alignment
- Existing rail
- Watercourses
- Major roads
- Minor roads
- Tunnel
- Bridges
- EIS disturbance footprint (surface disturbance only)
- Ecology study area
- Local Government Areas



A3 scale: 1:80,000

0 1 2 3 4 5km

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Issue date: 23/03/2021 Version: 1
Coordinate System: GDA 1994 MGA Zone 56

Gowrie to Helidon

Figure 5.1: Location of bridges that will provide for fauna movement

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 mitigation 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, 2015c; van der Grift et al. 2015). Criteria that can be used to measure effectiveness include:

- Rates of vehicle strike
- 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.

Table 5.2 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 threatened flora and fauna species have not completed within the Project disturbance footprint as part of Project surveys detailed in this report. ARTC is committed to undertaking 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 5.2 Project impact mitigation measures

Delivery phase	Aspect	Proposed mitigation measures
Detailed design	Flora and fauna	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. This will avoid unnecessary clearing and require inputs from the design team, construction contractor, and where applicable, the constructing authority.
		■ The final extent of the Project disturbance footprint (within the maximum disturbance footprint assessed in this report) will be confirmed during the detailed design phase. ■ A Flora and Fauna Sub-plan will be developed as part of the Construction Environmental Management Plan (CEMP) and will be comply with any relevant approval conditions. This plan will include appropriate criteria, directives and procedures in relation to: – Methods and sequencing of protected plant surveys, including seasonal timing, in accordance with the requirements of Protected Plants Assessment Guidelines (DES 2020L). Flora species to be targeted through these surveys include: ■ MSES flora: – Finger panic (*Digitaria porrecta*) – A sedge (*Cyperus clarus*) – Slender milkvine (*Marsdenia coronata*) – Bailey's cypress (*Callitris baileyi*) – Caustis (*Caustis blakei subsp. macrantha*) – Methods and sequencing of pre-clearance 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: ■ MSES fauna: – Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) – Powerful owl (*Ninox strenua*) – Grey snake (*Hemiaspis damelii*) ■ MNES fauna (non-threatened migratory species): – Common sandpiper (*Actitis hypoleucos*) – Fork-tailed swift (*Apus pacificus*) – Sharp-tailed sandpiper (*Calidris acuminata*) – Pectoral sandpiper (*Calidris melanotos*) – Red-necked stint (*Calidris ruficollis*) – Oriental cuckoo (*Cuculus optatus*) – Latham's snipe (*Gallinago hardwickii*) – Caspian tern (*Hydroprogne caspia*) – Black-faced monarch (*Monarcha melanopsis*) – Yellow wagtail (*Motacilla flava*)

Delivery phase	Aspect	Proposed mitigation measures
		– Satin flycatcher (*Myiagra cyanoleuca*) – Eastern osprey (*Pandion haliaetus*) – Glossy ibis (*Plegadis falcinellus*) – Pacific golden plover (*Pluvialis fulva*) – Rufous fantail (*Rhipidura rufifrons*) – Spectacled monarch (*Symposiachrus trivirgatus*) – Common greenshank (*Tringa nebularia*) – Marsh sandpiper (*Tringa stagnatilis*) – Staging works so that they avoid animal breeding periods as much as possible within areas of habitat (large watercourses) – Staged and sequential clearing protocols, which will help maintain connectivity during construction – Animal handling protocols, including engagement of an approved fauna handler with a valid damage mitigation permit – Relocation of plants and habitats, for threatened species – Requirements for inspections and corrective actions during construction and rehabilitation activities – Biodiversity/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. – Corrective actions should the outcomes not achieve the adopted objectives ■ Surveys of representative remnant and regrowth vegetation communities that will be impacted by the Project will be undertaken during the detailed design phase 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 2020b) to enable a condition assessment of vegetation communities that require offset for the Project. ■ A Soil Management Plan will be developed and will be comply with any applicable approval conditions, The Soil Management Plan will include the following procedures and protocols relevant to potential impacts to the receiving environment: – Soil/land conservation objectives for the Project – Identification of problem soils – Management of problem soils, such as: ■ Acid sulfate soils, which may occur in proximity to wetland features and water storages ■ Erosive or dispersive soils, ■ Cracking clays (vertosols), ■ Saline soils. – Specification of the type and location of erosion and sediment controls. The erosion and sediment control measures will be developed by a Certified Professional in Erosion and Sediment Control and be in accordance with the International Erosion Control Association's *Best Practice Erosion and Sediment Control Guidelines* (2008). Details will include: ■ Locations for specific temporary/permanent erosion and sediment control measures, such as:

Delivery phase	Aspect	Proposed mitigation measures
		– Sediment retention basins – Scour protection – Sediment fencing – Berms and other surface flow diversions. ■ Nomination of location-specific erosion controls will include consideration of site conditions, proximity to environmental values, adjoining land uses, climatic and seasonal factors, and will be based on an erosion risk assessment. ■ Minimise the area of disturbance during each stage to that required to enable the safe construction, operation and maintenance of the rail corridor: ■ Scheduling of works with consideration to periods of higher rainfall (summer months) ■ Establishing and specifying the monitoring and performance objectives for handover on completion of construction ■ Stockpiling and management/segregation of topsoil where it contains native plants seedbank or weed material ■ Vehicle, machinery and imported fill hygiene protocols and documentation, in accordance with the requirements of the *Biosecurity Act 2014* ■ 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 ■ Based on the outcome of flora, fauna and 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 MSES, 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). This will help maintain connectivity during construction ■ 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 there is limited evidence of these species being successfully translocated, even though some are used in the horticultural industry. ■ BioCondition surveys of representative remnant and regrowth vegetation communities that will be impacted by the Project will be undertaken during the detailed design phase to enable a condition assessment of vegetation communities that require offset for the Project.
	Riparian vegetation and aquatic habitats	■ On-groundwater assessment to confirm the statis of all watercourses/waterways under the Water Act and the Fisheries Act which will information design requirements and where applicable approvals ■ Project design minimises impacts to waterways, riparian vegetation and in-stream flora and habitats by: – Adopting a waterway crossing structure hierarchy: bridges 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.

Delivery phase	Aspect	Proposed mitigation measures
		– 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. – 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 Project 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 ■ Developing ESCPs for implementation during pre-construction, construction and commissioning. ■ The design will continue to be developed to minimise the extent of impacts to waterways, riparian vegetation and in-stream flora and habitats, in accordance with the intent of: – Riverine protection permit exemption requirements (WSS/2013/726). Where the Project is unable to comply with the exemption requirements, a riverine protection permit will be sought for works within a watercourse – Accepted development requirements for operational work that is constructing or raising waterway barrier works (DAF 2018), e.g. for the dimensions, design and configuration of new culvert crossings. – Where the Project is unable to comply with the *Accepted development requirements for operational work that is constructing or raising waterway barrier works*, a development approval for operational work that is constructing or raising waterway barrier works will be sought ■ Design modifications during the detailed design phase will be subject to re-runs of the existing flood models to demonstrate continued compliance with the design objectives of the Project, including for extent and time of inundation, afflux and flow velocities.
	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

Delivery phase	Aspect	Proposed mitigation measures
		■ 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.
	Fauna passage[1,2]	■ Further fauna movement opportunities will be investigated (refer existing Project design structures described in Section 5.2.1) and, where appropriate, developed during detailed design including: – Identify potential conflict or opportunities between this Project and the adjacent Toowoomba Bypass project, including fauna fencing and passages that complement the existing structures under the Toowoomba Bypass, while ensuring that species are not direct to an area between the projects where there are no movement opportunities. Noting that DTMR are current assessing the effectiveness of the measures adopted on the Toowoomba Bypass and these lessons learnt may inform the measures being considered by ARTC – Assessment of the compatibility of each approach with the general design principles at each location – Consideration of safety requirements for the rail corridor and adjoining properties. For example, elevated fauna crossing structures may provide insufficient clearance for double-stacked trains. – Consultation with adjoining landholders to confirm the acceptability of a fauna movement solution and ensure compatibility with their land use operation, e.g. grazing, animal husbandry etc. ■ 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 including: – Assessment of the compatibility of each approach with the general fencing principles at each location – Consideration of safety requirements for the rail corridor and adjoining properties. – Consultation with adjoining landholders to confirm the acceptability of a localised fencing approach and ensure compatibility with their land use operation – Consideration for maintenance constraints that a fauna connectivity or fencing opportunity may introduce. ■ Fauna fencing will be designed in reference to guidelines documented in 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. ■ Priority will be given to fauna fencing in areas identified as State, regional or local fauna movement corridors to channel fauna toward safe movement options (i.e. culverts) to limit vehicle strikes and associated incidents

Delivery phase	Aspect	Proposed mitigation measures
		■ A 3 m buffer clear of woody vegetation on the habitat side of the fauna exclusion fence will be provided to ensure that species cannot use vegetation to climb onto the exclusion fencing.
	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. Detailed design to minimise the need for ongoing maintenance and inspection to maintain fish passage. ■ Design modifications during the detailed design phase will be subject to re-runs of the existing flood models to demonstrate continued compliance with the design objectives of the Project, including for extent and time of inundation, afflux and flow velocities.
	Flora	■ Construction areas including compounds, stockpiles, fuel storage areas, laydown areas and staff parking will be located and established outside the tree protection zone as defined in AS4970-2009 Protection of trees on development sites (Australian standards 2009).
	Weeds and pests	■ A Biosecurity Management Plan will be developed as a component of the CEMP. This Plan will include: – Requirements for pre-clearing and operational surveys to determine the risk of weeds or pest animals being present within the Project disturbance footprint – Maps of the existing extent, confirmed through surveys, and severity of weed infestation (e.g. restricted matters including Climbing asparagus fern, Opuntioid cactus, Lantana and Giant rats tail grass) and weed management requirements – Pest animal management controls, including protocols to manage Red imported fire ants, *Phytophthora cinnamomic* and Myrtle rust – Site hygiene and waste management procedures to deter pest animals – Locations of vehicle washdown (light vehicle and oversize vehicles) and rumble grids – Weed surveillance and treatment during construction and rehabilitation activities such as: ■ Vehicle and plant washdown requirements for fleet moving from low risk areas to and high risk areas ■ Weed certification requirements for vehicles, plant and materials arriving onto the construction site – Requirements in relation to pesticide and herbicide use, including any limitations on use. Restrictions may apply in proximity to watercourses, known areas of threatened species habitat or land uses sensitive to spray-drift from the application of pesticides and herbicides (e.g. organic farming practices) – Erosion and sediment control risks associated with broad scale weed removal or treatment – Corrective actions should the outcomes not achieve the adopted objectives. ■ Property-specific weed hygiene requirements will be developed in consultation with the relevant landowners/operators prior to pre-construction/construction activities occurring on that property, outside of the permanent footprint. Protocols, where agreed, will be documented in individual property management agreements.

Delivery phase	Aspect	Proposed mitigation measures
	Rehabilitation	■ A Reinstatement and Rehabilitation Plan will be developed for the Project, as a component of the CEMP. This Plan will be based on the Inland Rail Landscape and Rehabilitation Strategy and location-specific reinstatement commitments. As a minimum it will establish the following: – Location-specific objectives for rehabilitation, reinstatement and/or stabilisation. Objectives will differ within the permanent disturbance footprint and outside of this area for temporary construction works areas. Outside of the rail corridor, property-specific and township-specific rehabilitation and landscaping requirements may apply. – Timeframes for rehabilitation and/or reinstatement/stabilisation works to be achieved – Details of the actions and responsibilities to progressively rehabilitate, regenerate, and/or revegetate areas – Include rehabilitation requirements such as: ■ Milling and removal of bitumen pavement, ■ Removal of any decommissioned culverts, ■ Tyning and ripping of base and sub-base material, ■ Application of soil ameliorants, ■ Topsoiling and/or compost blanket, ■ Stabilisation and rehabilitation (e.g. planting and or seeding) ■ Near fauna passage structures. – Consideration for maintenance or performance issues of rehabilitation e.g. vegetation that does not grow and obscure signals or impact the longevity of rail infrastructure – Procedures, timeframes, measurable performance objectives and responsibilities for monitoring the success of rehabilitation and/or reinstatement/stabilisation areas – Corrective actions should the outcomes not achieve to the objectives adopted ■ Where temporary construction facilities/borrow pits are required, land will be returned to a stable condition.
	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. ■ The significant residual impact to habitat for MNES and MSES will be re-calculated for the Project at the conclusion of the detailed design process. ■ Re-calculated impacts will be used to confirm the Project's offset obligations under Commonwealth and State requirements ■ An Environmental Offsets Management Plan will be developed in consultation with DAWE, DAF and DES. ■ ARTC's Environmental Offset Delivery Strategy for the Project is provided as Appendix J
Pre-construction	Flora and fauna	■ The Fauna and Flora Sub-plan, as a component of the CEMP, will be implemented (refer above). ■ 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. ■ Scheduling of construction activities to minimise time of works in or adjacent to drainage lines, waterways or watercourses particularly during periods of flow.

Delivery phase	Aspect	Proposed mitigation measures
	Landscape, rehabilitation and stabilisation	▪ The Reinstatement and Rehabilitation Plan will guide the approach to rehabilitation and be implemented progressively during preconstruction and construction phase activities
	Weeds and pests	▪ Undertake pre-construction survey and mapping of weeds/pests within the Project disturbance footprint, during the detailed design in accordance with the Biosecurity Management Plan (refer above) in preparation of works proposed during pre-construction.
	Erosion and sediment control	▪ Implement appropriate site stabilisation treatments, including seeding and planting requirements, in the ESCPs and Reinstatement and Rehabilitation Plan.
	Flora	▪ Protected plant surveys, in accordance with the requirements of the NC Act, will be undertaken as required in support of pre-construction enabling works. Such works may include additional geotechnical investigations to confirm the viability of borrow pit locations or re-fencing works. ▪ Prior to any pre-construction clearing works being undertaken, the clearing extents/site boundary/limit of works will be clearly defined with flagging or marking tape. 'No go' areas will also be marked. ▪ A suitably qualified person will undertake targeted surveys, in particular, remnant and regrowth vegetation to confirm the presence/absence of threatened species habitat or threatened species.
Construction	Flora and fauna	▪ Project clearing extents are limited to that which is required to safely construct, operate and maintain the Project, in accordance with the approved Project 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). ▪ Where possible, minimise loss of canopy vegetation and works that will lead to the proliferation of weed species1 ▪ 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 sequence 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. ▪ A qualified Fauna Spotter Catcher will undertake pre-clearance surveys of habitats and vegetation. 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 Air Quality Sub-plan to minimise dust impacts including dust monitoring and suppression methods. ▪ Topsoil stockpiles will be a maximum of 2.5 m in height to avoid heat sterilisation of the seed bank ▪ Topsoil stockpiles will be managed to maintain the viability of soil seed banks for threatened flora species[1].

Delivery phase	Aspect	Proposed mitigation measures
	Riparian vegetation and aquatic habitats	■ 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. ■ The Surface Water and Hydrology Sub-plan, as a component of the CEMP, will be implemented (refer above). ■ Implement the site-specific ESCPs. ■ Works 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. ■ 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].
		■ Minimise clearance of remnant vegetation to that necessary for construction. and safe operation[1,2,3] ■ Clearly mark designated revegetation/rehabilitation zones and other no-go areas (including large significant trees) prior to any vegetation clearing. High visibility tape, barricade webbing or similar will be utilised. All contractors are to be briefed on clearing requirements and restrictions (including fines) to prevent over-clearing of these areas. Implement the 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 material1.Where practical, loss of canopy vegetation and works that will lead to the proliferation of weed species will be minimised ■ Topsoil stockpiles will be a maximum of 2.5 m in height to avoid heat sterilisation of the seed bank ■ Topsoil stockpiles will be managed to maintain the viability of soil seed banks for threatened flora species[1]. ■ 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.
	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	■ Fauna fencing will be installed in accordance with a fencing strategy, which will be finalised and documented in the detailed design[1,2].

Delivery phase	Aspect	Proposed mitigation measures
	Weeds and pests	■ The Biosecurity Management Plan, as a component of the CEMP, will be implemented (refer above) ■ 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 ■ 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
	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.
	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.
	Rehabilitation and landscaping	■ Construct landscaping treatments in accordance with the landscape design. ■ Implement the Soil Management Plan. ■ Undertake progressive rehabilitation and reinstatement of disturbed areas in accordance with the Reinstatement and Rehabilitation Plan and the Landscape and Rehabilitation Management Plan.
Operation	Riparian vegetation and aquatic habitats	■ Maintenance activities (other than for rail activities) and refuelling will be carried out a minimum of 50 m from riparian vegetation and waterways, with appropriate interception measures in place to avoid impacts to waterways, aquatic habitats, and groundwater ■ 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.

Delivery phase	Aspect	Proposed mitigation measures
	Weeds and pests	■ Weed management protocols for the operational rail corridor and other ARTC facilities will be in accordance with the requirements of the QLD *Biosecurity Act 2014* 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	■ Cross drainage structures will be inspected to assess physical condition and performance, structural integrity and corrective measures in accordance with ARTC's Structures Inspection Engineering Code of Practice (ETE-09-01) ■ 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. ■ Record vehicle strikes with fauna 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 TSRC 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).

5.2.3 Flora and fauna management and monitoring

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 5.2). It is acknowledged the effectiveness of these measures may not be subject to rigorous peer-reviewed analysis.

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.

In addition, 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 and relevant State survey guidelines will be undertaken. The surveys will aim to address any changes to the Project design and footprint and limitations associated with the existing surveys (e.g. access constraints during previous surveys, relevance of the surveys (i.e. some surveys area over four years old or were during suboptimal periods due to the dry conditions), 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.

EIS Chapter 23: Draft Outline Environmental Management Plan of the EIS provides further context and the framework for implementation of these proposed mitigation and management measures.

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 mitigation measures.

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 Section 3.5 and EIS Chapter 4: Assessment methodology.

Potential impacts to environmental values due to construction of the Project have been assessed in Sections 5.1.1 and 5.1.2. For the purposes of impact assessment, the maximum potential direct disturbance to each receptor (e.g. 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 a highly conservative approach (application of the precautionary principle) to the estimation of potential Project related 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 impacts identified during this assessment will be significantly reduced during the Project stages following the primary approval phase.

The initial significance assessment was undertaken on the assumption that the design measures factored into the Project design have been implemented (refer Section 5.2.1). The residual significance level of the potential impacts is reassessed taking into consideration the implementation of the proposed additional mitigation measures listed in Table 5.2. This has been split into consideration of the construction phase, the commissioning and reinstatement phase, and operations. Offsets in response to residual impacts are discussed in Section 5.4.

5.3.1 Quantification of potential magnitude of impacts

Quantitative estimations of the potential magnitude of disturbance was undertaken for each of the sensitive environmental receptors identified during the desktop and field components of the Project EIS using predictive habitat modelling. The feasibility design of the Project disturbance footprint was used to calculate the "unmitigated' disturbance area as a percentage of the extent of the occurrence of the sensitive environmental receptor within the broader Project context (i.e. the ecology study area).

Calculated estimates of potential disturbance magnitudes for each of the sensitive environmental receptors is provided in the following tables:

- Migratory birds which are not threatened under the EPBC Act – Table 5.3
- NC Act listed conservation significant species – Table 5.4
- Other MSES – Table 5.5.

The magnitude of impacts is determined using techniques and tools that facilitate an estimation of the **extent**, **duration** and **frequency** of the impacts as described in Table 3.5 and Table 3.6.

It is noted there are matters/receptors that cannot be quantified in the following tables but may be subject to impacts from the Project. This refers to potential 'waterway barriers to fish passage' as addressed in Section 4.2.7. The Project will require crossing structures at 24 mapped waterways along the alignment. Impacts to fish passage will be mitigated during the final design/approval phase of the Project. While these impacts are unable to be quantified on this receptor, an assessment of significant residual impacts is addressed in Section 5.3.4.1.

Table 5.3 Estimation of potential magnitude of disturbance for each migratory species within Project disturbance footprint

Species name	Common name	NC Act status	EPBC Act status	Predicted habitat within the Project disturbance footprint (ha)* (456.81 ha)			Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance			Magnitude of disturbance area (based on total habitat available) (refer Table 3.5 for magnitude criteria)#
				Potential habitat	Important habitat	Total habitat	Potential habitat	Important habitat	Total habitat	
Actitis hypoleucos	Common sandpiper	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Apus pacificus	Fork-tailed swift	SLC	M	226.16	201.19	427.35	5.04	7.21	**5.87**	Moderate
Calidris acuminata	Sharp-tailed sandpiper	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Calidris melanotos	Pectoral sandpiper	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Calidris ruficollis	Red-necked stint	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Cuculus optatus	Oriental cuckoo	SLC	M	1.93	1.53	3.46	4.34	2.05	**2.91**	Moderate
Gallinago hardwickii	Latham's snipe	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Hydroprogne caspia	Caspian tern	SLC	M	13.25	0.00	13.25	3	0	**2.96**	Moderate
Monarcha melanopsis	Black-faced monarch	SLC	M	66.06	1.53	67.59	11.09	1.67	**9.84**	Moderate
Motacilla flava	Yellow wagtail	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Myiagra cyanoleuca	Satin flycatcher	SLC	M	1.93	1.53	3.46	4.34	2.05	**2.91**	Moderate
Pandion haliaetus	Osprey	SLC	M	8.90	0.00	8.90	3.3	0	**3.27**	Moderate
Plegadis falcinellus	Glossy ibis	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Pluvialis fulva	Pacific golden plover	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Rhipidura rufifrons	Rufous fantail	SLC	M	15.71	1.53	17.24	4.48	1.88	**3.99**	Moderate
Symposiachrus trivirgatus	Spectacled monarch	SLC	M	1.93	1.53	3.46	4.34	2.05	**2.91**	Moderate
Tringa nebularia	Common greenshank	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate
Tringa stagnatilis	Marsh sandpiper	SLC	M	8.90	56.85	65.75	3.27	8.23	**6.83**	Moderate

Table notes:

M = Migratory SLC = Special least concern

* There is potential for each of the sensitive environmental 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.

Refer Section 4.3.4 areas of predicted habitat for species identified as potentially occurring within he Ecology study area

Table 5.4 Estimation of potential magnitude of disturbance for each NC Act conservation significant flora and fauna species (excluding matters of national environmental significance) within the Project disturbance footprint

Species name	Common name	NC Act status	Predicted habitat within the Project disturbance footprint (ha)* (456.81 ha)				Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance				Magnitude of total habitat disturbance area (refer Table 3.5 for magnitude criteria)#
			General	Essential	Core	Total habitat	General	Essential	Core	Total habitat	
NC Act threatened flora											
Callitris baileyi	Bailey's cypress	NT	213.09	0.00	0.00	**213.09**	7.99	N/A	N/A	**7.99**	Moderate
Caustis blakei subsp. macrantha	Caustis	V	10.41	0.00	0.00	**10.41**	4.93	0.00	N/A	**4.94**	Moderate
Cyperus clarus	A sedge	V	0.00	0.00	0.00	**0.00**	0.00	0.00	N/A	**0.00**	Negligible
Digitaria porrecta	Finger panic grass	NT	43.25	5.27	0.00	**48.52**	6.10	14.27	N/A	**6.50**	Moderate
Marsdenia coronata	Slender milkvine	V	51.02	0.00	0.00	**51.02**	16.25	N/A	N/A	**16.25**	High
NC Act threatened fauna											
Calyptorhynchus lathami	Glossy black-cockatoo	V	21.58	0.00	0.00	**21.58**	4.56	N/A	N/A	**4.56**	Moderate
Ninox strenua	Powerful owl	V	99.05	0.00	0.00	**99.05**	7.59	0.00	N/A	**7.59**	Moderate
Hemiaspis damelii	Grey snake	E	0.00	0.00	0.00	**0.00**	0.00	N/A	N/A	**0.00**	Negligible
NC Act 'Special least concern' animals											
Ornithorhynchus anatinus	Platypus	SLC	46.83	0.00	0.00	**46.83**	6.13	0.00	N/A	**5.70**	Moderate
Tachyglossus aculeatus	Short-beaked echidna	SLC	161.69	0.00	0.00	**161.69**	5.73	N/A	N/A	**5.73**	Moderate

Table notes:

E = Endangered V = Vulnerable NT = Near threatened SLC = Special least concern;

* There is potential for each of the sensitive environmental 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.

\# Sensitive environmental receptors that recorded a magnitude of "N/A" were not subject to an assessment of impact significance as it was not subject to either direct or indirect impacts.

Refer Section 4.3.4 areas of predicted habitat for species identified as potentially occurring within he Ecology study area

Table 5.5 **Estimation of potential magnitude of disturbance for each of the environmental sensitive environmental receptors (excluding threatened and migratory species) identified for the Project**

Sensitive environmental receptor	Total coverage of environmental sensitive environmental receptor within the ecology study area (ha) (7,700.22 ha)	Total unmitigated potential disturbance area associated within the Project (ha) (456.81 ha)	Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.5 for magnitude criteria)[#]
State significant environmental constraints (MSES)				
Regulated vegetation (VM Act)				
Offset area, Voluntary Declaration (Category A)	264.27	0.00	**0.00**	Negligible
'Endangered' remnant vegetation (REs) (Category B)	352.61	9.80	**2.78**	Moderate
'Of concern' remnant vegetation (REs) (Category B)	1,095.78	89.62	**8.18**	Moderate
'Least concern' remnant vegetation (REs) (Category B)[@]	841.82	13.39	**1.59**	Low
High value regrowth vegetation (HVR) (Category C)	1,030.49	106.49	**10.33**	Moderate
Regulated vegetation within a defined distance to watercourses and wetlands – Category B	137.05	4.30	**3.17**	Moderate
Regulated vegetation within a defined distance to watercourses and wetlands – Category C	68.42	5.58	**8.16**	Moderate
MSES wildlife habitat	1020.97	105.66	**10.35**	Moderate
Essential habitat	2,208.36	112.36	**5.09**	Moderate
Nature Conservation (Koala) Conservation Plan 2017 mapping				
Koala Priority Areas	232.53	10.18	**4.38**	Moderate
Koala Habitat Areas	2,861.83	213.73	**7.47**	Moderate
Koala Habitat Restoration Areas[@]	1,281.30	79.42	**6.20**	Moderate
Locally Refined Koala Habitat Areas[@]	13.44	0.99	**7.29**	Moderate
Wetlands				
State significant wetlands (HES)	2.4	0.00	**0.00**	Negligible
State significant wetlands (HEV)	6.59	0.00	**0.00**	Negligible

Sensitive environmental receptor	Total coverage of environmental sensitive environmental receptor within the ecology study area (ha) (7,700.22 ha)	Total unmitigated potential disturbance area associated within the Project (ha) (456.81 ha)	Percentage (%) disturbance to sensitive environmental receptors within the ecology study area based on the unmitigated potential disturbance	Magnitude of disturbance area (refer Table 3.5 for magnitude criteria)#
'Least concern' flora and fauna* (NC Act) and Priority Back on Track flora and fauna species@				
'Least concern' flora and fauna	7,700.22	456.81	**5.93**	Moderate
Priority Back on Track species (not listed under the EPBC Act or NC Act)	7,700.22	456.81	**5.93**	Moderate
Biodiversity Planning Assessment (BPA) (incorporating Bioregions 11 and 12) @				
Local or Other Values	39.72	10.74	**27.04**	High
Non Bioregion Ecosystem	10.17	0.00	**0.00**	Negligible
Regional	253.99	0.00	**0.00**	Negligible
State	1,080.65	62.56	**5.79**	Moderate
State Habitat for EVNT taxa	874.64	39.70	**4.54**	Moderate
Regional Riparian corridors	163.61	9.76	**5.97**	Moderate
State Riparian corridors	264.92	17.17	**6.48**	Moderate
State Terrestrial corridors	3,930.86	230.80	**5.87**	Moderate

Table notes:

a Commonwealth significant ecological constraints focus on matters of national environmental significance, where applicable these matters are also subject to protection under the NC Act

* There is potential for each of the sensitive environmental 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.

\# Sensitive environmental receptors that recorded a magnitude of "N/A" were not subject to an assessment of impact significance as they were not subject to either direct or indirect impacts.

@ Receptor not identified as an MSES

5.3.2 Initial significance of potential impacts

Following the assessment of the sensitivity of sensitive environmental receptors, identification of the potential impacts to these receptors and the assessment of the magnitude of impact, an assessment of the impact of the Project on each sensitive environmental receptor was undertaken (refer Table 5.6).

The magnitude of impacts presented in Table 5.6 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), surface water and hydrology (refer EIS Chapter 13), groundwater (refer EIS Chapter 14) and noise and vibration (refer EIS Chapter 15).

The impact assessment of the Project on sensitive environmental receptors (refer Table 5.6) presents an initial assessment of impact (i.e. application of mitigation measures already incorporated into the design) for each sensitive environmental receptor, as well as the residual impact following the application of Project's mitigation measures.

Where a sensitive environmental receptor was found to have a significance rating of Low, Moderate, High or Major, the sensitive environmental receptor has subsequently been assessed against the relevant significant impact guidelines (refer Section 5.3.3 and Section 5.3.4).

Table 5.6 Initial assessment of significance of impacts of the Project upon identified sensitive environmental receptors

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
Commonwealth receptors (EPBC Act listed migratory species)								
Commonwealth Significant Ecological Constraint (Species listed as migratory under the EPBC Act): ■ Common sandpiper (*Actitis hypoleucos*) ■ Fork-tailed swift (*Apus pacificus*) ■ Sharp-tailed sandpiper (Calidris acuminata) ■ Pectoral sandpiper (Calidris melanotos) ■ Red-necked stint (*Calidris ruficollis*) ■ Oriental cuckoo (*Cuculus optatus*) ■ Latham's snipe (Gallinago hardwickii) ■ Caspian tern (Hydroprogne caspia) ■ Black-faced monarch (*Monarcha melanopsis*)	High	Construction	■ Habitat loss from vegetation clearing/removal ■ Fauna species injury or mortality ■ Reduction in biological viability of soil to support plant growth due to soil compaction ■ Displacement of flora and fauna species from invasion of weed and pest species ■ Edge effects ■ Habitat fragmentation ■ Barrier effects ■ Noise, dust, and light impacts ■ Increase in litter (waste) ■ Aquatic habitat degradation ■ Tunnel construction	High	Major	■ Flora and fauna (detailed design, preconstruction and construction proposed mitigation measures) ■ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ■ Weeds and pests (pre-construction and construction and commissioning) ■ Erosion and sediment control (pre-construction and construction and commissioning) ■ Riparian vegetation and aquatic habitats (detailed design, construction and commissioning) ■ Landscape, rehabilitation and stabilisation (detailed design, pre-construction, construction and commissioning)	Moderate	High (refer to Section 5.3.3 for assessment against MNES Significant Impact guidelines for migratory species)

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
▪ Yellow wagtail (*Motacilla flava*) ▪ Satin flycatcher (*Myiagra cyanoleuca*) ▪ Osprey (Pandion haliaetus) ▪ Glossy ibis (Plegadis falcinellus) ▪ Pacific golden plover (*Pluvialis fulva*) ▪ Rufous fantail (Rhipidura rufifrons) ▪ Spectacled monarch (Symposiachrus trivirgatus) ▪ Common greenshank (*Tringa nebularia*) ▪ Marsh sandpiper (*Tringa stagnatilis*)		Commissioning and reinstatement	▪ Fauna species injury or mortality ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts ▪ Aquatic habitat degradation	Low	Moderate	▪ Flora and fauna (design, preconstruction and construction proposed mitigation measures) ▪ Weeds and pests (preconstruction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Fauna species injury or mortality ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts ▪ Aquatic habitat degradation	Low	Moderate	▪ Weeds and Pests (operations) ▪ Riparian vegetation and aquatic habitats (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State receptors								
State Significant Ecological Constraint (VM Act): ■ 'Endangered' remnant vegetation (REs) (Category B)	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 and fauna species from invasion of weed and pest species ■ Edge effects ■ Habitat fragmentation ■ Barrier effects ■ Increase in litter (waste)	High	Major	■ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ■ Weeds and pests (pre-construction and construction mitigation measures) ■ Erosion and sediment control (pre-construction and construction) ■ Riparian vegetation and aquatic habitats (construction)	Moderate	High (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	■ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	■ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ■ Weeds and pests (pre-construction and construction mitigation measures) ■ Erosion and sediment control (preconstruction and construction) ■ Riparian vegetation and aquatic habitats (construction) ■ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	■ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	■ Weeds and pests (operations) ■ Riparian vegetation and aquatic habitats (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ 'Of concern' remnant vegetation (REs) (Category B) ▪ Regulated vegetation within a defined distance to watercourses and wetlands Category B and C	Moderate	Construction	▪ Displacement of flora and fauna species from invasion of weed and pest species	High	High	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction)	Moderate	Moderate
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	▪ Weeds and pests (operations) ▪ Riparian vegetation and aquatic habitats (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ 'Least concern' remnant vegetation (REs) (Category B)	Low	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste)	Moderate	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction)	Low	Negligible
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Negligible	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Negligible	▪ Weeds and pests (operations) ▪ Riparian vegetation and aquatic habitats (operations)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ Remnant vegetation (REs) (Category B) associated with a mapped watercourse	Low	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste)	High	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction)	Moderate	Low
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Low	▪ Weeds and pests (operations) ▪ Riparian vegetation and aquatic habitats (operations)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Ecological Constraint (VM Act): ▪ High value regrowth (HVR) vegetation (Category C)	Moderate	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste) ▪ Aquatic habitat degradation	High	High	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction)	Moderate	Moderate (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Low	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Moderate	Moderate	▪ Weeds and Pests (operations) ▪ Riparian vegetation and aquatic habitats (operations)	Low	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (VM Act): ▪ MSES wildlife habitat ▪ Essential habitat	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 and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste) ▪ Tunnel construction	High	Major	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Fauna passage (design, construction)	Moderate	High (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Riparian vegetation and aquatic habitats (construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species;	Low	Moderate	▪ Weeds and pests (operations) ▪ Riparian vegetation and aquatic habitats (operations) ▪ Fauna fencing (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
Nature Conservation (Koala) Conservation Plan 2017 mapping, including: ▪ Koala Priority Areas ▪ Koala Habitat Areas ▪ Koala Habitat Restoration Areas ▪ Locally Refined Koala Habitat Areas	High	Construction	▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Habitat loss ▪ Barrier effects ▪ Fragmentation ▪ Noise, dust, and light impacts ▪ Tunnel construction	High	Major	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction)	Moderate	High (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts	Low	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts	Low	Moderate	▪ Weeds and pests (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Environmental Constraint (species listed as threatened under the NC Act): ■ Flora: – A sedge (*Cyperus clarus*) ■ Fauna: – Grey snake (*Hemiaspis damelii*)	High	Construction	■ Displacement of flora and fauna species from invasion of weed and pest species ■ Barrier effects ■ Noise, dust, and light impacts ■ Tunnel construction	Low	Moderate	■ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ■ Weeds and pests (pre-construction and construction mitigation measures) ■ Erosion and sediment control (pre-construction and construction)	Negligible	Low (refer to Section 5.3.4 for assessment against MSES Significant Impact guidelines)
		Commissioning and reinstatement	■ Displacement of flora and fauna species from invasion of weed and pest species ■ Noise, dust, and light impacts	Low	Moderate	■ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ■ Weeds and pests (pre-construction and construction mitigation measures) ■ Erosion and sediment control (pre-construction and construction) ■ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	■ Displacement of flora and fauna species from invasion of weed and pest species ■ Noise, dust, and light impacts	Low	Moderate	■ Weeds and pests (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Environmental Constraint (species listed as threatened under the NC Act): ■ Flora: – Bailey's cypress (*Callitris baileyi*) – Caustis (*Caustis blakei subsp. macrantha*) – Finger panic (*Digitaria porrecta*) ■ Fauna: – Glossy black-cockatoo (*Calyptorhynchus lathami*) – Powerful owl (*Ninox strenua*)	High	Construction	■ Habitat loss from vegetation clearing/removal ■ Fauna species injury or mortality ■ Reduction in biological viability of soil to support plant growth due to soil compaction ■ Displacement of flora and fauna species from invasion of weed and pest species ■ Edge effects ■ Habitat fragmentation ■ Barrier effects ■ Noise, dust, and light impacts ■ Increase in litter (waste) ■ Aquatic habitat degradation ■ Tunnel construction	High	Major	■ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ■ Weeds and pests (pre-construction and construction mitigation measures) ■ Erosion and sediment control (pre-construction and construction)	Moderate	High (refer to Section 5.3.4 for assessment against Si guidelines)
		Commissioning and reinstatement	■ Fauna species injury or mortality ■ Displacement of flora and fauna species from invasion of weed and pest species ■ Noise, dust, and light impacts	Low	Moderate	■ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ■ Weeds and pests (pre-construction and construction mitigation measures) ■ Erosion and sediment control (pre-construction and construction) ■ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	▪ Habitat loss from vegetation clearing/removal ▪ Fauna species injury or mortality ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Noise, dust, and light impacts ▪ Increase in litter (waste) ▪ Aquatic habitat degradation	Low	Moderate	▪ Weeds and pests (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Environmental Constraint (species listed as threatened under the NC Act): ▪ Flora: – *Marsdenia coronata* (Slender milkvine)	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 ▪ Habitat fragmentation ▪ Barrier effects ▪ Noise, dust, and light impacts ▪ Tunnel construction	Major	Major	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction)	High	Major (refer to Section 5.3.4 for assessment against SRI guidelines
		Commissioning and reinstatement	▪ Displacement of flora species from invasion of weed species ▪ Noise, dust, and light impacts	Low	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	▪ 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 ▪ Habitat fragmentation ▪ Barrier effects ▪ Noise, dust, and light impacts	Low	Moderate	▪ Weeds and pests (operations)	Negligible	Low
State significant Environmental constraint: ▪ 'Special least concern' fauna species: – Platypus (*Ornithorhynchus anatinus*) – Short-beaked echidna (*Tachyglossus aculeatus*)	Moderate	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Fauna species injury or mortality ▪ Displacement fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Noise, dust, and light impacts ▪ Increase in litter (waste) ▪ Aquatic habitat degradation ▪ Tunnel construction	High	High	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction)	Moderate	Moderate (refer to Section 5.3.4 for assessment against SRI guidelines)

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Commissioning and reinstatement	▪ Displacement of fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts	Low	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts	Low	Low	▪ Weeds and pests (operations)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint: ▪ Priority Back on Track flora and fauna species (that are not listed under as threatened under the provisions of the EPBC Act or NC Act)	Low	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Fauna species injury or mortality ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Noise, dust, and light impacts ▪ Increase in litter (waste) ▪ Aquatic habitat degradation ▪ Tunnel construction	High	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Aquatic fauna (design and construction) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Fauna passage (design and construction) ▪ Fauna fencing (design and construction)	Moderate	Low (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Negligible	Negligible	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	▪ Fauna species injury or mortality ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts ▪ Aquatic habitat degradation	Moderate	Low	▪ Weeds and pests (operation) ▪ Fauna fencing (operation)	Negligible	Negligible
State significant ecological constraint: ▪ Flora and fauna species not listed under the EPBC Act but listed as 'Least concern' under the provisions of the NC Act and flora that is listed as 'Special least concern' under the provisions of the NC Act	Low	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Fauna species injury or mortality ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Noise, dust, and light impacts ▪ Increase in litter (waste) ▪ Aquatic habitat degradation. ▪ Tunnel construction	High	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Aquatic fauna (design and construction) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Fauna passage (design and construction) ▪ Fauna fencing (design and construction)	Moderate	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Negligible	Negligible	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Negligible
		Operation	▪ Fauna species injury or mortality ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Noise, dust, and light impacts ▪ Aquatic habitat degradation	Moderate	Low	▪ Weeds and pests (operation) ▪ Fauna fencing (operation)	Negligible	Negligible

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ BPA habitat values for 'Endangered', 'Vulnerable' and 'Near threatened' taxa	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 and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste) ▪ Aquatic habitat degradation ▪ Tunnel construction	High	Major	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Fauna passage (design and construction) ▪ Fauna fencing (design and construction)	Moderate	High (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Weeds and pests (operation) ▪ Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ BPA habitat values for 'Endangered', 'Vulnerable' and 'Near threatened' taxa (regional)	Moderate	Construction	▪ (Habitat loss from vegetation clearing/removal ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste) ▪ Tunnel construction	Low	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Fauna passage (design and construction) ▪ Fauna fencing (design and construction)	Negligible	Low (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Weeds and pests (operation) ▪ Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State significant ecological constraint (BPA): ▪ State significant corridors	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 and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste) ▪ Aquatic habitat degradation ▪ Tunnel construction	Low	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Fauna passage (design and construction) ▪ Fauna fencing (design and construction)	Negligible	Low (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Moderate	▪ Weeds and pests (operation) ▪ Fauna fencing (operation)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
State Significant Ecological Constraint (BPA): ▪ Regional significant corridors	Moderate	Construction	▪ Habitat loss from vegetation clearing/removal ▪ Reduction in biological viability of soil to support plant growth due to soil compaction ▪ Displacement of flora and fauna species from invasion of weed and pest species ▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Increase in litter (waste) ▪ Tunnel construction	Low	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Fauna passage (design and construction) ▪ Fauna fencing (design and construction)	Negligible	Low (refer to Section 5.3.4 for assessment against SRI guidelines)
		Commissioning and reinstatement	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Flora and fauna (design, pre-construction and construction proposed mitigation measures) ▪ Weeds and pests (pre-construction and construction mitigation measures) ▪ Erosion and sediment control (pre-construction and construction) ▪ Landscape, rehabilitation and stabilisation (design, pre-construction, construction)	Negligible	Low

Sensitive environmental receptor(s)	Sensitivity[1]	Phase	Potential impacts [2]	Initial significance (application of initial mitigation measures presented in Section 5.2.1)		Application of proposed mitigation measures presented in Table 5.2, by "Environmental value impacted" and "Delivery phase"	Residual significance following the application of Project mitigation measures presented in Table 5.2[3]	
				Magnitude[1]	Significance		Magnitude	Significance[4]
		Operation	▪ Displacement of flora and fauna species from invasion of weed and pest species	Low	Low	▪ Weeds and pests (operation) ▪ Fauna fencing (operation)	Negligible	Low

Table notes:

1 Refer to Section 3.5.1 and Section 3.5.2 for the assessment methodology for 'sensitivity' and 'magnitude' criteria.

2 Potential impacts to Sensitive environmental receptors identified in the table above, are based upon those presented in Section 5.1.2

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.

4 In instances where the mitigated significance returns a rating of High or above, offsets may be an option to reduce the residual ecological impacts in the long term. Offset for biodiversity values are discussed further in Section 5.4.

5.3.3 Significant residual impact assessment for migratory species

This section assesses the potential for significant residual impacts from the Project upon migratory species, which are not threatened under the EPBC Act, using the relevant criteria outlined in the MNES Significant Impact Guideline. In accordance with the MNES Guideline (DEWHA 2013), the Project is likely to have a significant impact upon a migratory species if there is a possibility that it will:

- Substantially modify, destroy or isolate an area of important habitat for a migratory species
- Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species
- Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species.

An area of important habitat for a migratory species is:

- Habitat utilised by a migratory species within a region that supports an ecologically significant proportion of the population of the species
- Habitat that is of critical importance to the species at particular life-cycle stages
- Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species.

It should be noted that the migratory species relevant to the Project are also listed as SLC under the NC Act, however there are no significant residual impact guidelines applicable to migratory species.

The following sections assess the potential for significant residual impact on the migratory species identified as potentially occurring within the Project disturbance footprint using the criteria set out in the MNES Guideline.

As outlined in Section 4.2.2.2, there are 18 migratory species relevant to the ecology study area (i.e. that are identified in desktop searches, have predicted habitat within the ecology study area, and are not listed as threatened under the EPBC Act).

The ecology, life history and distribution of these species are presented in Appendix B and summarised in Section 5.3.3.1 (aerial migrants), Section 5.3.3.2 (marine migrants), Section 5.3.3.3 (woodland migrants) and Section 5.3.3.4 (wetland migrants). Relevant Commonwealth documents applicable to each species including threat abatement plans, approved conservation advice, and recovery plans are summarised in Appendix B.

The assessment of significant impacts on the identified migratory species from the Project is based on:

- Current knowledge of the species, including local populations, specimen records and habitat requirements (refer Appendix B and Sections 5.3.3.1, 5.3.3.2, 5.3.3.3 and 5.3.3.4)
- Predictive habitat modelling for each species (refer Appendix G) based on the habitat assumptions associated with each species (refer Appendix A), along with the findings of ecological surveys. Where 'suitable habitat' is referred to in the following assessments it refers to the predicted habitat area output of the habitat modelling as specific to the species addressed.
- The current understanding and layout of the Project (refer Section 1.1)
- Information on potential impacts of Project during construction and operation (refer Section 5.1.2)
- Proposed Project mitigation measures (refer Table 5.2).

A summary of the findings of the significant residual impact assessment for migratory species is provided in Table 5.7.

Table 5.7 Summary of the results of the significant impact assessment for migratory species

Migratory species	Status		Results of assessment	Table containing assessment against MNES Guidelines
	EPBC Act	NC Act		
Aerial migrants (refer Section 5.3.3.1 for more details)				
Fork-tailed swift (*Apus pacificus*)	M	SLC	No significant impact likely	Table 5.8
Marine migrants (refer Section 5.3.3.2 for more details)				
Common sandpiper (*Actitis hypoleucos*)	M	SLC	No significant impact likely	Table 5.9
Sharp-tailed sandpiper (*Calidris acuminata*)	M	SLC	No significant impact likely	Table 5.9
Pectoral sandpiper (*Calidris melanotos*)	M	SLC	No significant impact likely	Table 5.9
Red-necked stint (*Calidris ruficollis*)	M	SLC	No significant impact likely	Table 5.9
Latham's snipe (*Gallinago hardwickii*)	M	SLC	No significant impact likely	Table 5.9
Caspian tern (*Hydroprogne caspia*)	M	SLC	No significant impact likely	Table 5.9
Pacific golden plover (*Pluvialis fulva*)	M	SLC	No significant impact likely	Table 5.9
Common greenshank (*Tringa nebularia*)	M	SLC	No significant impact likely	Table 5.9
Marsh sandpiper (*Tringa stagnatilis*)	M	SLC	No significant impact likely	Table 5.9
Woodland migrants (refer Section 5.3.3.3 for more details)				
Rufous fantail (*Rhipidura rufifrons*)	M	SLC	No significant impact likely	Table 5.10
Oriental cuckoo (*Cuculus optatus*)	M	SLC	No significant impact likely	Table 5.10
Spectacled monarch (*Symposiachrus trivirgatus*)	M	SLC	No significant impact likely	Table 5.10
Black-faced monarch (*Monarcha melanopsis*)	M	SLC	No significant impact likely	Table 5.10
Satin flycatcher (*Myiagra cyanoleuca*)	M	SLC	No significant impact likely	Table 5.10
Wetland migrants (refer Section 5.3.3.4 for more details)				
Yellow wagtail (*Motacilla flava*)	M	SLC	No significant impact likely	Table 5.11
Eastern osprey (*Pandion haliaetus*)	M	SLC	No significant impact likely	Table 5.11
Glossy ibis (*Plegadis falcinellus*)	M	SLC	No significant impact likely	Table 5.11

Table notes:
M = migratory SLC = Special least concern

5.3.3.1 Aerial migrants

This section provides a summary of information related to the aerial migratory species that have potential to occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species.

Fork-tailed swift (*Apus pacificus*)

Fork-tailed swift is an aerial, insectivorous bird that weighs 30-40 grams (g). The species breeds in Siberia and migrates to Australia, arriving during October-September. The species feeds aerially on flying insects and possibly also roosts aerially. The species forages over all terrestrial habitats, and is most commonly observed over open habitats, such as woodlands and marshes. The species is less common over forest and rainforest (DAWE 2020c).

There are no significant threats to the species in Australia (DAWE 2020c). Habitat loss and predation by feral animals are potential threats, although the threat is thought to be negligible due to the wide range of the species (BirdLife International 2020).

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers a wide range of habitats important for this species, from inland open plains to wooded areas, where it is exclusively aerial. The threshold for an ecologically significant proportion of a population (individuals) is 1,000 individuals internationally and 100 individuals nationally. No area threshold can be determined for this species. The proportion likely to result in a significant impact if affected is 1,000 internationally and 100 nationally (DAWE 2020c).

The species was not recorded from the field investigations. However, this species has been record from within the ecology study area with a record from 2003 to the south of the Toowoomba Waste Management Centre approximately 120 m from the Project disturbance footprint and a second dated 2013 east of the Withcott Seedling Farm approximately 15 m from the Project disturbance footprint. Most records within a 50 km buffer of the Project disturbance footprint occur to the south of the alignment at the Toowoomba Range and north to Crows Nest. Other records exist near Oakey, Pittsworth and from Toowoomba to Marburg. Most records for this species occur closer to the coast as records are denser along the eastern seaboard of Australia (AoLA dataset).

Given this is an aerial species and does not breed in Australia, habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 427.35 ha of habitat (i.e. 226.16 ha of potential habitat and 201.19 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). Whilst this is a large area the predicted habitat estimates are conservative and are likely a vast overestimation. Furthermore, there will be large areas surrounding the Project left undisturbed and the thresholds outlined in the guidelines are not expected to be exceeded.

Assessment against the significant impact criteria for Fork-tailed swift is shown in Table 5.8.

Table 5.8 Assessment against the significant impact criteria: Aerial migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	The Project will impact areas of open floodplain and woodland that are suitable habitat for the species. This area is considered to constitute important habitat for the species, however the area of habitat in which this species is predicted to occur is likely a vast overestimation. As such it is not likely that the Project will substantially modify destroy or isolate important habitat. The Project is linear, and the species is aerial and there will be a vast amount of habitat available for this species that will be left undisturbed in the surrounding landscape.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Project is unlikely to result in the establishment of invasive species that are harmful to the Fork-tailed swift, noting that invasive species pose a negligible risk to the 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 feral predators (i.e. cats and foxes), along with invasive flora species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders.
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	The species breeds in Siberia. When over-wintering in Australia the species feeds aerially and possible also roosts aerially. It is considered unlikely that the Project will result in a disruption of the species' lifecycle.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on aerial migrants (Fork-tailed swift) will result from the Project

5.3.3.2 Marine migrants

This section provides a summary of information related each of the marine migratory species that have potential of occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species. Noting that none of these species were identified during the field investigations which may in part be due to the dry conditions prior and during the surveys but also limited presence of suitable habitat within the Project footprint.

Common sandpiper (*Calidris acuminata*)

Sharp-tailed sandpiper is a medium-sized summer migratory wader, typically 20 cm in length. This species does not breed in Australia. This species breeds in Siberia from June to August and then migrates south to Australia. They are most common around coastal environments but are also sparsely scattered around inland wetlands such as lakes, dams, claypans, sewage works and inundated vegetation.

Important habitat nationally and internationally for migratory shorebirds birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment* (DotE 2015b). Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). No important habitat has been identified. Threats identified include loss or degradation of habitat, disturbance and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

The species was not recorded from the field investigations; however the species has been recorded (1991) from a wetland (Hoods Dam) 500 m to the north east of the eastern extent of the Project (AoLA dataset). This artificial dam has been known to support a number of wetland bird species though this is dependent on presence of water. A number of other records are located within a 50 km buffer of the Project disturbance footprint. Most are located in the area between Gatton and Atkinsons Lagoon.

It is unlikely that habitat associated with the Project disturbance footprint is likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. The Project is not at the limit of this species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29), However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant impact on this species.

Assessment against the significant impact criteria for Common sandpiper is shown in Table 5.9.

Sharp-tailed sandpiper (*Calidris acuminata*)

Sharp-tailed sandpiper is a medium-sized summer migratory wader, typically 20 cm in length. This species does not breed in Australia. This species breeds in Siberia from June to August and then migrates south to Australia. They are most common around coastal environments but are also sparsely scattered around inland wetlands such as lakes, dams, claypans, sewage works and inundated vegetation (DAWE 2020c) .

Important habitat nationally and internationally for migratory shorebirds birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment* (DotE 2015b). Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). No important habitat has been identified. Threats identified include loss or degradation of habitat, disturbance and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

The species was not recorded from the field investigations, though the species has been recorded (1991 to 1993) from a wetland (Hoods Dam) 500 m to the north east of the eastern extent of the Project. This artificial dam has been known to support a number of wetland bird species though this is dependent on presence of water. A number of other records exist within a 50 km buffer of the Project disturbance footprint in multiple directions. Most are concentrated to the east in the area between Gatton and Atkinsons Lagoon, followed by to the east in the surrounds of Laidley.

It is unlikely that habitat associated with the Project disturbance footprint is likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. The Project is not at the limit of this species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29), However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is highly unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Sharp-tailed sandpiper is shown in Table 5.9.

Pectoral sandpiper (*Calidris melanotos*)

Pectoral sandpiper is a medium-sized migratory wader, ranging from 19 to 24 cm in length with a wingspan of 37 to 45 cm. Males of the species are generally heavier at 85 g whilst females eight around 60 g. Their flat back and plumpish body that tapers to a drawn-out rear is characteristic of the species (Higgins and Davies 1996). As an omnivore this species consumes a varied diet of algae, seeds, and invertebrates. They forage in grass-fringed waters moving slowly as they probe for food. This species does not breed in Australia, typically they breed in northern Russia and North America. Pectoral sandpiper occurs in Australia from September to June (Higgins and Davies 1996). Where the species occurs in Australia, they occupy the shallow waters of coastal habitats associated with saline wetlands and freshwater wetlands from the coast to inland systems. Foraging in these different types of habitat occurs in shallow water or soft mud at the edge of wetlands (Higgins and Davies 1996).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). No important habitat has been identified for this species. In Australia threats to the species are associated with habitat loss and degradation, particularly where juveniles stay in Australia year-round; disturbance from recreational activities where the species roosts and forages; and direct mortality as a result of human impacts include wind farms around migratory pathways, bird strike from aircraft and pollution from chemical or oil spills.

This species was not recorded from the field investigations and there are no Pectoral sandpiper records exist within the ecology study area. The closest record is located approximately 16 km north-west of the Project disturbance footprint at Oakey Army Aviation Centre and is not dated. The next closest record is located approximately 17 km north-west of the alignment at Oakey and is dated 1979. A number of other records exist within a 50 km buffer of the Project disturbance footprint. Most are located in the area between Gatton and Lake Clarendon, followed by at Lowood.

Given this is predominantly a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population or is at the limit of the species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). However, , there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. Given the species breeds outside of Australia there is no habitat associated with the Project that is considered important breeding habitat for the species. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is highly unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Pectoral sandpiper is shown in Table 5.9.

Red-necked stint (*Calidris ruficollis*)

The Red-necked stint is the smallest shorebird in Australia (Geering et al. 2007) measuring 13 to 16 cm in length, weighing 25 g and a wingspan of 29 to 33 cm. This species has a varied diet consisting of plant seeds and a range of invertebrates including molluscs, marine worms, gastropods, shrimp, spiders, beetles, flies and ants. The species does not breed in Australia. Breeding grounds are in Siberia and west Alaska, migration to Australia occurs sometimes in July but usually between August and early September. Most adult birds arrive before the end of September and juveniles begin to arrive late September or early October with most arriving by early November. In general Red-necked stints return to their breeding grounds across Australia from late March with most leaving in April (Higgins & Davies 1996). In Australia the species is predominantly associated with coastal areas including inlets, bays, lagoons, estuaries with intertidal mudflats, spits, inlets, banks, and occasionally protected sandy shores. They will occasionally occupy beaches, rocky shores, reefs or shoals along with artificial/modified habitat such as sewage farms and agricultural land that gets flooded (Higgins & Davies 1996). The species will often roost in habitat that provides sufficient shelter but will also roost on exposed reef, open beaches, amongst beach cast seaweed, mud and even dried cow-pats (Hobbs 1961).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). No important habitat has been identified for this species. In Australia threats to Red-necked stint includes the loss of important habitat which results in reduced availability of foraging and roosting sites. In order to migrate successfully migratory species must build up the required stores of energy needed to travel such distances; disturbance impacts their ability to do so. In Australia juveniles remain at sites considered important for the species year-round until they reach maturity. Habitat can be impacted directly as a result of land clearing, inundation, infilling or draining. Indirect impacts or loss of suitable habitat result from poor water quality and changes to hydrology along with changes to habitat structure at roosting sites (DEWHA 2010).

This species was not recorded from the field investigations and there are no Red-necked stint records exist within the ecology study area. The closest record is located approximately 15 km north of the Project disturbance footprint at Cooby Creek Reservoir and is dated 2018. The next closest record is located approximately 18 km to the east near Gatton and is not dated. A number of records exist within a 50 km buffer of the Project disturbance footprint in multiple directions. Most are concentrated to the east in the surrounds of Atkinsons Dam, followed by the surrounds of Gatton and Laidley.

Given this is predominantly a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population or is at the limit of the species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. Given the species breeds outside of Australia there is no habitat associated with the Project that is considered important breeding habitat for the species. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is highly unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Red-necked stint is shown in Table 5.9.

Latham's snipe (*Gallinago hardwickii*)

Latham's snipe is an omnivorous medium-sized migratory wader, typically 30 cm in length. It feeds on plant material, seeds, molluscs, crustaceans, arachnids and insects. The species does not breed in Australia. This species breeds in Japan and far eastern Russia, and then migrates to Australia during the northern hemisphere winter (between August and January). They inhabit wetlands such as swamps, creek or river margins, lakes, dams, claypans, sewage works and inundated vegetation/floodplains. They prefer areas that include some form of shelter or cover (low/dense vegetation). Latham's Snipe has also been recorded near artificial habitats such as airfields, ploughed paddocks, irrigation channels, dairy farms and drainage ditches. Their roosting habitats include dense vegetation near foraging habitats. They could also potentially occur in Bluegrass *Dichanthium* dominant grasslands in the Brigalow Belt Bioregion (DAWE 2020c).

Important habitat nationally and internationally for migratory shorebirds birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat supporting Latham's snipe is treated differently to other migratory wader species due to its different habits and habitat use (it generally occurs solitarily on wetlands rather than coastal habitats and may occurs on inland habitats). Important habit for this species is described as areas that have previously been identified as internationally important for the species, or areas that support at least 18 individuals of the species (DotE 2015b). No important habitat has been identified within the ecology study area. Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

The species was not recorded from the field investigations, though the species has been recorded (1990 and 1991) from a wetland (Hoods Dam) 500 m to the north east of the eastern extent of the Project. This artificial dam has been known to support a number of wetland bird species though this is dependent on presence of water.

The species has also been recorded from an area approximately 1 km north of the Project disturbance footprint near Gowrie Junction and is not dated. The next closest record is located approximately 1.5 km south of the Project disturbance footprint near Helidon and is dated 2015. A number of other records exist within a 50 km buffer of the Project disturbance footprint in all directions. Most are concentrated in the surrounds of Gatton, followed by at Seven Mile Lagoon and Atkinsons Lagoon.

While the species is likely to occur occasionally on wetlands (including vegetated farm dams) habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population (i.e.18 individuals), hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29)), However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Latham's snipe is shown in Table 5.9.

Caspian tern (*Hydroprogne caspia*)

The Caspian tern (*Hydroprogne caspia*) is the largest tern species within Australia possessing long, slender wings and a tail that is slightly forked. The species feeds predominantly on small to medium sized fish 5 to 25 cm in length. They will also feed opportunistically on the eggs and young of other birds, carrion and a range of terrestrial and aquatic invertebrates. They typically forage during the morning patrolling up to 15 m above the water shallow plunging from a hover when prey is spotted becoming fully submerged when doing so. Prey is eaten during flight (Higgins and Davies 1996). The species is thought to travel up to 60 km from nesting sites foraging for food (Birdlife International 2010). They can be found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It is found around large mudflats, saltmarsh, mangroves and seagrass. Habitats include embayments, harbours, river estuaries, deltas, lagoons, tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and salt flats. It will also use artificial wetlands including sewage farms, saltworks and dams. Offshore the species will stay close to islands that provide shelter and rarely venture beyond the reef (Higgins and Davies 1996).

Important habitat nationally and internationally for migratory shorebirds birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. No important habitat has been identified within the ecology study area. Threats identified include loss or degradation of habitat, chick predation by silver gulls, cats and wild dogs, disturbance from humans and livestock at breeding sites, entanglement in discarded fishing equipment, avian disease, toxic bioaccumulation, severe weather and changing climatic conditions (Birdlife International 2010; O'Neill and Channels 1997; Minton and Deleyev 2001; del Hoyo et al. 1996).

This species was not recorded from the field investigations, though there are two Caspian tern records occur at the eastern end of the ecology study area. The species has been recorded from Hoods Dam (1991 and 2012) at the Lockyer Valley. The second record is from 2013 and detailed to have occurred at Lockyer Creek during tropical cyclone Oswald (refer Appendix B). The next nearest record within a 50 km buffer of the Project disturbance footprint occurs at Gatton approximately 15 km east of the Project. The record is from 2012 located at a small water body in the outskirts of the Gatton township to the west of the Gatton Racecourse. Further records occur with the Gatton township whilst other records from within a 50 km buffer of the Project disturbance footprint occur from Gatton to Laidley and north to Atkinsons Lagoon to the east of the Project. Several sparse records occur to the west, north-west and north of the Project.

While the species is likely to occur occasionally at habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 13.25 ha of potential habitat in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29), However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Caspian tern is shown in Table 5.9.

Pacific golden plover (*Pluvialis fulva*)

The Pacific golden plover is a medium sized upright wader. The species breeds in Arctic tundra in northern hemisphere summer and migrates to the southern hemisphere in winter. It is estimated that 4 per cent (approximately 9,000) of the world's population of Pacific golden plover occur in Australia, present between September and May. This species inhabits coastal areas, feeding on sandy or muddy shores. They roost on sandy beaches, rocky points or exposed reefs. Moreton Bay Ramsar listed areas are considered to be important habitat within Australia (DAWE 2020b).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). No important habitat has been identified for this species. Habitat loss, over-tourism and strikes from aircraft in airfields are potential threats to the species (DAWE 2020c). Whilst not specific to the Pacific golden plover, predation by invasive species such as fox and cats is also a threatening process (DotE 2015b). Introduction of exotic tall grass species could also reduce the habitat of this species. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion).

The species was not recorded from field investigations and there are no Pacific golden plover records do not exist from within the Project disturbance footprint or from within the ecology study area. No records for this species occur within the Project disturbance footprint or the ecology study area. Records occur between Gatton and Atkinsons Lagoon including recent (2018). Several records exist from Cooby Creek Reservoir from 2018 approximately 13 km from the Project disturbance footprint. Whilst database records exist inland for this species, most occur along the eastern coastline.

Habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29), However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is highly unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Pacific golden plover is shown in Table 5.9.

Common greenshank (*Tringa nebularia*)

Common greenshank is a large migratory wader, typically 30-35 cm in length. This species generally feeds on molluscs, crustaceans, insects, and occasionally fish and frogs (DAWE 2020c). Common greenshank breeds in Palaearctic region (Birdlife 2019). It then migrates through the East Asian-Australasian Flyway to Western Australia and north around the Torres strait around November. This species does not breed in Australia. They are found in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. When inland they inhabit swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and salt flats (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion) (DEH 2005).

The species was not identified from the field investigations, thought it has been recorded (1991) from a wetland 500 m to the north east of the eastern extent of the Project. This artificial dam has been known to support a number of wetland bird species though this is dependent on presence of water.

The closest record is located approximately 15 km north-west of the Project disturbance footprint at Oakey Army Aviation Centre and is not dated. The next closest record is located approximately 18 km north-west of the alignment near Oakey and is dated 2000. A number of other records are located within a 50 km buffer of the Project disturbance footprint to the north and east of the alignment. Most are concentrated at Seven Mile Lagoon, Atkinsons Lagoon, Gatton and Laidley.

Given this is a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Common greenshank is shown in Table 5.9.

Marsh sandpiper (Tringa *stagnatilis*)

Marsh sandpiper is a medium-sized migratory wader, typically 22-26 cm in length. This species generally feeds on molluscs, crustaceans, insects, and occasionally fish (DAWE 2020c). Marsh sandpiper breeds in Palaearctic and subarctic North America, Europe and Russia. It then migrates through the East Asian-Australasian Flyway to Western Australia and north around the Torres strait around November. This species does not breed in Australia. They are found in permanent or ephemeral wetlands, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains, and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes (DAWE 2020c).

Important habitat nationally and internationally for migratory birds has been described in the *Wildlife Conservation Plan for Migratory Shorebirds – Department of the Environment*. Habitat of international importance is considered as an area of suitable habitat that has the capacity to regularly support 1 per cent of individuals in a population of one species or sub-species of waterbird or a total of 20,000 individual waterbirds. Habitat of national importance is considered similarly in that habitat can regularly support 0.1 per cent of the flyaway population of a single species or 2,000 individual shorebirds or 15 species of migratory shorebirds (DotE 2015b). Threats identified include loss or degradation of habitat, vehicle strikes and pollution. Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion). Migratory waders in general can be threatened by the increase in invasive species by either predation (feral cats, dogs and foxes), or habitat degradation (carp, weed incursion) (DEH 2005).

This species was not recorded from the field investigations and there are no Marsh sandpiper records occur within the Project disturbance footprint. The species has been recorded (1991 to 1993) from a wetland 500 m to the north east of the eastern extent of the Project (i.e. Hoods Dam). This artificial dam has been known to support a number of wetland bird species though this is dependent on presence of water. Other records from within a 50 km buffer of the Project disturbance footprint occur at Highfields, Oakey, Cooby Creek Reservoir, and between Gatton, Laidley and Atkinsons Lagoon. Records for this species occur along the coast and extensively across inland Australia.

Given this is a coastal species habitat associated with the Project disturbance footprint is not likely to support an ecologically significant proportion of a population, hold critical importance for breeding or is at the limit of the species range. There is an estimated 65.75 ha of habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). However, there are few wetlands present in the Project footprint with the main wetland habitat being a dam to the north east of the eastern extent of the Project. The Project is not at the limit of this species range. A review of the literature has not identified an area of habitat in which the species is declining associated with the Project. Therefore, the Project is unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Marsh sandpiper is shown in Table 5.9.

Table 5.9 Assessment against the significant impact criteria: Marine migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	A total of 56.85 ha of important habitat has been mapped within the Project disturbance footprint for these marine migrants through the predictive habitat modelling (refer Table 4.29). This value equates to 8.23% of the available modelled important habitat for these species within the ecology study area (refer Table 5.3). The majority of this habitat is associated with riverine wetlands and watercourses, while lacustrine and palustrine wetlands within and directly downstream of the Project disturbance footprint are limited (refer Section 4.2.8). Despite this figure, the majority of important habitat for these marine migrants occurs in coastal environments. Therefore, the proposed work is not likely to substantially modify, destroy or isolate important habitat for the marine migrants.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Project is unlikely to result in the establishment of invasive species that are harmful to marine migrant species, with a number of the species already established in the area. However, there is a risk that the Project results in new infestations or the proliferation of existing invasive 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 feral predators (i.e. cats and foxes), along with invasive aquatic species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders..
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	The marine migrants described in this assessment do not breed in Australia. When over-wintering in Australia the large proportion of the respective populations occur in coastal regions and may only use inland wetlands as stop overs on their migratory journey. Disturbance as a result of the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of marine migrant species.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on marine migrants will result from the Project.

5.3.3.3 Woodland migrants

This section provides a summary of information related each of the five woodland migratory species that have potential of occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species.

Oriental cuckoo (*Cuculus optatus*)

The Oriental cuckoo does not breed in Australia, it migrates to from north-east Asia during its non-breeding season which occurs from September to May (DAWE 2020c). During the northern hemisphere autumn, the species migrates south to Indonesia, New Guinea and northern Australia. Whilst some individuals remain in Australia through winter most return north in autumn (Morcombe 2003). This species utilises habitat associated with the coastal regions of northern and eastern Australia including offshore islands. This species primarily utilises a variety of habitat including monsoon rainforest, wet sclerophyll forest and open woodlands (DAWE 2020c) however, will also occupy vine scrub, riverine thicket, paperbark swamps and mangroves (Morcombe 2003).

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat as any non-breeding habitat that this species occupies including monsoonal rainforest, vine thicket, wet sclerophyll forest or open Acacia, Casuarina or Eucalypt wooded areas. The threshold for an ecologically significant proportion of a population (individuals) is 10,000 internationally and 1,000 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 250,000 ha internationally and 25,000 ha nationally. The proportion likely to result in a significant impact if affected is 10,000 ha internationally and 1,000 ha nationally (DAWE 2020c).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). A review of the available literature does not reveal any impacts from invasive species on the Oriental cuckoo.

The species was not recorded from the field investigations and there are no Oriental cuckoo records from within the Project disturbance footprint or the ecology study area. The closest record is located approximately 1.5 km south of the Project disturbance footprint near Helidon and is dated 2014. The next closest record is located approximately 2 km south-east of the alignment at Helidon and is dated 2014. A number of other records exist within a 50 km buffer of the Project disturbance footprint. Most are concentrated in the surrounds of Pittsworth and at the western section of the Lockyer Reserves.

There is an estimated 3.46 ha of habitat (i.e. 1.93 ha of potential habitat and 1.53 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint(refer Table 4.29). This species is associated with coastal habitat in northern and eastern Australia, this is evident by a large density of specimen backed records closer to the coast and a lack of records inland. The Project is unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Oriental cuckoo is shown in Table 5.10.

Black-faced monarch (*Monarcha melanopsis*)

The Black-faced monarch migrates between Australia and New Guinea. During the summer breeding months this species is found along the eastern coastal region of Australia, during winter the species retreats to the north overwintering in New Guinea. Rather than making the full migration north to New Guinea a portion of the population remains in northern Australia during winter usually consisting of younger birds (DAWE 2020c). This species utilises rainforest as breeding habitat selecting trees with large leaves as nesting sites where they construct a nest at the top of the tree, in smaller saplings or in low shrubs. The species is known to breed from the Atherton region of QLD's wet tropics, SEQ and near Lake Entrance in south-east Victoria (DAWE 2020c). Breeding generally occurs between October and March although there is regional variation across the species' range. Eggs hatch between 13 and 15 days with fledging occurring seven days or more later. Fledgling success appears to be poor for this species with an estimated 0.1 fledged young per nest per breeding event (BA NRS 2002).

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat to be wet sclerophyll forest in sheltered gullies with dense understorey consisting of ferns and shrubs. The threshold for an ecologically significant proportion of a population (individuals) is 4,600 internationally and 460 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 2,600 ha internationally and 260 ha nationally. The proportion likely to result in a significant impact if affected is 465 (individuals) internationally and 47 nationally (DAWE 2020c).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). Threats to this species include collision with windows (Taplin 1991) and lighthouses (Makin 1961). Invasive species that have the potential to impact the Black-faced monarch includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (DAWE 2020c).

This species was not recorded from field investigations, though database records indicate the occurrence of Black-faced monarch within the Project disturbance footprint. The record is located near Gowrie Junction however is not dated; a lack of date does not make this record unreliable. Another record is located within the ecology study area approximately 500 m north of the alignment near Gowrie Junction and is dated 1999. The next closest record is located approximately 1 km south of the Project disturbance footprint, north of Prince Henry Heights, and is dated 1998. A number of other records exist within a 50 km buffer of the Project disturbance footprint in all directions of the alignment. Most are concentrated to the north-east near Ravensbourne National Park and to the south of Toowoomba. Broadly speaking this species is recorded predominantly in forested areas consisting of national parks and nature reserves along the eastern seaboard of Australia.

There is an estimated 67.59 ha of habitat (i.e. 66.06 ha of potential habitat and 1.53 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The Project is unlikely to have a significant residual impact on this species.

Assessment against the significant impact criteria for Black-faced monarch is shown in Table 5.10.

Satin flycatcher (Myiagra *cyanoleuca*)

Satin flycatchers tree species including paperbarks, eucalypts and banksias for nest building constructing nests in the outer branches (Gilbert 1935, (BA NRS 2002). The species lays three or four eggs in a clutch with both sexes incubating the eggs for short durations over a period of 17 days (BA NRS 2002). Breeding occurs between November and January where the species occurs above 600 m above sea level in south-eastern Australia (Frith 1969). This varies slightly at lower elevations and different regions in Australia. Satin flycatchers will occupy eucalypt forests with an open understorey or with a grass as ground cover, they are not associated with rainforest (DAWE 2020c).

This species generally occupies eucalypt forest that occurs near wetlands or waterways. Compared to other flycatcher species they tend to occupy forests that are taller and wetter frequently in gullies (DAWE 2020c). The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat as essential habitat during breeding which includes high elevation eucalypt forest and woodland whilst common habitat includes tall wet sclerophyll forest associated with gullies or waterways and open grassy woodlands. Migratory habitat is more general whilst wintering habitat includes rainforest, mangroves and paperbark swamps. The threshold for an ecologically significant proportion of a population (individuals) is 17,000 internationally and 1,700 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 4,400 ha internationally and 440 ha nationally. The proportion likely to result in a significant impact if affected is 1,700 (individuals) internationally and 170 nationally (DAWE 2020c).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). Nest parasitism from cuckoo species could be considered as a threat to the species (Brooker & Brooker 1989). The main threats to this species result from land clearing and logging of mature forest in Australia's south-east (Blakers et al. 1984). Invasive species that have the potential to impact the Satin flycatcher includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (DAWE 2020c).

Satin flycatcher was observed in the ecology study area during field investigations for the Project at G2H site T17 (refer Section 4.2.2.1 and Figure 4.19). The next nearest records occur approximately 1.5 km south of the Project disturbance footprint to the east of Toowoomba with four records at this located dated between 2000 and 2001. Other records within a 50 km buffer of the Project disturbance footprint occur throughout the Toowoomba Range, Lockyer Reserves, Crows Nest, Pittsworth and Oakey. Records are largely confined to forested reserves and national parks.

There is an estimated 3.46 ha of habitat (i.e. 1.93 ha of potential habitat and 1.53 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The loss of habitat as a result of the Project is below the threshold and as such a significant residual impact is unlikely.

Assessment against the significant impact criteria for Satin flycatcher is shown in Table 5.10.

Spectacled monarch (*Symposiachrus trivirgatus*)

Breeding for Spectacled monarch typically occurs between September and April nesting in the vertical fork of a tree sampling or shrub located near a water body or watercourse. Two eggs are typically laid with the female undertaking most of the incubation. The incubation period is typically between 15 and 18 days. Both parents feed young until a few days after fledging which occurs 17 to 20 days after the young hatch (DAWE 2020c).

The Spectacled monarch typically occupies rainforests, mangroves and wet gullies associated with dense wet eucalypt forests (Morcombe 2003). Other densely vegetated habitats are utilised by this species including mangroves, drier forest and woodlands (DAWE 2020c).

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat as dense vegetation consisting mostly of rainforest, moist forest or wet sclerophyll forest along with mangroves, drier forest and woodlands that provide dense vegetation. The threshold for an ecologically significant proportion of a population (individuals) is 6,500 internationally and 650 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 2,100 ha internationally and 210 ha nationally. The proportion likely to result in a significant impact if affected is 650 (individuals) internationally and 65 nationally (DAWE 2020c).

Threats to this species includes the substantial loss or modification of important habitat, the construction of tall or large structures (e.g. buildings, wind turbines, over-head powerlines, etc.) or actions that would cause a serious disruption to an ecologically significant proportion of a population (DAWE 2020c). Invasive species that have the potential to impact the Spectacled monarch includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (DAWE 2020c).

Spectacled monarch was observed in the ecology study area during field investigations for the project at G2H site T17 (refer Section 4.2.2.1 and Figure 4.19). The next closest record is located approximately 3 km south of the Project disturbance footprint near Prince Henry Heights and is dated 2006. The next closest record is located approximately 3.5 km south of the alignment, also near Prince Henry Heights, and is dated 2014. A number of other records exist within a 50 km buffer of the Project disturbance footprint. Most are concentrated south of the alignment in the surrounds of Prince Henry Heights and to the north-east in Ravensbourne National Park. Generally, records for this species occur within forested reserves and national parks. The majority of records exist to the east between Ipswich, Brisbane and the Gold Coast Hinterland.

There is an estimated 3.46 ha of habitat (i.e. 1.93 ha of potential habitat and 1.53 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). The loss of habitat as a result of the Project is below the threshold and as such a significant residual impact is unlikely.

Assessment against the significant impact criteria for Spectacled monarch is shown in Table 5.10.

Rufous fantail (*Rhipidura rufifrons*)

Rufous fantails typically breed from September to February with the majority of eggs laid between November and December. Breeding occurs slightly later at higher elevations with two to four eggs typically laid in a small nest that forms a cup-shape. Nesting material consists of a variety of plant material, moss and spider web (Higgins et. al 2006). Nests are constructed in trees, shrubs or vines between 34 cm and six metres from the ground and are typically placed 1.6 m high (Higgins et. al 2006). It is suggested that trees with big leaves are selected as to hide the nest (Huggett 2000). Both male and female will share incubation of the eggs, if the first nesting attempt is unsuccessful the pair will re-lay a second clutch (Higgins et. al 2006). Incubation takes between 5 and 17 days (Huggett 2000).

Where Rufous fantails are found in east and south-east Australia, they are associated with primarily wet sclerophyll forest, typically in gullies with a dense understorey of ferns. The species also occurs in sub-tropical to temperate regions where rainforest exists. Rufous fantails appear to have a tolerance for secondary forest. Whilst migrating they will stopover in drier sclerophyll forest and woodland ecosystems that have a shrubby, heath like understorey. In the north and north-east of their distribution they are known to occupy tropical rainforest, monsoonal rainforest and various type of vine thicket (Higgins et. al 2006).

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat as moist habitat with dense vegetation, across mangrove, rainforest, riparian forest and thickets, along with wet eucalypt forest with a dense understorey. A wider range of habitat becomes important for this species during migration including dry eucalypt forest/woodlands and Brigalow shrublands. The threshold for an ecologically significant proportion of a population (individuals) is 48,000 internationally and 4,800 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 7,500 ha internationally and 750 ha nationally. The proportion likely to result in a significant impact if affected is 3,400 (individuals) internationally and 344 nationally (DAWE 2020c).

The main threat to this species is thought to be fragmentation of habitat through the loss of core moist forest breeding habitat as a result of land clearing and urban encroachment particularly where clearing has occurred along remnant forest along migratory routes (Huggett 2000). Invasive species that have the potential to impact the Spectacled monarch includes Black rat (*Rattus rattus*) and exotic vines associated with riparian area (DAWE 2020c).

This species was not recorded from field investigations though there are Rufous fantail records from within the Project disturbance footprint to the east of Mount Kynoch dated 2000. Several records occur within the ecology study area to the north of the Project disturbance footprint to the east of Mount Kynoch and Blue Mountain Heights dated. Two of these records are old (1978) and two are dated from 2000 and 2001. Records for this species from within a 50 km buffer of the Project disturbance footprint occur to the north and south of the alignment along the range from Toowoomba to Crows Nest. Records to the west and east of the range are largely scattered and sparse. Generally, records for this species occur within forested reserves and national parks.

Given the extensive remnant habitat that will not be disturbed adjacent to and surrounding the Project a significant impact resulting from a loss of important habitat is unlikely. Few records occur within and around the ecology study compared to those in the surrounding areas, it is unlikely that a significant proportion of the population will be impacted. There is an estimated 17.24 ha of habitat (i.e. 15.71 ha of potential habitat and 1.53 ha of important habitat) in which this species is predicted to occur within the Project disturbance footprint (refer Table 4.29). Given this species occupies forests and woodlands that provide dense understory vegetation areas of open forest and woodland are not contained within the Project disturbance footprint. The loss of habitat as a result of the Project is below the threshold and as such a significant residual impact is unlikely.

Assessment against the significant impact criteria for Rufous fantail is shown in Table 5.10.

Table 5.10 Assessment against the significant impact criteria: Woodland migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	Only a very small area of important habitat for woodland migrants (i.e. 1.53 ha) is predicted to occur in the Project disturbance footprint (refer Table 4.29). The total area of predicted habitat considered important for woodland migrants that occurs within the Project disturbance footprint is below the guideline threshold (1,000 ha) for all woodland migrant species outlined above.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Project is unlikely to result in the establishment of invasive species that are harmful to woodland migrant species, with a number of the species already established in the area. However, there is a risk that the Project results in new infestations or the proliferation of existing invasive 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 feral predators (i.e. cats and foxes) with measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders.
Seriously disrupt the lifecycle of an ecologically significant proportion of the population of a migratory species	Whilst breeding habitat for woodland migrants may occur within the Project disturbance footprint the predicted area for various habitats may not be representative of the actual breeding habitat available for these species. Therefore, the areas provided are likely to be a vast over estimation, furthermore these areas fall below the guideline thresholds. No confirmed nest sites were identified within the Project disturbance footprint during field investigations, with a species management plan to be developed to tamper with any breeding place under Section 335 of the Nature Conservation (Animals) Regulation 2020. Disturbance as a result of the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of woodland migrant species.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on woodland migrants will result from the Project.

5.3.3.4 Wetland migrants

This section provides a summary of information related each of the three wetland migratory species that have potential of occur within the ecology study area and assesses these species against the MNES significant impact criteria for migratory species.

Glossy ibis (*Plegadis falcinellus*)

Glossy ibis is the smallest ibis in Australia and known to live up to 8 years on average. Glossy Ibis feed on aquatic invertebrates such as molluscs and crustaceans. They have been occasionally observed to feed on fish, frogs and tadpoles, dryland invertebrates, lizards, small snakes and nestling birds. They sexually mature in one or two years and typically breed from mid-spring to the end of summer and may persist breeding from September to April pending the availability of resources. They normally lay up to 3-6 eggs at a times, and chicks take 25-28 days to fledge. Parents will care for young several weeks after fledging. This species forms colonies for nesting, sometimes with a mix of other species of ibis and colonial birds. Nesting material consists of a platform nest of sticks, usually with a lining of aquatic plants, between the upright branches of trees or shrubs growing in water. (Birdlife 2019). Australian breeding habitat types include vegetated swamps in the semi-arid and arid regions. In QLD this species breeds in Channel Country and wetlands of the Bulloo, Diamantina and Georgina River systems, occasionally including Cooper Creek (DAWE 2020c).

Globally they occur in North America, Europe, Asia, and Africa. In Australia, Glossy ibis are found from Kimberley down south to the Eyre Peninsula and east to QLD, NSW and Victoria. Glossy ibis' preferred habitat for foraging and breeding are freshwater marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation. The species is occasionally found in wooded swamps, artificial wetlands (such as irrigated fields. No important habitat has been identified.

The main threat to this species is thought to be wetland destruction or degradation, this includes water diversion and drainage alteration. Increasing salinity, groundwater extraction human disturbance, pollution and grazing also threaten the species. Invasive species that have the potential to impact the Glossy ibis include invasive plants that can alter or degrade the health of wetland ecosystems and exotic fish (tilapia) species that may outcompete with food resources (DAWE 2020c).

The species was not recorded during field investigations and there are no records for Glossy Ibis do not occur within the Project disturbance footprint however do occur within the ecology study area. Three recent (2009 – 2014) records occur at the eastern end of the ecology study area near Helidon. The majority of records within a 50 km buffer of the Project disturbance footprint occur between Gatton, Laidley, Rosewood and Coominya. Other scattered records occur at Oakey, Cooby Creek Reservoir and Pittsworth. Generally, records for this species occur both along the eastern coastline and extensively throughout inland Australia.

The Project will intersect a number of waterways/watercourses and various construction phase activities are likely to impact environmental values (e.g. water quality and vegetation structure and composition) associated with these features (refer EIS Appendix L: Surface water or information on water quality impacts). An area of 65.75 ha of predicted habitat for this species (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) occurs in the Project disturbance footprint (refer Table 4.29).

Assessment against the significant impact criteria for Glossy ibis is shown in Table 5.11.

Eastern osprey (*Pandion haliaetus*)

The Eastern osprey (*Pandion haliaetus*) is a medium-sized raptor with a total length of 50 to 65 cm and wingspan 145 to 170 cm. Ospreys are one of the most widely distributed birds of prey, second to the Peregrine falcon. They are distributed globally occupying both temperate and tropical regions across all continents except Antarctica. Their diet mainly consists of fish, however, have been known to feed on crustaceans, insects, reptiles, birds and mammals (DAWE 2020c). They live on average 30 years, and have clutch sizes of one to four eggs, with brooding attempts separated by periods of up to three years. They typically inhabit coastal habitat and terrestrial wetlands of tropical and temperate Australia. Less frequently they are seen travelling over heath, woodland or forest when travelling between foraging sights (DAWE 2020c). No important populations have been identified in Australia, although a management plan has been developed for NSW and one is proposed for South Australia.

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat as moist habitat with dense vegetation, across mangrove, rainforest, riparian forest and thickets, along with wet eucalypt forest with a dense understorey. A wider range of habitat becomes important for this species during migration including dry eucalypt forest/woodlands and Brigalow shrublands. The threshold for an ecologically significant proportion of a population (individuals) is 48,000 internationally and 4,800 nationally. The area threshold for the loss of important habitat likely to result in a significant impact is 7,500 ha internationally and 750 ha nationally. The proportion likely to result in a significant impact if affected is 3,400 (individuals) internationally and 344 nationally (DAWE 2020c).

Major threats include habitat loss or degradation, bioaccumulated pollutants, and food reduction due to competition with fisheries. Any invasive species that has the capacity to greatly reduce fish abundance is considered harmful to this species.

Eastern osprey records are absent from the Project disturbance footprint area and the ecology study area. A number of records for the species occur from a single location to the south of Helidon along Lockyer Creek dated 2013. Other records within a 50 km buffer of the Project disturbance footprint occur at Cooby Creek Reservoir, Crows Nest, Atkinsons Lagoon and Gatton. Most records for this species are confined to the eastern seaboard, inland records are sparse and largely confined to waterways and watercourses.

The Project will intersect a number of waterways/watercourses and various construction phase activities are likely to impact water quality associated with these (refer EIS Appendix L: Surface water). There are 24 individually mapped waterways which cross the Project alignment. Of these waterways, several are intersected multiple times (refer EIS Appendix L: Surface water). An area of 8.90 ha of predicted potential habitat for this species occurs in the Project disturbance footprint (refer Table 4.29).

Assessment against the significant impact criteria for Eastern osprey is shown in in Table 5.11.

Yellow wagtail (*Motacilla flava*)

Yellow wagtails are a small passerine wagtail around 15-16 cm long. Several races exist for this species however these are typically uniform grey-green or olive-green across the back and rump. The breast to vent underparts, become bright yellow during breeding. This species does not breed in Australia and only breeding males are known to visit Australia. The species that breed in Europe, Siberia and Alaska migrate to Africa, south and south-east Asia, Indonesia and Papua New Guinea. They regularly migrate to the coastal regions of Australia during summer from Broome to north-east QLD from November to April (Pizzey and Knight 2003). This species prefers open habitat near water, swamp margins, salt marshes, human modified landscapes such as sewage ponds and playing fields and can be found on drier inland plains (Morcombe 2003).

The *Draft Referral Guideline for 14 birds listed as migratory species under the EPBC Act* (DotE 2015a) considers important habitat as mostly well-watered open grasslands and the fringes of wetlands. Roosts in mangroves and other dense vegetation. The threshold for an ecologically significant proportion of a population (individuals) is 10,000 internationally and 1,000 nationally. No area threshold can be determined for this species. The proportion likely to result in a significant impact if affected is 10,000 internationally and 1,000 nationally (DAWE 2020c).

Severe fragmentation of habitat, a reduction in habitat quality can lead to a decrease in the area of occurrence for the Yellow wagtail. These factors have potentially led to a general decrease in the population size (Birdlife International 2020). It is not known if invasive species have the potential to impact the Yellow wagtail (DAWE 2020c).

The species was not recorded from the field investigations, while there are no database records of the Yellow wagtail within the Project disturbance footprint, ecology study area or from within a 50 km buffer of the Project disturbance footprint. The Toowoomba and Lockyer Valley areas are outside the species known distribution in Australia, though the habitat modelling by the Commonwealth indicates that the species may occur. The nearest records for this species occur a little more than 50 km north-east of the Project disturbance footprint at Wynnum North from 2014. Only a few other records occur along the coast between Brisbane and Caboolture. Most database records for this species occur in northern Australia (on the coast) and are of single individuals.

An area of 65.75 ha of predicted habitat (i.e. 8.90 ha of potential habitat and 56.85 ha of important habitat) for this species occurs in the Project disturbance footprint (refer Table 4.29). A lack of database records combined with the fact that the Project is outside of the species' Australian migratory distribution means a significant impact on this species is unlikely. The Project is not likely to exceed thresholds for this species as outlined in the guidelines referring to a loss of an ecologically significant proportion of a population.

Assessment against the significant impact criteria for Yellow wagtail is shown in Table 5.11.

Table 5.11 Assessment against the significant impact criteria: Wetland migrants

Criterion	Assessment against the significance criteria
Substantially modify, destroy or isolate an area of important habitat for a migratory species	A total of approximately 56.85 ha of predicted important habitat occurs in the project disturbance footprint for the Yellow wagtail and Glossy Ibis whilst no predicted important habitat occurs in the project disturbance footprint for the Osprey. Compared to the available habitat in the surrounding landscape the important habitat affected for Yellow wagtail and Glossy ibis (ie. proposed disturbance constitutes approximately 8.23% of the available important habitat within the ecology study area, refer Table 5.3), this is not likely to result in a significant reduction of habitat for these species. The majority of this habitat is associated with riverine wetlands and watercourses, while lacustrine and palustrine wetlands within and directly downstream of the Project disturbance footprint are limited (refer Section 4.2.8). Therefore, no significant impact is anticipated as a result of the modification, destruction or isolation of important habitat.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the species	The Project is unlikely to result in the establishment of invasive species that are harmful to wetland migrant species, with a number of the species already established in the area. However, there is a risk that the Project results in new infestations or the proliferation of existing invasive 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 feral predators (i.e. cats and foxes), along with invasive aquatic and flora species, with the measures to align with existing pest management plans developed by the local councils, DAF and where applicable landholders..
Seriously disrupt the lifecycle of an ecologically significant proportion of the population if a migratory species	Whilst breeding habitat for wetland migrants (excluding Yellow wagtail) may occur within the Project disturbance footprint the predicted area for various habitats may not be representative of the actual breeding habitat available for these species. Therefore, the areas provided are likely to be a vast over estimation, furthermore these areas fall below the guideline thresholds. No confirmed nest sites were identified within the Project disturbance footprint during field investigations, with a species management plan to be developed to tamper with any breeding place under Section 335 of the Nature Conservation (Animals) Regulation 2020. Disturbance as a result of the Project is not likely to seriously disrupt the lifecycle of an ecologically significant proportion of wetland migrant species.
Assessment of potential for significant impacts	Under the three-part test detailed above, it is considered unlikely a 'significant impact' on wetland migrants will result from the Project.

5.3.4 Significant residual impact assessment for Matters of State Environmental Significance

There are two significant residual impact guidelines which outline how to assess whether a prescribed activity will, or is likely to have a significant residual impact on an MSES:

- Significant Residual Impact Guideline (Nature Conservation Act 1992 Environmental Protection Act 1994 Marine Parks Act 2004) (SRI Guideline (DEHP)) and,
- Significant Residual Impact Guidelines for matters of state environmental and prescribed activities assessable under the Sustainable Planning Act 2009(SRI Guideline DSDIP)).

The guidelines do not specifically relate to a coordinated project under the SDPWO Act, however the ToR notes that where a significant residual impact will occur on a prescribed environmental matter as outlined in the Environmental Offsets Regulation 2014, the offset proposal(s) must be consistent with the requirements of Environmental Offsets Act 2014 and the latest version of the Queensland Environmental Offsets Policy.

Under the Offsets Regulation a significant residual impact is:

> *"an adverse impact, whether direct or indirect, of a prescribed activity on all or part of a prescribed environmental matter that:*
>
> *a) remains, or will or is likely to remain, (whether temporarily or permanently) despite on-site avoidance and mitigation measures for the prescribed activity; and*
>
> *b) is, or will or is likely to be, significant."*

Table 5.12 presents a preliminary significant residual impact assessment of the MSES relevant to the Project based on the relevant SRI guidelines. Though it is noted under the Planning Regulation 2017 the Project is afforded a number of exemptions for assessable development (e.g. the Project is government supported infrastructure and thus clearing of regulated vegetation is no assessable). Further the guidelines relates only to MSES and does not apply to matters of local environmental significance (MLES) or MNES. Noting that significant residual impacts on MNES, including MSES (i.e. threatened species under the NC Act) in accordance with has been undertaken in EIS Appendix J: Matters of National Environmental Significance.

The areas of significant impacts are based on the overall Project disturbance footprint. This may be an overestimation of the final impact area following design refinements for the Project.

A total of 216.98 ha of regulated vegetation, across nine (9) REs occurs within the Project disturbance footprint, as mapped by the Department of Resources (refer Table 4.19). This includes 9.8 ha of remnant 'Endangered' REs, 89.62 ha of remnant 'Of concern' REs, 13.39 ha of remnant 'Least concern' REs and 106.49 ha of high value regrowth (Category C) vegetation (refer Table 4.19 and Table 4.20 for more information). Least Concern REs and high value regrowth is listed as Category C vegetation and is not a prescribed environmental matter under the Offsets Regulation. As such, it is not treated further in the following assessment.

The State Development Assessment Provision requires assessment of the Project against the criteria set out in the SRI Guideline (DSDIP). The SRI Guideline (DSDIP) criteria details when an action is likely to have a 'significant residual impact' to a MSES as defined in the Offsets Regulation.

Assessment of significant residual impacts for MSES identifies as present in the desktop and field review, and in accordance with the SRI Guideline (DSDIP) is presented in Table 5.12. Noting for that for connectivity and threatened flora species the SRI Guideline (DEHP) has been referenced. While the criteria is the same in both guidelines for protected wildlife (though the SRI Guideline (DSDIP) has a specific category for protected plants) and is similar to the criteria used in the MNES Guidelines.

The impacts to 'regulated vegetation' are based on the current VM Act vegetation mapping as will be required when considering environmental offsets. The areas of significant impacts are based on the overall Project survey area and is likely to be a substantial overestimation of the final impact area following final design refinements for the Project.

Table 5.12 Preliminary significant residual impact assessment for matters of state environmental significance

MSES	Significant Residual Impact Guideline criteria (DSDIP 2014)	Significant Impact
Regulated vegetation		
'Endangered' or 'Of concern' regional ecosystem (RE)	An action is LIKELY to have a SRI on an '**Endangered' or 'Of concern' RE** if the action will result in: (a) clearing of more than 5ha of 'Endangered' or 'Of concern' RE vegetation; (b) clearing that results in an overall area (not confined to property boundaries) of 'Endangered' or 'Of concern' RE vegetation of less than 5ha; **OR** (c) clearing that results in the physical separation of 'Endangered' and 'Of concern' RE communities within and on adjoining sites.	**Significant impact anticipated.** The Project disturbance footprint encompasses 9.8 ha of 'Endangered' and 89.62 ha of 'Of concern' remnant vegetation (Category B). Clearing will result in the clearing of more than 5 ha of 'Endangered' and 'Of concern' vegetation, and may result in the physical separation of 'Of concern' and 'Endangered' communities.
A prescribed RE *(Category B other than grassland)* within a defined distance from the defining banks of a relevant watercourse or relevant drainage feature *(Appendix 3 of the QLD Environmental Offsets Policy)*	An action is LIKELY to have a SRI on **remnant vegetation within the defined distance of a watercourse** if the action will result in: a) permanent removal of vegetation within the defined distance of a stream order 2 or higher where no rehabilitation is proposed; b) building of an online detention basin greater than 1ha in size or other similar works that result in the clearing of vegetation which fragments up and downstream remnant areas on any stream order; OR c) permanent clearing of more than 0.5ha of an 'Endangered' or 'Of concern' RE, within the defined distance of a watercourse.	**Significant impact anticipated.** The defined distance for 1st and 2nd order, 3rd and 4th order, 5th order streams and greater in the Project disturbance footprint is 25 m, 50 m and 100 m respectively from a defined bank. The removal of the vegetation associated with Project construction is expected to be permanent and will not be rehabilitated. The Project will require the permanent removal of **4.30 ha of Category B** vegetation within the defined distance of a watercourse.
Remnant vegetation intersection with a VM Act wetland	An action is Likely to have a SRI on remnant vegetation intersecting with a wetland if the action will result in: (a) clearing within the defining banks of a defined wetland area exceeding the thresholds specified in Table 2, SDAP Module 8; (b) clearing involving the permanent removal of more than 25% of the vegetation located within 50m of the defining bank of a defined wetland; or (c) clearing involving the permanent removal of more than 50% of the vegetation located between 50m and 100m of the defining bank of a defined wetland.	**Significant impact not anticipated.** There are no areas of remnant vegetation associated with a VM Act wetland within the ecology study area, with the nearest wetlands occurring along the Warrego Highway approximately 1.6 km south of the eastern extent of the Project.

<table>
<tr><th>MSES</th><th>Significant Residual Impact Guideline criteria (DSDIP 2014)</th><th>Significant Impact</th></tr>
<tr><td>Essential Habitat (EH)</td><td>An action is LIKELY to have a SRI on EH if the action will result in:
- clearing of EH exceeding the thresholds specified in Table 1 of SDAP Module 8 (shown below) and resulting in a greater than 10% permanent reduction in the extent of EH mapped on site.
<table>
<tr><th colspan="3">Clearing limits per regional ecosystem</th></tr>
<tr><td>Structure Category</td><td>Width (m)</td><td>Area (ha)</td></tr>
<tr><td>Dense and mid-dense</td><td>10</td><td>0.5</td></tr>
<tr><td>Sparse and very sparse</td><td>20</td><td>2</td></tr>
<tr><td>Grassland</td><td>25</td><td>5</td></tr>
</table></td><td>Significant impact anticipated.
There will be permanent removal of 112.36 ha of Category B regulated vegetation mapped as essential habitat within the Project disturbance footprint. Refer to Section 4.2.3 for more details.</td></tr>
<tr><th colspan="3">Connectivity areas</th></tr>
<tr><td>Connectivity areas</td><td>In deciding if a SRI is likely to occur on a connectivity area, an administering agency (that is the State) must consider the significance of the vegetation in the context of the local and the regional landscape. The measure of impact significance is based on how the prescribed activity will change the size and configuration of remnant vegetation areas and the level of fragmentation that will result at the local scale (5 km radius) given regard to the regional scale (20 km radius). Impact significance is measured by the reduction in the extent of remnant vegetation and increase in patchiness at the local scale.
In highly fragmented landscapes at the regional scale, a SRI on connectivity areas will be associated with smaller impacts compared to impacts within regionally intact landscapes, as the extent and configuration of existing connectivity areas in fragmented landscapes is limited.</td><td>Significant impact anticipated.
The landscape Project impacts to the extent of remnant vegetation in the area have been analysed using DESs ‘landscape fragmentation and connectivity’ tool (as per the SRI Guideline (DEHP)).
A development impact on connectivity areas is determined to be significant if either of the following tests are true:
1. The change in the core remnant ecosystem extent at the local scale (post impact) is greater than a threshold determined by the level of fragmentation at the regional scale; or
2. Any core area that is greater than or equal to 1 hectare is lost or reduced to patch fragments (core to non-core).
The analysis determined (based on significance test 2) that the number of core remnants occurring in the area will be reduced from 17 to 15 due to Project impacts. While this reduction is not significant, this will result in a change from core to non-core remnant. The area of impact was calculated at 122.87 ha.</td></tr>
<tr><th colspan="3">Wetlands and watercourses</th></tr>
<tr><td>A wetland in a wetland protection area, or wetlands of high ecological significance shown on the map of QLD wetland environmental values
A wetland or watercourse in high ecological value waters</td><td>An action is likely to have a SRI on a wetland or watercourse if:
(a) works are undertaken within a wetland in a WPA, a wetland of HES or the bed or banks of a HEV watercourse that will result in a permanent degradation of the landform, vegetation or water quality;
(b) in an urban area, works are undertaken within 50m of a wetland in a WPA, a wetland of HES or the bed or banks of a HEV watercourse that will result in a permanent and significant change to surface or groundwater hydrology or water quality; OR</td><td>Significant impact not anticipated.
The works are not considered to be in an ‘urban area’ as defined under Schedule 24 of the Planning Regulation 2017.
There are also no HEV wetlands and watercourses within the Project disturbance footprint. However, HEV wetlands and watercourses are present within the Project disturbance footprint at the eastern extent, 200 m upstream and 50 m respectively. Noting that it is unclear whether the watercourses is present, with the lower reach impacted by the Roma Brisbane Gas Pipeline and likely to be a drainage line under the Water Act.</td></tr>
</table>

MSES	Significant Residual Impact Guideline criteria (DSDIP 2014)	Significant Impact
	(c) in a non-urban area, works are undertaken within 200m of a wetland in a WPA, a wetland of HES, or the bed or banks of a HEV watercourse that will result in a permanent and significant change to surface or groundwater hydrology or water quality	The wetlands/watercourses are located upstream of the Project and it is unlikely that a permanent and significant change to the function of the wetland or watercourse, including surface hydrology and water quality as a result of the Project will occur. However, notwithstanding the above, mitigation measures will be implemented to ensure that there will be no permanent degradation of the landform, vegetation or water quality associated with the HES wetland area. However, notwithstanding the above, mitigation measures will be implemented to ensure that there will be no permanent degradation of the landform, vegetation or water quality associated with the HES wetland area.
Protected wildlife habitat		
An area contains plants that are 'Endangered' wildlife or 'Vulnerable' wildlife	Plants - Protected wildlife habitat (plants that are 'Endangered' or 'Vulnerable' wildlife)* An action is unlikely to have a SRI on a plant that is 'Endangered' or 'Vulnerable' wildlife if the action will result in: (a) clearing of plants that are threatened wildlife and not located within a natural setting (i.e. does not meet the definition of 'in the wild' under the Nature Conservation Act 1992) where the proposal includes translocation; (b) clearing of up to 10% of the total number of plants that are threatened wildlife occurring on a site where the proposal results in 90% of all plants that are threatened wildlife being retained and protected as a reserve or similar; (c) clearing of regenerating plants that are threatened wildlife which have previously been cleared within the last 5 years and that are historically maintained through slashing or grazing; OR (d) the proposed relocation of an area of plants that are threatened wildlife less than 1000m^2 not occurring in a relatively natural ecological situation (e.g. bushland), to a permanent retention area via an approved management plan. Refer to the assessment of the SRI Guideline (DEHP) significant impact criteria for 'Vulnerable' and 'Near threatened' flora (refer Table 5.16 and Table 5.17).	**Significant impact anticipated.** Protected plant trigger maps indicate that 'Endangered' or 'Vulnerable' flora exists within the Project disturbance footprint towards the start of the western section of the alignment, at the eastern side of the tunnel north of Toowoomba and at the eastern end of the alignment to the south of the Lockyer Reserves. Three 'Vulnerable' species have been predicted to occur within the Project disturbance footprint: *Caustis blakei* subsp. *macrantha*, *Cyperus clarus* and *Marsdenia coronata.* The Project will result in the clearing of a population of *Marsdenia coronata* (12 individuals) near the eastern tunnel portal and as such the Project will have a significant residual impact on Protected wildlife habitat (plants that are 'endangered' or 'vulnerable' wildlife). While no significant residual impact is likely on *Caustis blakei* subsp. *macrantha* and *Cyperus clarus* (i.e. no clearing of these plants). The significant residual impact assessment for these species against the SRI Guideline (DEHP) is provided in Table 5.16. Two 'Near threatened' species have been predicted to occur within the Project disturbance footprint, *Callitris baileyi* and *Digitaria porrecta*. The DSDIP 2014 SRI Guideline does not apply to these species, though given that the *Digitaria porrecta* is present in the Project disturbance footprint a significant residual impact on this species is likely (refer Table 5.17).

MSES	Significant Residual Impact Guideline criteria (DSDIP 2014)	Significant Impact
		An assessment of the Protected wildlife habitat criteria as outlined in the SRI Guideline (DEHP) is also provided Table 5.16 for the three Vulnerable flora species and Table 5.17 for the two Near threatened flora species. This assessment also confirmed that a significant residual impact likely as a result of the clearing of *Marsdenia coronata* and *Digitaria porrecta,* but also concluded that the Project will have a significant residual impact on *Callitris baileyi.* There are several other threatened flora species considered as MSES, which are also listed as MNES. These species have been assessed under the MNES Guideline and as such are not assessed here (refer EIS Appendix J: Matters of National Environmental Significance for detals).
A habitat for an animal that is: ■ 'Endangered' wildlife, or ■ 'Vulnerable' wildlife, or	Animals - Protected wildlife habitat (habitat for an animal that is 'Endangered' or 'Vulnerable' wildlife or a 'Special least concern' animal)* Refer to the assessment of the SRI Guideline significant impact criteria for 'Vulnerable' fauna (refer Table 5.13 and Table 5.14) and 'Special least concern' fauna (refer Table 5.15).	**Significant impact anticipated.** There is potential for a significant impact to the Glossy black-cockatoo and Powerful owl as a result of the Project (refer Table 5.13 and Table 5.14).A significant residual impact on the Grey snake as a result of the Project is not anticipated (refer Table 5.14). There are several other threatened fauna species considered as MSES, which are also MNES. These species have been assessed under the MNES Guideline and as such are not assessed here (refer EIS Appendix J: Matters of National Environmental Significance technical report).
A habitat for an animal that is: a 'Special least concern' animal *(an echidna or a platypus)*	An action is LIKELY to have a SRI on a special least concern (non-migratory) animal wildlife habitat if the action will result in: (a) a long-term decrease in the size of a local population; (b) a reduced extent of occurrence of the species; (c) fragmentation of an existing population; (d) reduced gene flow among populations; OR (e) disruption to ecologically significant locations (breeding, feeding or nesting sites) of a species.	**Significant impact not anticipated** There is no mapped wildlife habitat for special least concern (non-migratory) within the Project disturbance footprint. However, predictive habitat modelling indicates that there is 161.69 ha of general habitat for the Short-beaked echidna. Both species were also identified from the during the field investigations, with the platypus identified in from Gowrie Creek where the Project is in tunnel. There is a risk of groundwater drawdown impacting on Gowrie Creek in short-term but the risk to the species is considered to be low. An assessment against the criteria is provided in Table 5.15.

MSES	Significant Residual Impact Guideline criteria (DSDIP 2014)	Significant Impact
Waterway providing for fish passage		
Any part of a waterway providing for passage of fish (other than that part of a waterway within an urban area) only if the construction, installation or modification of waterway barrier works will limit the passage of fish along the waterway	An action is likely to have a SRI on a waterway providing for fish passage if the action will result in: a) a permanent modification to the volume, depth, timing, duration or flow frequency of the waterway; b) permanent modification or fragmentation of fish habitat including but not limited to in stream vegetation, snags and woody debris, substrate, bank or riffle formation necessary for breeding and/or survival of native fish species; c) the mortality or injury of fish species; or d) works that permanently reduce the level of fish passage provided in a tidal waterway or a waterway identified as a major high-risk waterway for waterway barrier works, to a level that would increase stress on fish populations. Where waterway crossings are constructed in accordance with 'What is not a waterway barrier work?' (DAF, 2021) or in accordance with the Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works (DAF, 2018), the works do not result in a significant residual impact.	**Significant impact not anticipated** There are 24 individual mapped waterways which cross the Project alignment. Of these eight are mapped as green, nine are mapped as orange, four are mapped as red and three are mapped as purple. Of these waterways, several are intersected multiple times (refer EIS Appendix L: Surface water quality. It is noted that some of the other waterways present in the Project disturbance footprint (refer Section 4.2.5) will also provide fish passage. The following is also applicable for these waterways. The Project has potential to permanently modify fish habitat, although it is anticipated final design will maintain flows along creek lines via installation of culverts/bridges at crossings. The culverts are designed in to meet the Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works (DAF, 2018), while the bridges structures are not considered a waterway barrier. This will be considered during detailed design. Permanent fragmentation of fish habitat will not occur. The final Project design will ensure that the localised impacts due to waterway crossings will not lead to permanent modifications to habitat necessary for native fish breeding or survival. The Project crosses three purple waterways, with bridge structures proposed over Gowrie Creek and Lockyer. Two new access roads are also proposed over Rocky Creek and will be designed to ensure fish passage is maintained. Mitigation measures will be in place to minimise/eliminate mortality/injury to fish species from instream works required for the Project. Notwithstanding the above, an action is UNLIKELY to have a SRI on a waterway providing for fish passage if: (a) measures have been put in place to provide equal or better fish passage for the waterway during construction and operation activities; AND (b) the waterway is restored to its existing condition immediately on completion of the works; OR (c) for works that permanently alter existing fish passage, equal or better passage will be provided immediately on completion of the works.

5.3.4.1 Matters of state environmental significance threatened species assessments

Sections 4.2.1.1 and 4.2.2.1 details the threatened species as known or possibly occurring within the ecology study area. The ecology study area provides possible habitat values for a number of threatened species, including a number of species listed as MNES and MSES. Assessment of the occurrence and potential impact significance of the Project to MNES species that are a controlling provision under the EPBC Act (including species listed under the provisions of the NC Act) is provided within EIS Appendix J: Matters of National Environmental Significance.

The ecology study area provides predicted habitat suitable for Caustis ('Vulnerable' under the NC Act), *Cyperus clarus* ('Vulnerable' under the NC Act), Slender milkvine ('Vulnerable' under the NC Act), Bailey's cypress ('Near threatened' under NC Act) and Finger panic grass ('Near threatened' under NC Act). *Cyperus clarus,* Slender milkvine and Finger panic grass have all been recorded in the ecology study area. Table 5.16 provides an assessment for Caustis*, Cyperus clarus* and Slender milkvine; and Table 5.17 provides an assessment for Bailey's cypress and Finger panic grass according to the SRI Guideline (DEHP) criteria (DEHP 2014a). Noting that the criteria for protected plants in the SRI Guideline (DSDIP)

The ecology study area also provides predicted habitat suitable for Glossy black-cockatoo ('Vulnerable' under the NC Act), Powerful owl ('Vulnerable' under the NC Act), Grey snake ('Endangered' under the NC Act), Platypus (SLC under the NC Act), and Short-beaked echidna (SLC under the NC Act). Predictive habitat mapping for these species has been based on ground-truthed data and is considered conservative in approach for assessment of impacts at the primary approval stage of the Project (i.e. is likely to overestimate potential impacts as a result of the Project).

The SRI Guideline criteria in the DSDIP 2014 and DEHP 2014a for assessing significant impacts to 'Vulnerable' species are the same, and are similar in some respects to the criteria set out for threatened fauna species in the MNES Guideline. Table 5.13 provides a significant impact assessment for Glossy black-cockatoo and Table 5.14 provides a significant impact assessment for Powerful owl and Grey snake.

An assessment against the Special least concern (non-migratory) animal wildlife habitat criteria (Short-beaked echidna and Platypus) is provided in Table 5.15.

Table 5.13 Matters of state environmental significance significant residual impact criteria – 'Vulnerable' Fauna (Glossy black-cockatoo)

Criteria	Assessment against significance criteria (Glossy black-cockatoo)
Lead to a long-term decrease in the size of a local population of the species	There are three significant populations within SEQ (based on sightings and feed tree localities): the southern Moreton Bay Islands, the hinterland of the Gold Coast and Noosa. The largest populations west of the Great Dividing Range in southern Queensland are found in the Barakula, Chinchilla and Dunmore areas. There are a number of records along the escarpment of the Great Dividing Range, with an environmental group identifying feed tree localities within upper Lockyer. As such it can be assumed that there is a local population inhabiting the upper Lockyer area (Glossy Black Conservancy 2010). The species was not recorded during the field investigations, including breeding, roosting and feeding sites, however habitat and the primary food source (i.e. Allocasuarina or Casuarina trees) were confirmed from with the Project footprint (e.g. between Ashlands Drive and Lockyer Creek). The absence of the species during the surveys may be a result of the species known movement patterns, with the species known to move around SEQ in response to resource availability and breeding requirements. Glossy Black-Cockatoos are rarely found away from Allocasuarina or Casuarina trees, with the birds showing a strong fidelity to particular trees. They have a strong preference for woodland dominated by Allocasuarina, or where Allocasuarina is dominate in the mid-stratum, with roosting also occurring within 1 km of a reliable water source. The species is an obligate hollow nester requiring large hollow, which generally only forms in large eucalypts over 200-years old. This species is capable of traveling 10 km from roosting or nesting sites to feed trees and require large hollow trees for nesting (Glossy Black Conservancy 2010). There are several database records within the ecology study area to the north of the Project disturbance footprint to the east of Blue Mountain Heights dated 1978 and a single record from 1989 at the far eastern section of the alignment near the Lockyer Reserves. Recent records (2015) exist to the south of the Project disturbance footprint east of Toowoomba between 5 and 10 km of the alignment. Two records also occur to the north approximately 10 km from the Project disturbance footprint near Highfields dated 2005 and 2015. There is a predicted 21.58 ha of general suitable habitat for the species within the Project disturbance footprint (refer Table 4.28). The Project will result in the permanent removal of this habitat, including large hollows and the primary food source which are important for the species. The Project also poses a threat to the local population as a result of proliferation of predators (native and introduced), proliferation of disturbance tolerant species (native and introduced) which will compete for hollows and fire. However, these risks are considered manageable compared to habitat loss. Given the species is known to inhabit fragmentated landscapes, is highly vagile nature, and that breeding occurs outside of the Project footprint and there is substantial remnant vegetation surrounding the Project the loss of the habitat is unlikely to lead to the long-term decline in numbers of the existing population. However, the Project will result in the removal of large hollow bearing trees. These trees will not be replaced in the short term (i.e. the large and deeper hollows occupied by Glossy-black cockatoo can take over a 200-years to form). The removal of these trees has the potential to lead to the long-term decline in the size of an existing population especially if they are breeding hollows.
Reduce the area of occurrence of the species	The area of occupancy (area within its 'extent of occurrence' which is occupied by a taxon) is estimated to be 50,000 km^2 (Garnet et al. 2010) with the Project disturbance footprint estimated to contain 21.58 ha of general habitat considered suitable for the species (refer Table 4.28) The Project will not impede the movement of the species across the landscape, noting that there are no confirmed breeding sites and/or feeding sites in the Project disturbance footprint. As such the Project is unlikely to reduce the area of occupancy of the species.
Fragment an existing population	There are three significant populations within SEQ (based on sightings and feed tree localities): the southern Moreton Bay Islands, the hinterland of the Gold Coast and Noosa. The largest populations west of the Great Dividing Range in southern Queensland are found in the Barakula, Chinchilla and Dunmore areas. The Project disturbance footprint is estimated to contain 134.49 ha of habitat considered suitable for the species, although this is likely a substantial overestimation. There are large areas of similar habitat adjacent to the Project that would be considered suitable habitat for the species. The Project is linear and for a significant portion of the alignment subterranean. Connectivity between existing forested areas is likely to be maintained as a result. There are a number of records along the escarpment of the Great Dividing Range, with an environmental group identifying feed tree localities within upper Lockyer. As such it can be assumed that there is a local population inhabiting the upper Lockyer area (Glossy Black Conservancy 2010). The Project will not impede the movement of the species across the landscape, though it is acknowledged that the movement patterns and ranging behaviour is poorly understood.

Criteria	Assessment against significance criteria (Glossy black-cockatoo)
	Therefore, the Project is not likely to fragment and existing population of Grey falcon. The Project disturbance footprint is predicted to contain 21.58 ha of general habitat considered suitable for the species (refer Table 4.27 and Appendix G) although this is likely to be a substantial overestimate. There are extensive areas adjacent to the north and south of the Project disturbance footprint along the Toowoomba Range that would comprise suitable habitat for the species. The linear nature of the Project could fragment existing populations; however, this is an avian species and highly mobile. The Project is considered unlikely to fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	The Project disturbance footprint is predicted to contain 21.58 ha of general habitat considered suitable for the species (refer Table 4.28 and Appendix G) although this is likely to be a substantial overestimate. There are extensive areas adjacent to the north and south of the Project disturbance footprint along the Toowoomba Range that would comprise suitable habitat for the species. Although the Project is linear this is an avian species and highly mobile. The Project will not result in habitat isolation occurring on a local population of the species.
Result in invasive species that are harmful to a 'Vulnerable' species becoming established in the species habitat	The Project is considered unlikely to result in new invasive species becoming established in this species' habitat. However, an issue for the species as a result of the Project is the likely proliferation of native species tolerant to disturbance such as the Common brushtail possum which are known to prey on cockatoo eggs and young, along with competing for hollows. While other hollow dependent bird species such as Galah (*Eolophus roseicapillus*), Sulphur-crested cockatoo (*Cacatua galerita*) and the introduced Common myna (*Acridotheres tristis*). There are no known nesting sites within or adjacent the Project footprint and at this stage the risk is negligible. 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 feral predators (i.e. cats and foxes), along with invasive flora 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 population to decline	There are no known diseases which pose a risk to the species. 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 State recovery plan for Glossy black-cockatoo, while there is a recovery plan for the Kangaroo Island sub-species. The Project disturbance footprint comprises 21.58 ha of general habitat for the species (refer Table 4.28), with similar habitat in the surrounding area. The Project will remove hollow bearing trees, along with known food trees for the species. The Glossy Black-Cockatoo Conservation Guidelines notes that the species is an ecological specialist with poor recovery potential and the recovery of the species may be limited by the availability of nesting trees as there appear to be sufficient foraging resources within this region. The hollows required for the species can take over 200-years to form and the removal of hollows as a result of the Project may interfere with the recovery of the species in the long-term. The Project may also assist in the recovery of the species through the identification of new nest or feeding sites and potentially ongoing monitoring, along with opportunities to support local environmental groups and councils. The Project has the potential to interfere with the recovery of the species.

Criteria	Assessment against significance criteria (Glossy black-cockatoo)
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations include large tree hollows in which this species relies on for breeding and preferred *Allocasuarina/Casuarina* food trees. Given that this species has an affinity for particular food trees the loss of any trees could be considered a disruption to an ecologically significant location. The Project is likely to result in the removal of large old trees with large hollows which is a known threat to the species. Of the hollow bearing trees mapped within the Project disturbance footprint none were confirmed as supporting Glossy-black cockatoos. While *Allocasuarina/Casuarina* food trees were identified during the field investigations no feeding sites were confirmed. Other disruptions apart from clearing may be due to: ▪ Fires during construction and operations, though the risk is considered negligible. Also the railway corridor may be used in the future to access bushfires in previous remote areas ▪ Noise, dust and light pollution which may impact local movement patterns, prey interactions, breeding (e.g. masking calls) or result in the abandonment of nests Nevertheless, the Project has potential to disrupt an ecologically significant location. Ecological surveys in accordance with relevant guidelines are ongoing and will aim to map out these locations which will assist in identifying relevant mitigation measures (e.g. design to avoid the areas, reducing the footprint, designating the areas no-go zones especially when nesting or fledging). In addition, mitigation measures proposed for construction works will include but not be limited to the following the presence of qualified fauna spotter/catcher, erection of barricade fencing and relocation/replacement of hollows in adjacent areas. A species management plan will be developed to guide construction works, including tampering with a breeding place under Section 335 of the Nature Conservation (Animals) Regulation 2020. The Project has the potential to cause a disruption to an ecologically significant location for this species.
Assessment of potential for significant residual impacts	The Project is estimated to result in the clearance of 21.58 ha of potential habitat suitable for Glossy black-cockatoo (refer Table 4.28) which has potential to reduce the area of occurrence of the species and disrupt an ecologically significant location (large tree hollows and food trees). **Project has potential to cause a 'significant residual impact' on this species.**

Table 5.14 Matters of state environmental significance significant residual impact criteria – 'Vulnerable' Fauna (Powerful owl and Grey snake)

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Grey snake)
Lead to a long term decrease in the size of a local population of the species	The progress report from the *Powerful Owl Project in southeast Queensland*, indicates that there are at least 350 pairs in SEQ, with the potential for up to 950 pairs based on habitat modelling. There are few records of the species occurring west of the Great Dividing Range, while the escarpment areas is known to support breeding to the south and north of the Project, with records from the ecology study area in 2020. This species requires large tracts of old forest for nesting habitat with a pair occupying and defending an all-purpose territory year-round (Kavanagh 1997). The home range for the species has been recorded between 338 ha and 4,700 ha. The species was not identified from field investigations, however there are a number of database records from within the ecology study area and more recently in the surrounding area throughout the Toowoomba Range and Helidon Hills. Given the local records and the large home range, it is likely that the Project is part of a home range for a number of pairs of Powerful owls (e.g. along the escarpment and Helidon Hills, and potentially between the two areas). Predictive modelling indicates that there is 1305.07 ha of general habitat within the ecology study area, and 99.05 ha of general habitat located within the Project disturbance footprint (refer Table 4.28). This species requires large tracts of old forest for nesting habitat with a pair occupying and defending an all-purpose territory year-round (Kavanagh 1997). There is substantial remnant vegetation within and surrounding the Project to the north and south throughout the Toowoomba Range with a number of species records here and throughout the greater region. As such there will be substantial suitable habitat for the species in the surrounds that will not be disturbed by the Project. It is uncertain how many individuals may use habitat within the Ecology study area, or if they range into the Project disturbance footprint. The need for large hollow bearing trees within a bushland setting indicates that a reduction of mature trees has the potential to reduce suitable habitat for the species.	This species was not identified from the field investigations. In addition, the field investigations confirmed that preferred habitat for the species (i.e. woodlands (typically brigalow (*Acacia harpophylla*) and belah (*Casuarina cristata*) on heavy, cracking clay soils in association with water bodies or in areas with small gullies and ditches (gilgais)) was not present in the Project footprint. This type of community is prominent in the Brigalow Belt where core areas are known. The species range is extensive (~472,000 km^2), however suitable habitat is limited within this extent and as such the population is severely fragmented. Grey snakes are associated with woodlands associated with heavy cracking clay soils, particularly near water bodies, small gullies and ditches. Cracks in soil are utilised for refuge along with rocks, logs and other debris (DES 2020d). Within the Brigalow Belt the core area for the species is south of the Great Dividing Range between Dalby and Glenmorgan, with limited Gowrie/Oakey Creek catchment. While in Lockyer Valley most records are in the mid to lower reaches of Lockyer Creek catchment. The species was not identified from field investigations and there are no database records within the Project disturbance footprint or the ecology study area for this species. The nearest record exists approximately 7 km to the east of the Project disturbance footprint at the Lockyer Reserve dated 1996. Most records within a 50 km buffer of the Project disturbance footprint occur to the east from the Lockyer Reserves to Lowood. Most records for this species occur to the west and outside of a 50 km buffer of the Project disturbance footprint (AoLA 2020b). It may be assumed that there is no local population in the ecology study area, which is further supported by the absence of suitable habitat based on predictive habitat modelling (refer Table 4.28). As such it is considered unlikely the Project will lead to a long term decrease in the size of a local population.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Grey snake)
Reduce the area of occurrence of the species	The area of occupancy is estimated to be 195,000 km^2, while the home range of the species has been recoded between 338 ha and 4,700 ha. Breeding pairs have been confirmed to the north and south of the Project, while the species has also been identified from within the ecology study area. Noting that the ecology study area is likely part of a pairs home range. The Project disturbance footprint is estimated to contain 99.05 ha of general habitat for the species (refer Table 4.28). The Project is unlikely to be a barrier to movement of the local pairs. That is, highly vagile and will still be able to access the substantial remnant and regrowth vegetation surrounding the Project throughout the Toowoomba Range and to the east throughout the Helidon Hills. The recovery plan for large forest owls (DoEC 2006) notes that there are no barriers to dispersal or gene flow other than extensive treeless country. The Project will not impede the movement of the species across the landscape, noting that there are no confirmed breeding sites in the Project disturbance footprint. As such the Project is unlikely to reduce the area of occupancy of the species.	The species range is extensive (~472,000 km^2), however suitable habitat is limited within this extent and as such the area of occupancy is 464 km2. There is no predicted habitat for the species within the Project disturbance footprint or the surrounding ecology study area (refer Table 4.28). Given the lack of specimen backed records within the Project disturbance footprint, ecology study area and surrounding landscape the species is unlikely to be encountered in relation to the Project. There is substantial remnant and regrowth vegetation surrounding the Project throughout the Toowoomba Range and to the east throughout the Lockyer Reserves where the species is most likely to occur. The Project will incorporate fauna-friendly crossing structures allowing passage across the alignment, including within floodplains of Gowrie Creek, Oaky Creek, Six Mile Creek and Lockyer Creek. The structures will also provide an opportunity for the native vegetation to be retained (e.g. viaducts are up to 41 m above the ground level and in some area above the tree canopy). and a significant proportion of the alignment will be underground. Given the low likelihood of the species occurring in the area based on local records and presence of suitable habitat, it is unlikely that the Project will reduce the area of occupancy of the species.
Fragment an existing population	Breeding pairs have been confirmed to the north and south of the Project, while the species has also been identified from within the ecology study area. Noting that the ecology study area is likely part of a pairs home range. The linear nature of the Project will result in the fragmentation of local habitats, including mapped habitat for the Powerful owl (refer Section 5.1.2.7 and Appendix G). Rail lines are also known barrier to a number of species (refer Section 5.1.2.8), though this is unlikely to be the case for the Powerful owl a highly vagile species. The recovery plan for large forest owls (DoEC 2006) notes that there are no barriers to dispersal or gene flow other than extensive treeless country. The Project will not result in the fragmentation of an existing population.	Despite the species extensive range, the population is likely to be severely fragmented. The species was not identified from field investigations and there are no database records within the Project disturbance footprint or the ecology study area for this species. The nearest record exists approximately 7 km to the east of the Project disturbance footprint at the Lockyer Reserve dated 1996. Most records within a 50 km buffer of the Project disturbance footprint occur to the east from the Lockyer Reserves to Lowood. Most records for this species occur to the west and outside of a 50 km buffer of the Project disturbance footprint (AoLA 2020b). It may be assumed that there is no local population in the ecology study area, which is further supported by the absence of suitable habitat based on predictive habitat modelling (refer Table 4.28). Despite this the Project will incorporate fauna-friendly crossing structures allowing passage across the alignment, including within floodplains of Gowrie Creek, Oaky Creek, Six Mile Creek and Lockyer Creek. The Project will not result in the fragmentation of an existing population.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Grey snake)
Result in genetically distinct populations forming as a result of habitat isolation	The Project disturbance footprint is estimated to contain 99.05 ha of general habitat for the species (refer Table 4.28) and will intersect a State significant bioregional corridor. The recovery plan for large forest owls (DoEC 2006) notes that there are no barriers to dispersal or gene flow other than extensive treeless country. The Project will not result in genetically distinct populations forming as a result of habitat isolation.	The size of the population is unknown, and is considered fragmented across the species range. Further there is limited information on the genetic variability across the population. The species was not identified from field investigations and there are no database records within the Project disturbance footprint or the ecology study area for this species. The nearest record exists approximately 7 km to the east of the Project disturbance footprint at the Lockyer Reserve dated 1996. Most records within a 50 km buffer of the Project disturbance footprint occur to the east from the Lockyer Reserves to Lowood. Most records for this species occur to the west and outside of a 50 km buffer of the Project disturbance footprint (AoLA 2020b). It may be assumed that there is no local population in the ecology study area, which is further supported by the absence of suitable habitat based on predictive habitat modelling (refer Table 4.28). Despite this the Project will incorporate fauna-friendly crossing structures allowing passage across the alignment, including within floodplains of Gowrie Creek, Oaky Creek, Six Mile Creek and Lockyer Creek. Given the low likelihood of the species occurring in the area based on local records and presence of suitable habitat, the Project is unlikely to result in genetically distinct populations forming as a result of habitat isolation.
Result in invasive species that are harmful to a 'Vulnerable' species becoming established in the species habitat	The species is susceptible to predation from foxes. The Project is unlikely to result in the establishment of invasive species that are a threat to Powerful owls, with foxes already established in the area. However, there is a risk that the Project results in new infestations or the proliferation of existing invasive 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 feral predators (i.e. cats and foxes), 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.	Threats from invasive species include degradation of wetlands due to feral pigs, with pigs also competing with the Grey snake for frogs. Cane toads are also a threat to this 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 feral predators (i.e. cats and foxes), 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.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Grey snake)
Introduce disease that may cause the population to decline	The recovery plan for large forest owls (DoEC 2006) notes that there is a low incidence of natural pathogens in nestling and fledgling Powerful Owls, along with adult owls. 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.	There are no known diseases which are a threat to this species. 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	A NSW state recovery plan for large forest owls, which includes Powerful owl is available, however there is no recovery plan in QLD. Key recovery actions relevant to the Project include protecting strategic corridors, protection or improvement of owls prey base and control of introduced predators. The Project is located in a State significant bioregional corridor and has the potential to reduce connectivity of the corridor. The design involves a range of measures to maintain permeability across the alignment in the long-term though the use of a tunnel and viaducts. The Project disturbance footprint is estimated to contain 99.05 ha of general habitat considered suitable for the species (refer Table 4.28). The Project is likely to result in the removal of large old trees with large hollows which is a known threat to the species. Of the hollow bearing trees mapped within the Project disturbance footprint none were confirmed as supporting Powerful owls, however the removal of the trees will impact on the owls pre base As noted above, there is the potential for invasive species to use the rail corridor to move around the local landscape. As such there is a risk to the recovery of the species due to predation on fledglings. Therefore, the Project is has the potential to interfere with the recovery of the species.	The draft Queensland Brigalow Belt Reptile Recovery Plan (Richardson, R. 2009) applies to the Grey snake. Recovery actions focus on addressing issues associated with livestock, feral animals and changes to hydrology. As outlined above, there is a risk for the proliferation of invasive species as a result of the Project. ARTC will implement measures to manage the risk of invasive species proliferating within the region. The Project is located in the Gowrie Creek floodplain, and intersects the floodplains of Okay Creek, Rocky Creek, Six Mile Creek and Lockyer Creek. With the exception of these riverine wetlands, wetland habitats within and downstream of the Project are limited. Hydrological modelling indicates that there will be limited to no change to the hydrology of the watercourses intercepted by the Project outside of the Project footprint. The Project design also incorporates over 6 km of structures which will minimise the presence of infrastructure within floodplains and in-stream habitats. Given there are no records of the species in the ecology study area and suitable habitat is not present, along with the measures/findings above the Project is unlikely to interfere with the recovery of the species.
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations include large vertical tree hollows in which this species relies on for breeding (Kavanagh 1997). The removal of any large hollow bearing trees could be considered a disruption to an ecologically significant location. Large trees are contained within the Project disturbance footprint within the Toowoomba range and as such their removal may cause disruption to ecologically significant locations. Mitigation measures during clearing will include the presence of qualified fauna spotter/catcher, including pre-clearing habitat to identify potential habitat features (such as large tree hollows).	Ecologically significant locations include woodland heavy, cracking clay soils associated with water bodies, gilgai and low-lying watercourses Given that this species is associated with water bodies and watercourses the change or disruption to these systems or associated water flow could be considered a disruption to an ecologically significant location. This habitat type is limited within ecology study area, with no predicted habitat for the species present tin the Project disturbance footprint The Project is considered unlikely to cause a disruption to an ecologically significant location for this species.

Criteria	Assessment against significance criteria (Powerful owl)	Assessment against significance criteria (Grey snake)
Assessment of potential for significant residual impacts	**The Project has the potential to have a significant residual impact on this species** through the permanent loss of habitat and the potential to cause disruption to ecologically significant locations, including the removal of hollow bearing trees and gully vegetation.	**The Project is unlikely to have a significant residual impact on this species**

Table 5.15 Matters of state environmental significance significant residual impact criteria – 'Special least concern' fauna

Criteria	Assessment against significance criteria (Short-beaked Echidna)	Assessment against significance criteria (Platypus)
A long term decrease in the size of a local population	The echidna is Australia's most widespread native mammal occurring through Australia. There are four named subspecies, with the eastern Australia subspecies (*Tachyglossus aculeatus aculeatus*) relevant to the Project. The presence of variation within the subpopulations is minor and largely geographically continuous. As such it is assumed that any individuals within the ecology study area are part of this subpopulation. Echidnas have ranges observed between 21 and 93 ha and are able to live anywhere that provides a good supply of ants and termites (AoLA 2020a). These homes ranges tend to overlap, through the species is generally solitary except for mating. The species has been recorded form within the Project disturbance footprint where the alignment intersects Murphys Creek Road in Lockyer Valley. Two records exist to the north of the Project disturbance footprint within the ecology study area with one at Blue Mountain Heights (2014) and another to the east however this second record is old (1979). The Project disturbance footprint comprises 161.69 ha of predicted general habitat for the species (refer Table 4.28 and Appendix G). Construction activities impact on the local individuals inhabiting these areas through direct mortality or changes to the movement patterns, though this is unlikely to reduce the local population; especially as appropriate management measures are implemented during construction (e.g. pre-clearing surveys, relocation of individuals, temporary exclusion fencing etc). Given the linear nature of the Project there is the potential for the Project to act as a barrier to movement across the local landscape in the long-term. The current design incorporates a range of measures which will maintain permeability across the alignment including over 6 km of bridges and viaducts and a 6.24 km tunnel. In addition, there are a number of culverts proposed which may also facilitate fauna movement when complimented with fauna friendly fencing. The Project is not expected to lead to a long term decrease in the size of a local population.	Genetic studies suggest that there are four major platypus population units in Australia, respectively inhabiting Tasmania and King Island, New South Wales and Victoria, central Queensland, and north Queensland. The studies also indicated that there can be genetic differences between adjacent catchments and that the Great Dividing Range is not a major genetic barrier. The Platypus was identified as occurring within Gowrie Creek during EIS associated field investigations. This observation was documented in areas above the proposed tunnel (i.e. outside of the proposed project disturbance footprint) (refer Figure 4.19). There are no other records from Gowrie Creek catchment despite the creek being a perennial system. There is a single record from Lockyer Creek within the ecology study area upstream of the Project. Other records occur to the north and south of the Project disturbance footprint along Lockyer Creek. The specimens within the Lockyer Creek catchment are likely part of a local population. Noting that the alignment via the township of Murphys Creek was originally identified by locals as a potential risk to local platypus populations inhabiting Murphys Creek and the upper reaches of Lockyer Creek. Other records including recent (2014) occur to the north and south of the Project disturbance footprint along Murphys Creek. Records occur to the north of the Project disturbance footprint within and surrounding Crows Nest National Park located approximately between 20 and 30 km from the alignment. A few records occur to the east of the Project disturbance footprint between Gatton and Laidley however these do not have dates and are not considered reliable. The Project disturbance footprint comprises 46.83 ha of predicted general habitat for the species (refer Table 4.28 and Appendix G). This is a conservative estimate based on predictive mapping and is very likely a substantial overestimate given that the majority of this habitat is associated with ephemeral watercourses and drainage lines, and that there are limited permanent pools along the main channels of Oaky, Rocky, Six Mile and the Lockyer creeks to support this species. Prior to any in-stream works or works along the high water bank, pre-clearing surveys along the reach intersected by the Project will be undertaken to confirm the presence of platypus habitat, including burrows. Where detected migration measures and management strategies swill be developed and implemented during construction (e.g. mapping out burrows, avoiding works when dependent juveniles are present in burrows, working during daylight hours etc).

Criteria	Assessment against significance criteria (Short-beaked Echidna)	Assessment against significance criteria (Platypus)
		The Project is not likely to alter the hydrology of the catchment in the long-term (refer EIS Appendix M: Flooding and hydrology). There are some temporary barriers proposed as part of the construction works. Permanent waterway barriers will include culverts and roads which will be designed to minimise impacts to in-stream habitats, the riparian zone and banks, along with flows These barriers will mainly be associated with ephemeral watercourse in the upper reaches of Oaky, Rocky, Six Mile and the Lockyer creeks rather than the main channels. Other threats to the species relevant to the Project include ■ Degradation of water quality – more of a risk during construction especially sedimentation and litter, noting that sedimentation is already an issue in the Lockyer Creek channel. There is a low risk during operations. Further information is provided in EIS Appendix L: Surface Water. ■ Predation – a number of predators are already established in the area and there is a risk that the Project results in new infestations or the proliferation of existing invasive species. ARTC will manage biosecurity matters in accordance with relevant biosecurity plans during construction and operations. The Project will not lead to a long-term decrease in the size of a local population.
A reduced extent of occurrence of the species	The species is Australia's most widespread mammal, occupying a wide range of habitats throughout Australia. The Project disturbance footprint is estimated to contain 161.69 ha of general habitat considered suitable for the species (refer Table 4.28 and Appendix G). This is a wide-ranging species which occurs all over Australia and in most habitats. The Project will include measures to facilitate fauna movement across the alignment ensuring that the species can still utilise the existing landscape. There is potential for the Project to reduce the area of occupancy of the species but only to a minor extent.	The species range is extensive (~1,100,000 km^2), while the area of occupancy which is declining is estimated to be 12,000 km^2. The Project disturbance footprint comprises 46.83 ha of predicted general habitat for the species (refer Table 4.28 and Appendix G). This is a conservative estimate based on predictive mapping and is very likely a substantial overestimate of the actual habitat available for the species. The species is known from Gowrie Creek where the Project is within tunnel, with the record seven (7) km upstream of the Gowrie Junction Road bridge. The species may also be present in Lockyer Creek, and to a lesser extent Oaky Creek, Rocky Creek and Six Mile Creek which are ephemeral systems with limited presence of large permanent pools to act as refugia habitat. Impacts to waterways will be temporary and restricted to construction of crossing structures, with all crossings on viaduct or for roads design to ensure minimal impediment to baseline environment flows. The Project is not expected to reduce the area of occupancy of the species.

Criteria	Assessment against significance criteria (Short-beaked Echidna)	Assessment against significance criteria (Platypus)
Fragmentation of an existing population	There are four named subspecies, with the eastern Australia subspecies (*Tachyglossus aculeatus aculeatus*) relevant to the Project. The presence of variation within the subpopulations is minor and largely geographically continuous. As such it is assumed that any individuals within the ecology study area are part of this subpopulation. The Project disturbance footprint comprises 161.69 ha of general habitat for the species (refer Table 4.28). There are extensive areas surrounding the Project comprising suitable habitat for the species. This species is wide ranging and is able to live in a variety of habitats as long as food is available. Given the linear nature of the Project there is the potential for the Project to act as a barrier to movement across the local landscape in the long-term. The current design incorporates a range of measures which will maintain permeability across the alignment including over 6 km of bridges and viaducts and a 6.24 km tunnel. In addition, there are a number of culverts proposed which may also facilitate fauna movement when complimented with fauna friendly fencing. The species is also likely to show a degree of resilience to the noise, light and dust which can impact movement patterns. The Project will not fragment an existing population.	Genetic studies suggest that there are four major platypus population units in Australia, respectively inhabiting Tasmania and King Island, New South Wales and Victoria, central Queensland, and north Queensland. The studies also indicated that there can be genetic differences between adjacent catchments and that the Great Dividing Range is not a major genetic barrier. The Project is within tunnel where the Project intersects the known record of this species Gowrie Creek. Proposed works on Gowrie Creek are limited to the Gowrie Junction Road bridge approximately seven (7) km downstream of this record. The Project is within tunnel where the Project intersects the known record of this species Gowrie Creek. Proposed works on Gowrie Creek are limited to the Gowrie Junction Road bridge approximately seven (7) km downstream of this record. The Project is not likely to be a permanent barrier to the species movement with a viaduct over the main channel of Lockyer Creek, along with Oaky Creek and Six Mile Creek proposed. This will avoid works below the high water bank, while hydrology modelling indicates limit changes to flows in terms of depth and velocity. While access roads will be designed to minimise potential impediments to baseline environmental flows. Construction disturbance at crossings will be temporary and localised. The Project will not create flow disturbance or create new impoundments when construction is finished. The Project will not fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	No publications on genetic differences among populations have been published, though as noted above there are four subpopulations of echidna across Australia with the eastern Australia subspecies (Tachyglossus aculeatus aculeatus) relevant to the Project. The presence of variation within the subpopulations is minor and largely geographically continuous. As such it is assumed that any individuals within the ecology study area are part of this subpopulation. The Project disturbance footprint comprises of 161.69 ha of general habitat for the species (refer Table 4.28). There are extensive areas to the north and south of the Project that comprise suitable habitat for the species. This species is wide ranging and is able to live in a variety of habitats as long as food is available.	Genetic studies suggest that there are four major platypus population units in Australia, respectively inhabiting Tasmania and King Island, New South Wales and Victoria, central Queensland, and north Queensland. The studies also indicated that there can be genetic differences between adjacent catchments and that the Great Dividing Range is not a major genetic barrier. The Project is within tunnel where the Project intersects the known record of this species Gowrie Creek. Proposed works on Gowrie Creek are limited to the Gowrie Junction Road bridge approximately seven (7) km downstream of this record. The Project is not likely to be a permanent barrier to the species movement with a viaduct over the main channel of Lockyer Creek, along with Oaky Creek and Six Mile Creek proposed. This will avoid works below the high water bank, while hydrology modelling indicates limit changes to flows in terms of depth and velocity. While access roads will be designed to minimise potential impediments to baseline environmental flows.

Criteria	Assessment against significance criteria (Short-beaked Echidna)	Assessment against significance criteria (Platypus)
	Given the linear nature of the Project there is the potential for the Project to act as a barrier to movement across the local landscape in the long-term. The current design incorporates a range of measures which will maintain permeability across the alignment including over 6 km of bridges and viaducts and a 6.24 km tunnel. In addition, there are a number of culverts proposed which may also facilitate fauna movement when complimented with fauna friendly fencing. The species is also likely to show a degree of resilience to the noise, light and dust which can impact movement patterns. The Project is considered unlikely to cause fragmentation such that genetic isolation of populations will occur.	Construction disturbance at crossings will be temporary and localised. The Project will not create flow disturbance or create new impoundments when construction is finished. The Project will not cause fragmentation such that genetic isolation of populations will occur.
Disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations include ground timber such as hollow logs, caves and crevices in which the species may utilise for feeding, refuge and reproduction. Noting that the species does not have a fixed nest site. Field investigations have confirmed that these habitat features are present across Project disturbance footprint and that the species is present within the Project disturbance footprint. This species has potential to be encountered during vegetation clearing for the construction and operation of the Project, including the potential for the works to disrupt breeding. Echidnas have ranges observed between 21 and 93 ha and are able to live anywhere that provides a good supply of ants and termites (AoLA 2020a). These homes ranges tend to overlap, through the species is generally solitary except for mating. Mitigation measures during clearing will include the presence of qualified fauna spotter/catcher during clearing, including pre-clearing surveys to investigate potential habitat features. Individuals will be translocated to suitable habitat away from the works area. Other works will include the erection of temporary fencing to exclude fauna from construction sites, relocation of large woody debris into adjacent habitats, speed restrictions and ensure movement pathways are maintained. This works will be managed through a species management plan, including approval to tamper with any breeding place under Section 335 of the Nature Conservation (Animals) Regulation 2020. Given the linear nature of the Project there is the potential for the Project to act as a barrier to movement across the local landscape in the long-term. The current design incorporates a range of measures which will maintain permeability across the alignment including over 6 km of bridges and viaducts and a 6.24 km tunnel. In addition, there are a number of culverts proposed which may also facilitate fauna movement when complimented with fauna friendly fencing.	Ecologically significant locations for this species include streambank burrows which the species uses for breeding and resting. As noted above, the species prefers watercourses with permanent water, with the majority of the watercourses associated with the Project are ephemeral with limited occurrence of permeant pools near the proposed crossings. As such habitat for the species is likely only present in the main channel of Gowrie Creek (where the species was observed and Lockyer Creek). Works is limited in Gowrie Creek, with a tunnel proposed near the section of the creek the species was identified from (refer Section 4.3.2.2). Also, a bridge crossing is proposed at Gowrie Junction approximately 7 km downstream from the record. There are no other records of this species in Gowrie Creek and Oakey Creek catchments. For Lockyer Creek, along with Oaky Creek and Six Mile Creek, viaducts are proposed with spans above and outside of the main channel and the riparian zone. Other threats to the species relevant to the Project include predation by fox and wild dogs, litter, water extraction. Mitigation measures during construction disturbance will include pre-clearing surveys to investigate potential Platypus presence and burrows in the vicinity of crossing areas, with this works limited to major watercourses such as Gowrie Creek and Lockyer Creek. Platypus is known to have home ranges well over 2.5 km and will use multiple burrows. Specific measures to manage impacts during construction may include: ■ Works along banks or in-stream should ideally be scheduled outside the period when dependent juveniles are present in burrows. ■ Identify burrows as no-go zones The Project is considered unlikely to disrupt an ecologically significant location to the extent a significant impact is likely to occur on the species.

Criteria	Assessment against significance criteria (Short-beaked Echidna)	Assessment against significance criteria (Platypus)
	The Project is unlikely to disrupt an ecologically significant location to the extent a significant impact is likely to occur on the species.	
Assessment of potential for significant residual impacts	**The Project is unlikely to have a significant residual impact on this species**	**The Project is unlikely to have a significant residual impact on this species**

Table 5.16 Matters of state environmental significance significant residual impact criteria – 'Vulnerable' Flora (*Caustis blakei* subsp*. macrantha, Cyperus clarus* and *Marsdenia coronata*)

Criteria	Assessment against significance criteria (*Caustis blakei subsp. macrantha*)	Assessment against significance criteria (*Cyperus clarus*)	Assessment against significance criteria (*Marsdenia coronata*)
Lead to a long-term decrease in the size of a local population of the species	*Caustis blakei subsp. macrantha* is a shrub that inhabits tall open eucalypt forests with a sparse canopy, on sandstone ridges and soils derived from weathered sandstone. This species is restricted in its distribution to Murphys Creek and Helidon (DES 2020e). Further details are provided in Appendix B. The species has not been recorded from the field investigations and there are no database records for this species within the Project disturbance footprint or within the ecology study area. The nearest record occurs at Helidon to the east of the ecology study area however it is an old record (1962) and therefore not reliable. Most records occur within the Lockyer Reserves to the north-east of the eastern section of the alignment. The nearest of these is approximately 3 km from the Project disturbance footprint and is dated 2001. There is a predicted 10.41 ha of general habitat for the species within the Project disturbance footprint (refer Table 4.28 and Appendix G). This is a conservative estimate based on predictive mapping and may be a substantial overestimate of the actual habitat available for the species. Given the small area of predicted suitable habitat for the species within the Project disturbance footprint and the lack of database records within the ecology study area the Project is unlikely to lead to a long term decrease in the size of a local population of this species.	Cyperus clarus is a sedge that grows in grassland or open woodland, in heavy soils derived from basalt between Emerald and Delungra on the NSW north-west slopes. Further details are provided in Appendix B. Cyperus clarus has been recorded above the Toowoomba Range Tunnel (refer Section 4.3.2.2) and no impacts to the population are anticipated. The area is mapped as a potential GDE (i.e. unconsolidated sedimentary aquifer) and there is the potential that drawdown from the tunnels construction and operation may impact this community. However, groundwater modelling (refer EIS Appendix N: Groundwater) predicated any drawdown in the shallow aquifers as a result of the Projects construction and operation. There are also numerous specimen backed records in the area to the south of the Project, outside of the Project disturbance footprint (DES 2020f). No habitat for the species is estimated to occur within the Project disturbance area (refer Table 4.28 and Appendix G). Though it is noted that this species occurs in grassland or open woodland, in heavy soils derived from basalt, with attenuated grasslands a common feature of the Gowrie Creek floodplain. Given that the local population of the species is known to occur in the area above the tunnel and there are no short- or long-term drawdown impacts to the shallow Main Range Volcanic aquifer in this area as a result of the Project, the Project is not expected to lead to a long term decrease in the size of a local population.	*Marsdenia coronata* (Slender milkvine) is a herbaceous vine, which is restricted to SEQ where it commonly grows in rainforest or moist areas of open forest, especially in eucalypt forest. Further details are provided in Appendix B. *Marsdenia coronata* (12 individuals) has been recorded within the Project disturbance footprint from field investigations undertaken for the Project (refer Section 4.3.2.2). The remnant vegetation surrounding these records are also mapped as wildlife habitat and essential habitat under the VM Act. The majority of the records occur east of Ipswich approximately 60 km from the Project disturbance footprint. (DES 2020g). There is a record from the Great Dividing Range approximately 30 km south east of the Project. A total of 51.02 ha of general habitat for the species is estimated to occur within the Project disturbance footprint (refer Table 4.28 and Appendix G). This is a conservative estimate based on predictive habitat mapping and may be a substantial overestimate of the actual habitat available for this species. The Project is not likely to lead to a long term decrease in the size of a local population of the species (i.e. all the known individuals (12) or the local population with will be entirely removed in the short term).

Criteria	Assessment against significance criteria (*Caustis blakei subsp. macrantha*)	Assessment against significance criteria (*Cyperus clarus*)	Assessment against significance criteria (*Marsdenia coronata*)
Reduce the area of occurrence of the species	The species extent of occurrence is estimated to be 300 km^2, while the species area of occupancy is estimated at 68 km^2. The majority of the records are associated with Helidon Hills east of Lockyer Creek, including Lockyer National Park. The Project intersects the floodplain of Lockyer Creek near these records, however this area is unlikely to support the species (i.e. species occurs in tall open eucalypt forests with a sparse canopy, on sandstone ridges and soils derived from weathered sandstone). It is unlikely that the Project will reduce the area of occupancy of the species	The species extent of occurrence is estimated to be 326,000 km^2, while the species area of occupancy is estimated at 320 km^2. There are no individuals known from the Project disturbance footprint, though the species was identified from above the tunnel (refer Section 4.3.2.2). This population is unlikely to be impacted by the Project. Grasslands are also the main habitat type in the Gowrie Creek floodplain (refer Table 4.30), however no suitable for the species is not predicted to occur within the Project disturbance (refer Table 4.28 and Appendix G). It is unlikely that the Project will reduce the area of occupancy of the species but only to a minor extent.	The species extent of occurrence is estimated to be 23,000 km^2, while the species area of occupancy is estimated at 432 km^2. As noted in Section 4.3.2.2, the record has resulted in the area of occupancy extending and extent of occurrence increasing. The species has been confirmed to occur within the Project disturbance footprint and the Project is likely to reduce the area of occurrence of the species (i.e. clear all 12 individuals and surrounding habitat).
Fragment an existing population	All known records occur east of Lockyer Creek in the Helidon Hills area in a large are of contiguous remnant vegetation, with the Project avoiding this area. The Project disturbance footprint is estimated to contain 10.41 ha of general habitat considered suitable for the species (refer Table 4.28 and Appendix G), although this is likely a substantial overestimation. There are large areas of similar habitat adjacent to the Project at the Lockyer Reserves. This area would be considered suitable habitat for the species with a number of database records. The Project is linear and not likely to fragment an existing population for this species.	As noted in Section 4.3.2.2, this species, a population of *Cyperus clarus* was identified above the tunnel and as there are no proposed surface works in this area this population is unlikely to be impacted. Based on predictive habitat modelling no suitable habitat for the species occurs within the Project disturbance footprint (refer Table 4.28 and Appendix G). The Project is considered unlikely to fragment an existing population.	As noted in Section 4.3.2.2, this species has been confirmed to occur within the Project disturbance footprint and the Project is likely to remove the entire population (i.e. clear all 12 individuals and surrounding habitat). As such, the Project is considered unlikely to fragment an existing population.

Criteria	Assessment against significance criteria (*Caustis blakei subsp. macrantha*)	Assessment against significance criteria (*Cyperus clarus*)	Assessment against significance criteria (*Marsdenia coronata*)
Result in genetically distinct populations forming as a result of habitat isolation	All known records occur east of Lockyer Creek in the Helidon Hills area in a large are of contiguous remnant vegetation, with the Project avoiding this area. The Project is linear and will result in the fragmentation of a range of habitats and with the Toowoomba Bypass will result in the isolation of habitats (e.g. Wards Hill). There are no known populations of this species in these isolated habitats, though a patch of general habitat near Ch 17.0 km will be isolated as a result of the two projects (refer Appendix G). Given there are no known records in the area west of Lockyer Creek and that the known records are scattered across the area of extent, the Project is not likely to result in genetically distinct populations forming as a result of habitat isolation.	As noted in Section 4.3.2.2, this species, a population of *Cyperus clarus* was identified above the tunnel and as there are no proposed surface works in this area this population is unlikely to be impacted. Based on predictive habitat modelling no suitable habitat for the species occurs within the Project disturbance footprint (refer Table 4.28 and Appendix G). The Project disturbance footprint comprises no suitable habitat for the species. The Project, although linear in its design is not wide enough to separate this species into genetically distinct populations. The Project is not likely to result in genetically distinct populations forming through the process of habitat isolation.	As noted in Section 4.3.2.2, this species has been confirmed to occur within the Project disturbance footprint and the Project is likely to remove the entire population (i.e. clear all 12 individuals and surrounding habitat). The Project is linear and will result in the fragmentation of a range of habitats and with the Toowoomba Bypass will result in the isolation of habitats (e.g. Wards Hill). There are no known populations of this species in these isolated habitats, though a patch of general habitat near eastern tunnel portal will be isolated as a result of the two projects (refer Appendix G). Given that genetic material is spread via insect transmission and seeds can spread widely by wind, the formation of genetically distinct populations is not likely to occur. As such, the Project is considered unlikely to result in genetically distinct populations forming through the process of habitat isolation.
Result in invasive species that are harmful to a 'Vulnerable' species becoming established in the species habitat	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 5.1.2.4). 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 that are harmful to a 'Vulnerable' species becoming established in the species habitat.		
Introduce disease that may cause the population 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 these 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.		

Criteria	Assessment against significance criteria (*Caustis blakei subsp. macrantha*)	Assessment against significance criteria (*Cyperus clarus*)	Assessment against significance criteria (*Marsdenia coronata*)
Interfere with the recovery of the species	There is no State recovery plan for *Caustis blakei* subsp. *macrantha*. However, it is noted that there is the Biodiversity Recovery Plan for Gatton and Laidley Shires South-East Queensland 2003-2008 (Boyes, B 2004), while a range of management measures are recommended for this species under the back on track framework. The main threat to the recovery of the species from the Project is inappropriate fire regimes. Noting that the Project disturbance footprint is estimated to contain 10.41 ha of general habitat considered suitable for the species (refer Table 4.28), although this is likely a substantial overestimation. The species distribution is largely restricted to Helidon Hills to the north of the eastern section of the Project. The Project is not likely to interfere with the recovery of the species as suitable habitat for the species in the surrounding landscape will be left undisturbed.	The is no recovery plan for *C. clarus*. However, a range of management measures are recommended for this species under the back on track framework. As noted in Section 4.3.2.2, this species was identified from above the Toowoomba Range Tunnel and as such threats from clearing, weed proliferation and changes to hydrology are unlikely. It is unlikely that the Project will interfere with the recovery of the species.	No State recovery plan exists for *M. coronata* nor is there a relevant recovery plan. The Project is likely to interfere with the recovery of the species, through the loss of the local population and the estimated 51.02 ha of general habitat in which this species is predicted to occur (refer Table 4.28 and Appendix G). It is likely that the Project will interfere with the recovery of the species.
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations could be considered as populations/records of the species. The majority of the records and habitat suitable for the species is associated with Helidon Hills to the east of Lockyer Creek and north of the Project. No works are proposed in these areas, however there is the risk of fires as a result of the Project. Fire prevention measures will be implemented during construction and operations, along with ongoing communication with the local disaster management groups and Helidon Magazine group. The Project is unlikely to cause disruption to an ecologically significant location for this species.	Ecologically significant locations could be considered as populations/records of the species. As noted in Section 4.3.2.2, this species was identified from above the Toowoomba Range Tunnel and as such the area in which the species occurs can be considered to be an ecologically significant location. Given there is no disturbance above the tunnel in this location and that groundwater modelling indicates that drawdown as a result of the tunnels construction and operation is unlikely in the shallow aquifers, the Project is unlikely to cause disruption to an ecologically significant location for this species.	Ecologically significant locations could be considered as populations/records of the species. As noted in Section 4.3.2.2, this species was identified from the Project footprint and as such the area in which the species occurs can be considered to be an ecologically significant location. The Project is likely to result in the permanent loss of this population and as such will cause disruption to an ecologically significant location of a species.

Criteria	Assessment against significance criteria (*Caustis blakei subsp. macrantha*)	Assessment against significance criteria (*Cyperus clarus*)	Assessment against significance criteria (*Marsdenia coronata*)
Assessment of potential for significant residual impacts	The Project is estimated to result in the clearance of 10.41 ha of general habitat suitable for *Caustis blakei* subsp. *macrantha* (refer Table 4.28 and Appendix G). However, there are no records of the species west of Lockyer Creek which in part is due geology (i.e. species prefers sandstone hill tops) **The Project is unlikely to have a significant residual impact on this species**	The Project will result in no clearance of habitat suitable for *C. clarus*. The Project has the potential to reduce the area of occurrence for the species however this only on a local scale. The Project, although unlikely, has the potential to cause disruption to an ecologically significant location for this species. **The Project is unlikely to have a significant residual impact on this species**	The species has been confirmed as being present within the Project disturbance footprint, with the population to be cleared as a result of the Project. The Project will also result in the clearance of 51.02 ha of essential habitat suitable for *M. coronata*. **Project has potential to cause a 'significant residual impact' on this species.** Further measures will be undertaken during detailed design to avoid and/or minimise the impact, including reducing the extent of the disturbance footprint through this area and/or translocation of individuals.

Table 5.17 Matters of state environmental significance significant residual impact criteria – 'Near threatened' Flora (*Callitris baileyi* and *Digitaria porrecta)*

Criteria	Assessment against significance criteria (*Callitris baileyi*)	Assessment against significance criteria (*Digitaria porrecta*)
Lead to a long-term decrease in the size of a local population of the species	Callitris baileyi (Bailey's cypress) occurs on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, blue gum and spotted gum and is found sporadically throughout SEQ from the border to Goomeri and Bunya Mountains (DES 2020h). Further details are provided in Appendix B. No records exist for this species within the Project disturbance footprint or within the ecology study area, while the species was also not recorded from field investigations, including targeted protected plant surveys. The nearest record, dated 2019, occurs to the north of Helidon at the Lockyer Reserves approximately 3 km from the Project disturbance footprint. Other records for Callitris baileyi occur approximately 7 km north of the Project at Highfields and are also dated from 2019. As outlined in Table 4.18, RE 11.8.8 is known to support this species however this community is not present in the Project disturbance footprint. There is a predicted is a predicted 213.09 ha of general habitat for the species within the Project disturbance footprint (refer Table 4.28). This is a conservative estimate based on predictive mapping and may be a substantial overestimate of the actual habitat available for the species. As there are no records within the Project disturbance footprint the Project is not expected to lead to a long term decrease in the size of a local population for this species.	*Digitaria porrecta* (Finger panic grass) is associated with tussock grassland, open woodland and native pasture within the Brigalow Belt Bioregion in QLD (DES 2020i) and is at the edge of its range in relation to the Project. Further details are provided in Appendix B. *Digitaria porrecta* was recorded from attenuated grasslands associated with the Project disturbance footprint within the Gowrie area (refer Section 4.3.1.2) with the records at the eastern extent of its distribution (i.e. there are no records east of the Great Dividing Range). Essential habitat under the VM Act (refer Section 4.2.3) has been mapped for this species in the Gowrie Creek floodplain, though the species was recorded from non-remnant areas (i.e. attenuated grasslands in the rail and road corridors). There is a predicted 48.52 ha of total habitat (i.e. 43.25 ha general habitat and 5.27 ha essential habitat) for the species within the Project disturbance footprint (refer Table 4.28 and Appendix G). This is a conservative estimate based on predictive mapping and may be a substantial overestimate of the actual habitat available for the species. Given that the Project will result in the removal of the local populations of *Digitaria porrecta*, the Project is likely to lead to a long term decrease in the size of a local population of the species.
Reduce the area of occurrence of the species	The species extent of occurrence is estimated to be between 15,000 and 25,000 km^2, while the species area of occupancy is estimated at 450 km^2 (AoLA datasets). There is a predicted 213.09 ha of general habitat for the species within the Project disturbance footprint (refer Table 4.28 and Appendix G). There are no records in these areas, with the Project outside of the species area of occupancy. It is unlikely that the Project will reduce the area of occupancy of the species.	The species extent of occurrence is estimated to be between 15,000 and 30,000 km^2, while the species area of occupancy is estimated at 880 km^2. *Digitaria porrecta* has been recorded within the Project disturbance footprint (refer Section 4.3.1.2) with the Project likely to result in the permanent removal of the local populations. The species is associated with tussock grassland, open woodland and native pasture (DES 2020i). There is a predicted 48.52 ha of total habitat (i.e. 43.25 ha general habitat and 5.27 ha essential habitat) for the species within the Project disturbance footprint (refer Table 4.28).This is a conservative estimate based on predictive mapping and may be a substantial overestimate of the actual habitat available for the species. The Project has the potential to reduce the area of occurrence for this species through the permanent loss of existing populations and the removal of 5.27 ha of essential habitat.

Criteria	Assessment against significance criteria (*Callitris baileyi*)	Assessment against significance criteria (*Digitaria porrecta*)
Fragment an existing population	The Project disturbance footprint is estimated to contain 213.09 ha of general habitat considered suitable for the species (refer Table 4.28), although this is likely a substantial overestimation. There are large areas of similar habitat suitable for this species to the north and south of the alignment along the Toowoomba Range where other database records occur. The Project is linear and not likely to fragment an existing population for this species.	The species has been confirmed to occur within the Project disturbance footprint and the Project is likely to remove the entire population at each of the locations. As such, the Project is considered unlikely to fragment an existing population.
Result in genetically distinct populations forming as a result of habitat isolation	The Project disturbance footprint is estimated to contain 213.09 ha of general habitat considered suitable for the species (refer Table 4.28), although this is likely a substantial overestimation. There are large areas of similar habitat suitable for this species to the north and south of the alignment along the Toowoomba Range where other database records occur. The Project is linear and not likely to result in genetically distinct populations forming as a result of habitat isolation.	The species has been confirmed to occur within the Project disturbance footprint and the Project is likely to remove the entire population at each of the locations. There is a predicted 48.52 ha of total habitat (i.e. 43.25 ha general habitat and 5.27 ha essential habitat) for the species within the Project disturbance footprint (refer Table 4.28), although this is likely a substantial overestimation. There are large areas of habitat suitable for this species to the south-west of the alignment where other database records occur. The Project is linear and not likely to result in genetically distinct populations forming as a result of habitat isolation.
Result in invasive species that are harmful to a 'Vulnerable' species becoming established in the species habitat	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 disturbance footprint (refer Section 5.1.2.4). Introduced grasses such as *Chloris gayana* (Rhodes grass) and *Urochloa panicoides* (Liver seed grass) are also prevalent which is key threat to Finger panic grass. 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 that are harmful to a 'Vulnerable' species becoming established in the species habitat.	
Introduce disease that may cause the population 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 these species. Though 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.	

Criteria	Assessment against significance criteria (*Callitris baileyi*)	Assessment against significance criteria (*Digitaria porrecta*)
Interfere with the recovery of the species	There is no State recovery plan for *C. Baileyi* nor is there a relevant recovery plan for the species. However, it is noted that there is the Biodiversity Recovery Plan for Gatton and Laidley Shires South-East Queensland 2003-2008 (Boyes, B 2004), while a range of management measures are recommended for this species under the back on track framework. The main threats to the recovery of the species from the Project is inappropriate fire regimes and invasive species. The Project disturbance footprint is estimated to contain 213.09 ha of general habitat considered suitable for the species (refer Table 4.28), although this is likely a substantial overestimation. Noting that there are no known populations within the ecology study area. The species is distributed sporadically throughout SEQ (DES 2020h). Database records occur to the north and south of the alignment along the Toowoomba Range. The Project has the potential to interfere with the recovery of the species through the loss of suitable habitat.	No QLD State recovery plan exists for *D. porrecta* however a State recovery plan exists in NSW for the species. Recovery actions include the control of weeds, implementation of appropriate grazing regimes and monitoring of the species over time. The Project is likely to interfere with the recovery of the species, through the loss of the local populations and the predicted 48.52 ha of total habitat (i.e. 43.25 ha general habitat and 5.27 ha essential habitat) for the species within the Project disturbance footprint (refer Table 4.28 and Appendix G). There is also a risk from the Project as a result of fire and the proliferation of introduced grasses along the railway corridor and the surrounding area. It is likely that the Project will interfere with the recovery of the species.
Cause disruption to ecologically significant locations (breeding, feeding, nesting, migration or resting sites) of a species	Ecologically significant locations could be considered as small populations/sub-populations at risk of local extinction. This species was not recorded from the field investigations and the database records that occur outside of the Project disturbance footprint could be considered as sub-populations. These areas will be left undisturbed and are not likely to be impacted by the Project. Therefore, the Project is unlikely to cause disruption to an ecologically significant location for this species.	Ecologically significant locations could be considered as populations/records of the species. As noted in Section 4.3.1.2, this species was identified from the Project footprint and as such the area in which the species occurs can be considered to be an ecologically significant location. The Project is likely to result in the permanent loss of these populations and as such will cause disruption to ecologically significant locations of the species.
Assessment of potential for significant residual impacts	The Project is estimated to result in the clearance of 213.09 ha of general habitat suitable for *Callitris baileyi* which has potential to reduce the area of occurrence of the species (refer Table 4.28 and Appendix G). **Project has potential to cause a 'significant residual impact' to this species.** Further measures will be undertaken during detailed design to avoid and/or minimise the impact, including reducing the extent of the disturbance footprint through this area and/or translocation of individuals.	The species has been confirmed as being present within the Project disturbance footprint, with the populations to be cleared as a result of the Project. The Project will also result in the clearance of 5.27 ha of essential habitat for *Digitaria porrecta*. **Project has potential to cause a 'significant residual impact' to this species.** Further measures will be undertaken during detailed design to avoid and/or minimise the impact, including reducing the extent of the disturbance footprint through this area and/or translocation of individuals.

5.4 Biodiversity offsets

Residual impacts are those impacts that remain after the successful implementation of the avoidance hierarchy and mitigation measures (refer 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.

Although sensitive environmental receptors will be avoided where practicable and potential impacts will be minimised and mitigated to the greatest extent practical (refer Table 5.6), 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 and aquatic environmental sensitive environmental receptors, even after the implementation of all mitigation measures, including rehabilitation.

This section summarises the quantification of significant residual impacts to MNES (non-threatened migratory species) and MSES. The process by which ARTC propose to deliver Project offsets is set out in the ARTC Environmental Offset Delivery Strategy – QLD (refer Appendix J).

As noted previously MSES matters (i.e. threatened flora and fauna under the NC Act) which are also considered to be MNES are discussed in detailed in EIS Appendix J: Matters of National Environmental Significance.

5.4.1 Matters of national environmental significance (migratory species)

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'. For assessments under the EPBC Act, offsets are only required if residual impacts are significant."*

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 2013).

Residual impact significance is reflective of the potential for some Project activities to have a cumulative, irreversible and/or permanent impact upon a MNES, even after the implementation of all mitigation measures, including rehabilitation. In these cases, the residual impact 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 2013).

The significant impact assessments for non-threatened migratory species potentially impacted by the Project indicated that significant impacts are unlikely to occur for these species. As such the provisions of offsets for non-threatened migratory species listed under the EPBC Act is not required under the EPBC Act Offsets Policy.

5.4.2 Matters of State environmental significance

For MSES, impacts to prescribed environmental matters that are considered to constitute significant residual impacts are required to be offset in accordance with the Offsets Act. The Environmental Offsets Regulation 2014 and associated Offsets Policy, provide guidance related to offsets for MSES. The purpose of the Offsets Policy is to provide a decision-support tool to enable administrating agencies the ability to assess offset proposals to ensure that the requirements of the Offsets Act are met.

The assessment of prescribed MSES has been undertaken in accordance with the MSES significant impact criteria outlined in the relevant guidelines (refer Section 5.3.4).

Analysis indicates that significant residual impacts for the following sensitive environmental receptors, including MSES has the potential to occur as a result of the Project:

- 'Endangered' or 'Of concern' regional ecosystems (RE)
- Remnant vegetation within the defined distance of a watercourse
- Essential Habitat (EH)
- Connectivity areas
- Protected wildlife habitat for the following NC Act listed conservation significant flora and fauna species:
  - Glossy Black-cockatoo (*Calyptorhynchus lathami lathami*)
  - Powerful owl (*Ninox strenua*)
  - Bailey's Cypress (*Callitris baileyi*)
  - Finger Panic grass (*Digitaria porrecta*)
  - Slender milkvine (*Marsdenia coronata*)

A summary of anticipated significant residual impacts to MSES is presented in Table 5.18.

Table 5.18 Quantification of anticipated significant residual impacts that may require offsets

Sensitive environmental receptor	Identified significant residual impact
Regulated vegetation	
'Endangered' regional ecosystems (RE)	9.8 ha
'Of concern' regional ecosystems (RE)	89.62 ha
Remnant vegetation within a defined distance from a watercourse – Category B	4.30 ha
Essential Habitat (EH)	112.36 ha
Connectivity areas	
Regional Riparian corridors	9.76 ha
State Riparian corridors	17.17 ha
State Terrestrial corridors	230.8 ha
Protected wildlife habitat	
Glossy Black-cockatoo (*Calyptorhynchus lathami lathami*)	21.58 ha
Powerful owl (*Ninox strenua*)	99.05 ha
Bailey's Cypress (*Callitris baileyi*)	213.09 ha
Finger Panic grass (*Digitaria porrecta*)	48.52 ha
Slender milkvine (*Marsdenia coronata*)	51.02 ha
Koala Habitat Areas (core)	213.73 ha

It is worth noting that Bailey's cypress (*Callitris baileyi*) and Finger panic grass (*Digitaria porrecta*) are near threatened species under the NC Act and are not considered to be MSES. Connectivity that is a MSES was assessed using the 'landscape fragmentation and connectivity' tool (as per the SRI Guideline (DEHP, 2014)) and with an area of 122.87 ha impacted.

5.4.3 Provision of offsets

The Project will result in significant residual adverse impact on prescribed environmental matters, even after the implementation of all mitigation measures, including rehabilitation. Therefore, it is expected that environmental offsets will be required for the Project. Offsets will need to be provided in accordance with requirements of the EPBC Act, Offsets Act and/or other policies where relevant.

ARTC proposes to provide its offset obligation post-EIS, following the detailed design. Detailed offsets will be provided in multiple stages to align with the schedule of disturbance. The ARTC Environmental Offset Delivery Strategy – QLD has been provided in Appendix J.

6 Commitments

The approach outlined in this report is considered to be adequate to address the requirements of the ToR. 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 and State's survey guidelines will be undertaken, with some surveys already commencing. 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 (other than viaducts) and the supporting fencing across the Project alignment, targeting key locations (for example, in the Toowoomba Range and watercourses). ARTC will work with the relevant stakeholders including 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 ecology study area, including those associated with the SEQ Koala Conservation Strategy. Noting that DTMR are currently assessing the effectiveness of the fauna design measures implemented along the Toowoomba Bypass.

ARTC will also undertake on-ground assessments of the watercourses/waterways intersected by the Project to determine their status under the Water Act and Fisheries Act where applicable. This will be undertaken in consultation with DRDMW and DAF and will also assist in informing design requirements and secondary approvals.

Environmental offsets will be provided where Project works are found to have a significant residual impact on flora and fauna that are matters of national or State environmental significance following the results of the targeted surveys for threatened species outlined above.

An Environmental Offsets Management Plan will be prepared in consultation with DES/DAWE and submitted to the relevant authority for approval prior to any construction works. The Environmental Offsets Management 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 matters of national environmental significance
- Quantifies habitat values of lands associated with matters of national environmental significance 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 matters of national environmental significance.

- The Environmental Offsets Management 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 3.6, incorporating the projects identified in Table 3.10 and depicted in Figure 3.4. The assessment has been based on sensitive environmental receptors occurring within the Project disturbance footprint (refer Table 7.1).

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 bioregion. 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 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 are most appropriately considered at a biologically relevant spatial scale. A distance of 50 km from the Project was selected as many of the sensitive environmental receptors of relevance to the Project do not occur beyond this area, and if they do occur, any cumulative impacts associated with the Project are not considered to be relevant beyond this extent.

The total impact area of significant Sensitive environmental receptors contained within the combined footprint of the 20 projects occurring within the cumulative impact assessment area has been quantified and is provided in Table 7.1.

The quantitative method of assessment that has been applied establishes a percentage of impact to each significant sensitive environmental receptor as a combined consequence of all projects identified for the cumulative impact assessment. The results of the significance assessment of these cumulative impacts are presented in aggregated form in Table 7.2 (i.e. a level of cumulative impact significance is not attributed for each project.

The potential for cumulative impacts to ecological features will be managed through:

- Implementation of mitigation measures specified in Section 5.2.1 and Section 5.2.2.
- Development and implementation of the following, as components of the CEMP:
  - Biosecurity Management Plan
  - Soil Management Plan
  - Reinstatement and Rehabilitation Plan
  - Flora and Fauna Sub-plan
  - Waste and Resource Management Sub-plan

- Consultation with owners/operators of adjoining projects regarding the compatibility/comprehensiveness of management measures for the Project with their developments to achieve positive ecological outcomes
- Delivery of offsets for residual impacts to MNES and MSES due to the Project in accordance with the EPBC Act, Offsets Act.

Table 7.1 Cumulative impacts as calculated for within the cumulative impact assessment study area

Receptor	A. Extent within cumulative impact study area (1,083,068.32 ha)	B. Extent within cumulative impact Project disturbance footprint (defined projects (refer Figure 3.4) (17,985.74 ha)	C. Extent within cumulative impact Project disturbance footprint (defined projects (refer 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 (refer Table 3.11 for magnitude criteria) considering D and E
Commonwealth significant environmental constraints						
Migratory species						
Common sandpiper (*Actitis hypoleucos*)	72,845.87	500.41	566.16	0.78	11.61	Low
Fork-tailed swift (*Apus pacificus*)	1,082,164.28	17,919.27	18346.62	1.70	2.33	Low
Sharp-tailed sandpiper (*Calidris acuminata*)	75,917.13	523.12	588.87	0.78	11.17	Low
Pectoral sandpiper (*Calidris melanotos*)	72,845.87	500.41	566.16	0.78	11.61	Low
Red-necked stint (*Calidris ruficollis*)	72,845.87	500.41	566.16	0.78	11.61	Low
Oriental cuckoo (*Cuculus optatus*)	22,521.57	124.80	128.26	0.57	2.70	Low
Latham's snipe (*Gallinago hardwickii*)	74,736.62	500.43	566.18	0.76	11.61	Low
Caspian tern (*Hydroprogne caspia*)	25,030.51	141.68	154.93	0.62	8.55	Low
Black-faced monarch (*Monarcha melanopsis*)	26,601.47	404.23	471.83	1.77	14.33	Low
Yellow wagtail (*Motacilla flava*)	72,845.87	500.41	566.16	0.78	11.61	Low
Satin flycatcher (*Myiagra cyanoleuca*)	23,532.72	124.80	128.26	0.55	2.70	Low
Osprey (*Pandion haliaetus*)	23,374.80	136.94	145.83	0.62	6.10	Low
Glossy ibis (*Plegadis falcinellus*)	77,938.22	549.06	614.81	0.79	10.69	Low
Pacific golden plover (*Pluvialis fulva*)	73,049.20	500.41	566.16	0.78	11.61	Low
Rufous fantail (*Rhipidura rufifrons*)	30,480.03	263.61	280.85	0.92	6.14	Low
Spectacled monarch (*Symposiachrus trivirgatus*)	24,141.32	124.80	128.26	0.53	2.70	Low
Common greenshank (*Tringa nebularia*)	73,113.14	500.41	566.16	0.77	11.61	Low
Marsh sandpiper (*Tringa stagnatilis*)	75,407.25	523.04	588.78	0.78	11.17	Low

Receptor	A. Extent within cumulative impact study area (1,083,068.32 ha)	B. Extent within cumulative impact Project disturbance footprint (defined projects (refer Figure 3.4) (17,985.74 ha)	C. Extent within cumulative impact Project disturbance footprint (defined projects (refer 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 (refer Table 3.11 for magnitude criteria) considering D and E
State significant environmental constraints						
Regulated vegetation (VM Act)						
Category B – Remnant vegetation	233,689.14	1413.62	1526.42	0.65	7.39	Low
High value regrowth vegetation (HVR) (Category C)	50,435.02	249.12	355.60	0.71	29.94	Low
MSES wildlife habitat	32,797.91	198.73	304.39	0.93	34.71	Low
Essential habitat	118,752.11	843.16	955.52	0.80	11.76	Low
State Significant Environmental Constraint: *Nature Conservation (Koala) Conservation Plan 2017* mapping						
Koala Priority Areas	64,376.64	193.49	203.67	0.32	5.00	Low
Koala Habitat Areas	109,429.84	389.08	602.81	0.55	35.46	Low
Koala Habitat Restoration Areas	99,032.70	366.93	446.36	0.45	17.79	Low
Locally Refined Koala Habitat Areas	11,870.50	0.00	0.00	0.00	0.00	N/A
Threatened flora habitat (NC Act):						
Callitris baileyi	244,319.94	182.19	395.29	0.07	53.91	Low
Caustis (*Caustis blakei macrantha*)	17,983.67	69.77	80.18	0.39	12.98	Low
Cyperus clarus (A sedge)	46,796.79	862.75	862.75	1.84	0.00	N/A
Finger panic grass (*Digitaria porrecta*)	26,366.97	1,708.66	1757.18	6.48	2.76	Low
Slender milkvine (*Marsdenia coronata*)	2,990.29	0.06	51.08	1.71	99.88	Medium
Threatened fauna habitat (NC Act):						
Glossy black-cockatoo (*Calyptorhynchus lathami lathami*)	76,334.58	927.68	949.26	1.22	2.27	Low
Powerful owl (*Ninox strenua*)	82379.56	126.89	225.94	0.27	43.84	Low
Grey snake (*Hemiaspis damelii*)	42,877.80	138.47	138.47	0.32	0.00	N/A

Receptor	A. Extent within cumulative impact study area (1,083,068.32 ha)	B. Extent within cumulative impact Project disturbance footprint (defined projects (refer Figure 3.4) (17,985.74 ha)	C. Extent within cumulative impact Project disturbance footprint (defined projects (refer 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 (refer Table 3.11 for magnitude criteria) considering D and E
NC Act 'Least concern' and 'Special least concern' species						
Platypus (*Ornithorhynchus anatinus*)	61,099.06	925.98	972.81	1.52	4.81	Low
Short-beaked echidna (*Tachyglossus aculeatus*)	305,669.27	1,876.96	2038.65	0.61	7.93	Low
'Least concern' flora and fauna	1,083,068.32	17,985.74	18442.55	1.70	2.48	Low
Priority Back on Track species (not listed under the EPBC Act or NC Act)	1,083,068.32	17,985.74	18442.55	1.70	2.48	Low
Biodiversity Planning Assessment (BPA)						
Local or Other Values	4,669.07	54.39	65.13	1.39	16.49	Low
Non Bioregion Ecosystem	8,536.18	23.97	23.97	0.28	0.00	N/A
Regional	61,104.20	786.86	786.86	1.29	0.00	N/A
State	144,165.13	221.45	284.01	0.20	22.03	Low
State Habitat for EVNT taxa	28,861.43	294.41	334.11	1.16	11.88	Low
Regional Riparian Corridor	7,085.84	284.99	294.75	4.16	3.31	Low
State Riparian Corridor	19,067.54	50.17	67.34	0.35	25.50	Low
State Terrestrial	158,387.45	63.09	293.89	0.19	78.53	Low

Table 7.2 Significance assessment of cumulative impacts within the cumulative impact assessment area

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
Commonwealth Significant Ecological Constraint (Species listed as migratory under the EPBC Act): ■ Common sandpiper (*Actitis hypoleucos*) ■ Fork-tailed swift (*Apus pacificus*) ■ Sharp-tailed sandpiper (*Calidris acuminata*) ■ Pectoral sandpiper (*Calidris melanotos*) ■ Red-necked stint (*Calidris ruficollis*) ■ Oriental cuckoo (*Cuculus optatus*) ■ Latham's snipe (Gallinago hardwickii) ■ Caspian tern (Hydroprogne caspia) ■ Black-faced monarch (*Monarcha melanopsis*) ■ Yellow wagtail (*Motacilla flava*) ■ Satin flycatcher (*Myiagra cyanoleuca*) ■ Osprey (Pandion haliaetus) ■ Glossy ibis (Plegadis falcinellus) ■ Pacific golden plover (*Pluvialis fulva*) ■ Rufous fantail (Rhipidura rufifrons) ■ Spectacled monarch (Symposiachrus trivirgatus) ■ Common greenshank (*Tringa nebularia*) ■ Marsh sandpiper (Tringa stagnatilis)	■ Habitat loss from vegetation clearing/removal	1	3	1	3	8	Medium
	■ Edge effects ■ Habitat fragmentation ■ Barrier effects ■ Reduction in connectivity of biodiversity corridors	1	2	1	3	7	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
State Significant Environmental Constraint (VM Act): ■ Remnant vegetation (REs) (Category B).	■ Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	■ Edge effects ■ Habitat fragmentation ■ Barrier effects ■ Reduction in connectivity of biodiversity corridors	1	2	1	3	7	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

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ 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
State Significant Environmental Constraint (VM Act): ▪ High value regrowth (HVR) vegetation (Category C).	▪ Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	▪ Fauna species injury or mortality	1	1	1	2	5	Low
	▪ Dust and light and contaminant disturbance	1	1	1	2	5	Low
	▪ Increase in litter (waste)	1	1	1	2	5	Low
	▪ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	▪ Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low
State Significant Environmental Constraint: ▪ MSES wildlife habitat ▪ Essential habitat.	▪ 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

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ 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
State Significant Environmental Constraint: Nature Conservation (Koala) Conservation Plan 2017 mapping, including: ▪ Koala Priority Areas ▪ Koala Habitat Areas ▪ Koala Habitat Restoration Areas ▪ Locally Refined Koala Habitat Areas	▪ 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
	▪ Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
State Significant Environmental Constraint (species listed as threatened under the NC Act): **Flora**: ▪ Slender milkvine (*Marsdenia coronata*)	▪ Habitat loss from vegetation clearing/removal	2	3	2	3	10	High
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	3	7	Medium
	▪ Fauna species injury or mortality	1	1	1	3	6	Low
	▪ Dust and light and contaminant disturbance	1	1	1	3	6	Low

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ 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	Medium
State Significant Environmental Constraint (species listed as threatened under the NC Act): **Flora**: ▪ Bailey's cypress pine (*Callitris baileyi*) ▪ Caustis (Caustis blakei macrantha) ▪ Finger panic (*Digitaria porrecta*) **Fauna:** ▪ Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) ▪ Powerful owl (*Ninox strenua*)	▪ Habitat loss from vegetation clearing/removal	2	3	1	3	9	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	3	7	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	Medium
State Significant Environmental Constraint: ▪ 'Special least concern' fauna species: ▪ Short-beaked echidna (*Tachyglossus aculeatus*) ▪ Platypus (*Ornithorhynchus anatinus*)	▪ Habitat loss from vegetation clearing/removal	2	3	1	2	8	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	▪ Fauna species injury or mortality	1	1	1	2	5	Low
	▪ Dust and light and contaminant disturbance	1	1	1	2	5	Low
	▪ Increase in litter (waste)	1	1	1	2	5	Low

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	▪ Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low
State Significant Environmental Constraint: ▪ Priority Back on Track flora and fauna species (that are not listed under as threatened under the provisions of the EPBC Act or NC Act).	▪ Habitat loss from vegetation clearing/removal	2	3	1	1	7	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	▪ Fauna species injury or mortality	1	1	1	1	4	Low
	▪ Dust and light and contaminant disturbance	1	1	1	1	4	Low
	▪ Increase in litter (waste)	1	1	1	1	4	Low
	▪ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	▪ Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low
State Significant Environmental Constraint: ▪ Flora and fauna species not listed under the EPBC Act but listed as 'Least concern' under the provisions of the NC Act and flora that is listed as 'Special least concern' under the provisions of the NC Act.	▪ Habitat loss from vegetation clearing/removal	3	3	1	1	8	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	▪ Fauna species injury or mortality	1	1	1	1	4	Low
	▪ Dust and light and contaminant disturbance	1	1	1	1	4	Low
	▪ Increase in litter (waste)	1	1	1	1	4	Low

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	▪ Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low
State Significant Environmental Constraint (BPA): ▪ State habitat for EVNT taxa ▪ State habitat values ▪ State riparian Corridor ▪ State terrestrial corridor	▪ Habitat loss from vegetation clearing/removal	1	3	1	3	8	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	3	7	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
State Significant Environmental Constraint (BPA): ▪ Regional habitat values for EVNT taxa ▪ Regional habitat values ▪ Regional Riparian corridor.	▪ Habitat loss from vegetation clearing/removal	1	3	1	2	7	Medium
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	2	6	Low
	▪ Fauna species injury or mortality	1	1	1	2	5	Low
	▪ Dust and light and contaminant disturbance	1	1	1	2	5	Low
	▪ Increase in litter (waste)	1	1	1	2	5	Low

Receptor(s)	Potential impacts	Relevance factor of aspects				Sum of relevance factors	Impact significance
		Probability	Duration	Magnitude	Sensitivity		
	▪ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	2	6	Low
	▪ Displacement of species from invasion of weed and pest species	1	1	1	2	5	Low
State Significant Environmental Constraint (BPA): ▪ Local or other habitat values.	▪ Habitat loss from vegetation clearing/removal	1	3	1	1	6	Low
	▪ Edge effects ▪ Habitat fragmentation ▪ Barrier effects ▪ Reduction in connectivity of biodiversity corridors	1	2	1	1	5	Low
	▪ Fauna species injury or mortality	1	1	1	1	4	Low
	▪ Dust and light and contaminant disturbance	1	1	1	1	4	Low
	▪ Increase in litter (waste)	1	1	1	1	4	Low
	▪ Reduction in biological viability of soil to support growth due to soil compaction	1	2	1	1	5	Low
	▪ Displacement of species from invasion of weed and pest species	1	1	1	1	4	Low

Table notes:

1. Table 3.11 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 will be considered and/or mitigation measures applied to demonstrate improvement. Specific approval conditions required. Targeted monitoring program necessary

8 Conclusion

This Assessment Report has been prepared in accordance with Sections 11.91 to 11.103 of the *Terms of Reference for an environmental impact statement: Inland Rail - Gowrie to Helidon Project* issued on the 9 August 2017 by the Coordinator-General. This document has been prepared to accompany EIS Appendix J: Matters of National Environmental Significance, which specifically addresses the EPBC Act controlling provisions of the Project (i.e. threatened species and communities listed under the EPBC Act). Therefore, in order to avoid repetition, the EPBC Act controlling provisions of the Project have been excluded from this document. This technical report has been prepared for the purpose of supporting the primary approvals for the Project.

The ecology study area provides potential habitat for:

- Nine (non-MNES) NC Act listed threatened species (including five flora species, three bird species and one reptile species), with three flora species confirmed as being present during field surveys
- Two NC Act listed 'Special least concern' mammal species
- Eighteen non-threatened, migratory species listed under the EPBC Act.

In addition, a number of 'Endangered', 'Of concern' and 'Least concern' REs are also present within the ecology study area that are protected under the VM Act, as well as other sensitive environmental receptors, including protected areas, HVR vegetation and bioregional corridors (of local, regional and state significant).

Sensitive environmental receptors (i.e. MNES and MSES) 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. An assessment of the significance of impact from the Project for each sensitive environmental receptor was undertaken based on information gathered in the desktop analysis and field assessment phases.

The construction, commissioning and reinstatement, and operation of the Project has the potential to impact on sensitive environmental receptors in the following ways:

- 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
- Tunnelling activities.

The nature of each potential impact was considered in relation to the identified sensitive environmental receptors to derive an initial assessment of impact significance for the Project.

This was determined by assigning sensitivity and magnitude ratings which were then allocated a significance rating through the significance assessment matrix. The potential impacts upon the sensitive environmental receptors were then assigned a major, high, moderate, low or negligible rating.

The proposed mitigation measures for the Project were identified in order to reduce the significance of the potential impacts upon the sensitive environmental receptors. Following the application of the mitigation hierarchy (i.e. avoid, minimise, mitigate), which included a range of mitigation measures and management plans, the impacts to the identified sensitive environmental receptors were generally reduced.

Following initial impact assessment and the application of mitigation measures, each sensitive environmental receptor was then analysed to determine if the Project would result in significant residual impact in accordance with the relevant Commonwealth or State significant impact guidelines. This process allowed an assessment of the potential offsets required by the Project.

In accordance with the outcomes of the MNES significant impact guideline, there are no significant impacts expected for the following non-threatened EPBC Act listed migratory species:

- Common sandpiper (*Actitis hypoleucos*)
- Fork-tailed swift (*Apus pacificus*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Pectoral sandpiper (*Calidris melanotos*)
- Red-necked stint (*Calidris ruficollis*)
- Oriental cuckoo (*Cuculus optatus*)
- Latham's snipe (Gallinago hardwickii)
- Caspian tern (Hydroprogne caspia)
- Black-faced monarch (*Monarcha melanopsis*)
- Yellow wagtail (*Motacilla flava*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Eastern osprey (*Pandion haliaetus*)
- Glossy ibis (Plegadis falcinellus)
- Pacific golden plover (*Pluvialis fulva*)
- Rufous fantail (Rhipidura rufifrons)
- Spectacled monarch (Symposiachrus trivirgatus)
- Common greenshank (*Tringa nebularia*)
- Marsh sandpiper (*Tringa stagnatilis*).

Assessment of prescribed MSES was undertaken in accordance with the relevant MSES significant impact criteria. In addition, non-MNES were also analysed to determine the potential impacts associated with t project activities. Analysis indicated that the Project is likely/has the potential to result in significant residual impacts to the following sensitive environmental receptors:

- 'Endangered' REs: 9.8 ha
- 'Of concern' REs: 89.62 ha
- Remnant vegetation (Category B regulated vegetation) within the defined distance of a watercourse: 4.30 ha
- MSES Wildlife habitat: 105.66 ha
- Essential Habitat (EH): 112.36 ha
- Connectivity areas:
- Landscape fragmentation and connectivity 122.87 ha Protected wildlife habitat for the following NC Act listed conservation significant flora and fauna species:
  - Glossy black-cockatoo (*Calyptorhynchus lathami lathami*): 21.58 ha

  - Powerful owl (*Ninox strenua*): 99.05 ha
  - Bailey's cypress (*Callitris baileyi*): 213.09 ha
  - Finger panic (*Digitaria porrecta*): 48.52 ha
  - Slender milkvine (*Marsdenia coronata*): 51.02 ha
- Nature Conservation (Koala) Conservation Plan 2017 areas:
  - Koala Habitat Areas: 213.73 ha

Potential predicted cumulative impacts within 50 km of the Project were assessed incorporating the Projects disturbance footprint. Impacts 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.

The significance of the predicted cumulative impact as a result of the Project added to the other similar projects that occur within 50 km of the Project boundary are likely to be higher on the following Sensitive environmental receptors:

- EPBC Act listed, non-threatened migratory species:
  - Black-faced Monarch (*Monarcha melanopsis*) – Project impact makes a 14.33 per cent contribution to the clearing of approximately 471.83 ha (sum of cumulative impact) which constitutes 1.77 per cent of the available habitat within the cumulative impact assessment area
- NC Act listed species habitat:
  - Slender milkvine (*Marsdenia coronata*) – Project impact makes a 99.88 per cent contribution to the clearing of 51.08 ha (sum of cumulative impact) which constitutes 1.71 per cent of the available habitat within the cumulative impact assessment area
  - Finger panic grass (*Digitaria porrecta*) – Project impact makes a 2.76 per cent contribution to the clearing of 1,770.74 ha (sum of cumulative impact) which constitutes 6.48 per cent of the available habitat within the cumulative impact assessment area
  - Platypus (*Ornithorhynchus anatinus*) – Project impact makes a 4.81 per cent contribution to the clearing of 953.07 ha (sum of cumulative impact) which constitutes 1.52 per cent of the available habitat within the cumulative impact assessment area.

Mitigation measures identified as part of the Project commitments are likely to reduce the Project's contribution to cumulative project impacts within the broader region.

The sensitive environmental receptors 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 identified MNES and MSES. 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.

In order to mitigate the residual impacts to the sensitive environmental receptors identified above, environmental offsets will be required. ARTC proposes to provide its offset obligation post EIS, following the detailed design phase. The ARTC Environmental Offset Delivery Strategy – QLD has been provided as Appendix J and documents the approach to be taken in relation to the delivery of Project related offsets.

8.1 Post primary approval

ARTC will work with relevant stakeholders and agencies to implement the measures outlined above, along with the relevant approval conditions to further reduce the impacts on prescribed environmental matters following the issuing of primary Project approvals.

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APPENDIX

I

Terrestrial and Aquatic Ecology

Appendix A Predicted habitat modelling and methodology

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

Inland Rail Gowrie to Helidon EIS

Appendix A – Predictive habitat modelling methodology

Australian Rail Track Corporation

Reference: 3200

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1 Introduction

1.1 Background

For the purposes of the Inland Rail Project (Gowrie to Helidon) (the Project) predictive habitat models for conservation significant flora and fauna species have been prepared. These models have been designed to map the potential areas that are likely to be analogous to habitat associated with *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth (Cth)) (EPBC Act) and/or the *Nature Conservation Act 1992* (Queensland (Qld) (NC Act) conservation significant species. This mapping has the following objective:

- To provide predictive habitat modelling for EPBC Act and NC Act listed flora and/or fauna species to:
  - Identify areas of potential habitat for EPBC Act (no-threatened migratory species) and NC Act listed species
  - Facilitate the calculation of potential disturbance areas associated with the Project and to subsequently inform significant adverse residual impacts for matters of national environmental significance (MNES) and matters of state environmental significance (MSES).

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/migratory/special least concern 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 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 guidelines expectations. The *"How to use these guidelines"* statement includes:

'… 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 with direct and current survey efforts including dedicated ground truthing surveys of the database mapping and follow-up ecological assessments within the project area as part of the projects 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 species occurrence and the availability of information pertaining to available species habitat.

Nineteen data sources were accessed to identify threatened species that have potential to occur within the ecology study area. These data sources are listed in Table 1.1.

In addition, multiple ecological assessment were identified which describe the threatened species values, including species protected under the NC Act within the ecology 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) (2018 and 2020)	13/03/2020	Ecology study area	Records of flora and fauna, including conservation significant species listed under the EPBC Act and/or NC Act and those identified as MLES
Flying Fox Monitoring Program: https://data.qld.gov.au/dataset/flying-fox-monitoring-program (DES 2020a)	24/04/2020	Ecology study area	Shows the general location of Flying-fox roosts in QLD recorded by the DES and includes camp and survey data 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: https://www.ehp.qld.gov.au/wildlife/livingwith/flyingfoxes/roost-locations.html#flying_fox_roost_locations (DES 2020b)	24/04/2020	Ecology study area	Shows the general location of Flying-fox roosts in QLD recorded by the DES and includes 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	Ecology study area	Records of avian fauna, including threatened and migratory species listed under the EPBC Act
BPA mapping (QLD Government 2020a)	25/03/2020	Ecology study area	State, regional (MSES) and locally (MLES) significant biodiversity matters mapping. This mapping has been used to indicate the location of bioregional corridors (i.e. in the State, regional and local context). This mapping has also been used in the predictive modelling to identify core habitat areas
Back on Track species prioritisation framework (DERM 2010)	25/03/2020	SEQ NRM	The Back on Track species are categorised as Critical, High, Medium, or Low priority for the State and for the NRM regions. There is also a data deficient category according to three sets of criteria: probability of extinction, consequences of extinction and potential for successful recovery.
EPBC Act Protected Matters Search Tool (Australian Government 2020a)	25/03/2020	Ecology study area	Provides a "predictive" account of MNES identified within a specific area. Includes: ■ 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

Database/data source name	Database search date	Database search areas	Data type
Groundwater Dependent Ecosystems Atlas (BoM 2020)	25/03/2020	Ecology study area	Provides information related to 3 types of Ground water dependant ecosystems: Aquatic, Terrestrial and Subterranean.
Wildlife Habitat Map, version (DES 2020c)	25/03/2020	Ecology study area	Modelled habitat under the VM Act for a conservation significant species listed under the EPBC Act and/or the NC Act
Regulated Vegetation Management Map (QLD Government 2020b)	25/03/2020	Ecology study area	Mapping of REs and HVR that provide habitat for conservation significant species under the EPBC Act and/or NC Act
Register of critical habitat (Australian Government n.d.)	25/03/2020	Australian extent	Critical habitat listed under the EPBC Act
Map of Referable Wetlands (QLD Government 2020c)	25/03/2020	Regional extent	Includes State significant, referable wetlands, important wetlands in the Great Barrier Reef catchments and wetland REs
Wildlife Online database (DES 2020a) incorporating WildNet and Herbrecs datasets	25/03/2020	Ecology study area	Records of flora and vertebrate fauna, including conservation significant species listed under the EPBC Act and/or NC Act and MLES
QLD waterways for waterway barrier works (QLD Government 2020d)	25/03/2020	Ecology study area	Waterways where proposed waterway barrier works require assessment and approval under the Fisheries Act.
Watercourse Identification Mapping (QLD Government 2020e)	25/03/2020	Ecology study area	Known extent of watercourses and drainage features that are managed under the Water Act
Wetland Info database (Wetland info 2013)	25/03/2020	Impact assessment area	Provides interactive maps, species records, case studies and legislation associated with QLD wetlands
Fish Habitat Areas (QLD Government 2020f)	25/03/2020	Ecology study area	Boundaries of gazetted, declared fish habitat areas
QLD Springs Database (QLD Government 2019g)	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 (GDEs).
Matters of State Environmental Significance (QLD Government 2020h)	25/03/2020	Ecology study area	Location of MSES including: ■ Protected areas ■ Marine parks ■ Management A and Management B declared fish habitat areas ■ Threatened and 'Special least concern' wildlife listed under the NC Act ■ Regulated vegetation under the VM Act Wetlands in a wetland protection area or wetlands of high ecological significance ■ Wetlands and watercourses in high ecological value waters as defined in the *Environmental Protection (Water) Policy 2009,* Schedule 2 ■ Legally secured offset 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 ecology
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 and MSES. 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 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 ▪ Confirmation of the presence of Brush sophora* (*Sophora fraseri*)* in the Toowoomba Range area ▪ Observations of NC Act listed flora Finger panic (*Digitaria porrecta*) detected during preclearance surveys for geotechnical works ▪ Identification of Slender milk-vine (*Marsdenia coronata*) ▪ Identification of the planted specimen of Plunket mallee (*Eucalyptus curtsii*) – note species is considered to be outside of the jurisdiction of the NC Act as it is not considered to be “in the wild”
Inland Rail – Gowrie to Kagaru Geotechnical investigations. Protected plant survey reports (2019) Preclearance survey reports (2018 and 2019)	EMM (2018b, 2018c; 2019b, 2019c, 2019d)	▪ Observations of NC Act listed flora Finger panic (*Digitaria porrecta*) detected during preclearance surveys for geotechnical works ▪ Identification of Slender milk-vine (*Marsdenia coronata*) ▪ Identification of the planted specimen of Plunket mallee (*Eucalyptus curtsii*) – note species is considered to be outside of the jurisdiction of the NC Act as it is not considered to be “in the wild”
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 (scratches/scats) within ecology study area ▪ Collared delma* recorded as well as evidence of presence (skins) within ecology study area ▪ Lowland Rainforest of subtropical Australia TEC* confirmed within ecology study area

Table note:

* MNES are discussed further within EIS Appendix J: Matters of National Environmental Significance Technical report

In addition to the assessment of pre-existing datasets and reports identified above, the Project EIS field team has 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 Project ecology study area. Data associated with this field analysis aided in the validation and iteration of the predictive habitat mapping.

In addition to previous surveys and site-based investigations, recovery programs were assessed in order to identify areas of high conservation significance or of recognised conservation value for each of the MNES migratory species or NC Act threatened or near-threatened species subject to predictive habitat modelling.

Of the EPBC Act migratory species identified as potentially impacted by the project activities, eight are subject to the Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act (Commonwealth of Australia 2015). These consist of the following:

- Fork-tailed swift (*Apus pacificus*)
- Oriental cuckoo (*Cuculus optatus*)
- Black-faced monarch (*Monarcha melanopsis*)
- Yellow wagtail (*Motacilla flava*)
- Satin flycatcher (*Myiagra cyanoleuca*)
- Osprey (*Pandion haliaetus*)
- Rufous fantail (*Rhipidura rufifrons*)
- Spectacled monarch (*Symposiachrus trivirgatus*)

Information contained within the referral guidelines (including drafts) for the species identified above was used to assist in the preparation of predictive mapping for the relevant species.

2 Species included within the predictive habitat mapping model

A total of five conservation significant flora species and five conservation significant fauna species listed under the provisions of the NC Act (incorporating two Special least concern fauna species) were identified as occurring or potentially occurring within the ecology study area (refer Table 2.1 and Table 2.2).

In addition to the species identified above, 18 non-threatened migratory species as listed under the EPBC Act have also been identified as potentially occurring within the ecology study area (refer Table 2.3).

All species identified as potentially occurring within the ecology study area were subject to habitat modelling (refer Table 5.2)

Table 2.1 Conservation significant flora species identified from database searches

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence
				WildNet	Atlas of Living Australia	PMST	
Apocynaceae	*Marsdenia coronata**	Slender milk vine	V				Likely
Cupressaceae	*Callitris baileyi**	Bailey's cypress	NT				Possible
Cyperaceae	*Caustis blakei subsp. macrantha**	Caustis	V				Possible
Cyperaceae	*Cyperus clarus**	A sedge	V				Likely
Poaceae	*Digitaria porrecta**	Finger panic grass	NT		✓		Likely

Table notes:
V = Vulnerable NT = Near threatened PMST = EPBC Act Protected matters search tool
✓ = species present within database record within the ecology study area
* = species identified from Back on Track datasets or field based surveys

Table 2.2 Conservation significant fauna species identified from database searches

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence^
				WildNet	Atlas of Living Australia	PMST	
Birds							
Cacatuidae	*Calyptorhynchus lathami lathami*	Glossy black-cockatoo (eastern)	V	✓	✓		Likely
Cacatuidae	*Lophochroa leadbeateri*	Major Mitchell's cockatoo	V	✓			Unlikely^. The ecology study area does not support the species preferred habitat (semi-arid to arid woodlands) and is outside of the species natural range.
Strigidae	*Ninox strenua*	Powerful owl	V	✓	✓		Likely

Family	Species name	Common name	NC Act status	Data source			Likelihood of occurrence^
				WildNet	Atlas of Living Australia	PMST	
Invertebrates							
Lycaenidae	*Jalmenus eubulus*	Pale imperial hairstreak	V	✓			Unlikely^, requires mature stands of brigalow that are not present within the ecology study area
Mammals							
Ornithorhynchidae	*Ornithorhynchus anatinus*	Platypus	SLC	✓	✓		Likely
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked echidna	SLC	✓	✓		Likely
Reptiles							
Elapidae	*Hemiaspis damelii*	Grey snake*	E				Possible

Table notes:

E = Endangered V = Vulnerable SLC = Special least concern PMST = EPBC Act Protected matters search tool
✓= species present within database record within the ecology study area
* = Species identified from Back on Track datasets
^ = Species noted as Unlikely to occur are not discussed further in this report.

Table 2.3 Migratory fauna species identified from database searches

Family	Species name	Common name	Conservation status		Data source			Likelihood of occurrence
			EPBC Act	NC Act	WildNet	PMST	ALA	
Scolopacidae	*Actitis hypoleucos*	Common sandpiper	M	SLC	✓	✓		Possible
Apodidae	*Apus pacificus*	Fork-tailed swift	M	SLC	✓	✓		Possible
Scolopacidae	*Calidris acuminata*	Sharp-tailed sandpiper	M	SLC	✓	✓		Possible
Scolopacidae	*Calidris melanotos*	Pectoral sandpiper	M	SLC		✓		Possible
Scolopacidae	*Calidris ruficollis*	Red-necked stint	M	SLC	✓			Possible
Cuculidae	*Cuculus optatus*	Oriental cuckoo	M	SLC		✓		Possible
Scolopacidae	*Gallinago hardwickii*	Latham's snipe	M	SLC	✓	✓		Possible
Laridae	*Hydroprogne caspia*	Caspian tern	M	SLC	✓		✓	Possible
Scolopacidae	*Limosa limosa*	Black-tailed godwit	M	SLC	✓			Unlikely – Predominantly occurs in coastal habitats
Monarchidae	*Monarcha melanopsis*	Black-faced monarch	M	SLC	✓	✓		Possible
Motacillidae	*Motacilla flava*	Yellow wagtail	M	SLC		✓		Possible
Dicruridae	*Myiagra cyanoleuca*	Satin flycatcher	M	SLC	✓	✓		Possible

Family	Species name	Common name	Conservation status		Data source			Likelihood of occurrence
			EPBC Act	NC Act	WildNet	PMST	ALA	
Scolopacidae	*Numenius phaeopus*	Whimbrel	M	SLC	✓			Unlikely – Entirely occurs in coastal habitats
Pandionidae	*Pandion haliaetus*	Osprey	M	SLC	✓	✓		Possible
Scolopacidae	*Phalarops lobatus*	Red-necked phalarope	M	SLC			✓	Unlikely – Occurs in coastal to pelagic habitats and rarely occurs in Queensland
Threskiornithidae	*Plegadis falcinellus*	Glossy ibis	M	SLC	✓		✓	Possible
Charadriidae	*Pluvialis fulva*	Pacific golden plover	M	SLC	✓			Possible
Muscicapidae	*Rhipidura rufifrons*	Rufous fantail	M	SLC	✓	✓		Possible
Monarchidae	*Symposiachrus trivirgatus*	Spectacled monarch	M	SLC		✓		Possible
Scolopacidae	*Tringa nebularia*	Common greenshank	M	SLC		✓		Possible
Scolopacidae	*Tringa stagnatilis*	Marsh sandpiper	M	SLC	✓			Possible

Table notes:

M = Migratory

✓ = species present within database record within the Project ecology study area PMST = Protected Matters Search Tool

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 and migratory species listed in Table 2.1, Table 2.2 and Table 2.3 which have potential to occur within the ecology study area. This modelling provides an additional tool to assess the likely occurrence of species and communities of interest and facilitates impact assessment by allowing for the quantification of areas of habitat using GIS.

In addition to specimen specific vegetation associations that are identified within Table 5.1, Table 5.2 and Table 5.3, additional GIS layers and field derived information have been utilised to identify areas of habitat within the ecology study area where applicable to a species. These layers include:

- RE datasets (Version 11) and pre-clearing regional ecosystem layers
- High resolution aerial photography with site derived datasets (i.e. utilisation of condition data, species records and general observational data pertaining to species habitat)
- Historic records of conservation significant species (derived from government databases and previous ecological investigations)
- Field derived datasets related to habitat suitability and the presence of micro-habitat features
- Topographic and geological information
- Government derived cadastral datasets
- Drainage datasets (Waterway barrier works mapping).

4 Predictive habitat modelling categories

4.1 EPBC Act listed, non-threatened migratory species

4.1.1 General context

Each predictive habitat model allowed partitioning of non-threatened EPBC Act listed migratory fauna species using current scientific knowledge 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.

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

- Unlikely habitat
- Potential habitat
- Important habitat.

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 *Environment Protection and Biodiversity Conservation Act 1999*.

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 to assess the area as Important habitat. 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. 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. Impacts to *Potential habitat* are not considered to contribute towards significant impacts to an MNES as the loss of these areas is not deemed to be significant in accordance with the Commonwealth significant impact criteria. However, impacts 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, Important habitat has been identified for migratory species under the Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act. Important habitat for migratory birds is defined in Table 2 of the Draft Referral guideline for 14 birds listed as migratory species under the EPBC Act (Commonwealth of Australia 2015).

Species specific assumptions that define the Important habitat category for the above-mentioned species is provided in Table 5.1. Impacts to *Important habitat* are considered to contribute to significant impact to an MNES.

4.2 Non-matters of national environmental significance flora and fauna species

4.2.1 General context

Each predictive habitat model allowed partitioning of habitat for flora and fauna species using current scientific knowledge 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 5.2 and Table 5.3.

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

- Unlikely habitat
- General habitat
- Essential habitat
- Core habitat.

The use of these habitat definitions has been accepted by the Commonwealth Department of Environment and Energy (DotEE) for similar linear infrastructure project EISs (e.g. Santos Gas Field Development EIS) and negotiations with the regulators at the inception of the Project EIS has indicated that they are amenable to the use of this modelling for the Project EIS.

An overview of each of these categories for NC Act listed species is provided in the sections below. A schematic of the interaction between the habitat categories for NC Act listed species is presented in Figure 5.1.

4.2.2 Unlikely habitat

Unlikely habitat consisted 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.

4.2.3 General habitat

General habitat consisted 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 essential or core habitat (i.e. records of the species are considered anomalies as general microhabitat features are not considered to be present from a desktop perspective). General 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. General habitat may include areas of suboptimal habitat for species. Species specific assumptions that define the general habitat category are identified in Table 5.2 and Table 5.3.

4.2.4 Essential habitat

Essential habitat consists of areas containing resources that are considered essential for the maintenance of populations of the species (e.g. potential habitat for breeding, roosting, foraging, shelter) or areas that have been confirmed as containing suitable habitat as identified by a specimen backed record or indirect evidence of the species (i.e. scat, trace, track, fur/feather, distinctive vocalisation or other site based evidence). Essential habitat has been defined from known records (recorded within the past 30 years), generally with a 1 km buffer or site-based observation of the species during site investigations. In addition, if the 1 km buffer from the known record intersects an area identified as general habitat the general habitat rating was elevated to essential habitat. Species specific assumptions associated with the mapping of essential habitat, and instances that deviate from the above criteria are detailed in Table 5.2 and Table 5.3.

4.2.5 Core habitat

Core habitat consists of essential habitat in which the species is known, and the habitat is recognised under relevant recovery plans or other relevant plans/policies/regulations. Where essential habitat intersects with areas identified as important within the relevant bioregion specific Biodiversity Planning Assessment (BPA), these areas have been elevated to the core habitat category. Species specific assumptions associated with the mapping of core habitat areas are detailed in Table 5.2 and Table 5.3.

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 species was designed to provide a dynamic, robust and predictive GIS layer that could incorporate data from scientific literature, conservation listing advice, 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 EPBC Act listed non-threatened migratory species and NC Act threatened, near-threatened and special least concern species. Development of these layers had the ultimate objective to:

- Predict areas that have the potential to support EPBC Act listed non-threatened migratory species
- Predict areas that have the potential to support NC Act listed threatened and near-threatened flora and fauna species and special least concern species fauna species as listed under the NC Act
- Facilitate the quantification of impacts to inform later stages of the EIS process
- Facilitate the assessment of assessment of impact significance in accordance with relevant MNES and MSES significant impact criteria, policies and guidelines.

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, Table 5.2 and Table 5.3 . 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 ecology study area for all of the species modelled. Where this occurred, these species (i.e. without identified habitat within the ecology study area) did not undergo impact assessment as part of the Project EIS.

As the predictive habitat model has been designed to identify areas of potential habitat for NC Act and/or EPBC Act listed species, several assumptions to the model have been made and derived from scientific literature and expert advice. 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[1], 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.
- 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 and other habitat featured. 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, Table 5.2 and Table 5.3.
- Essential habitat/Important habitat – The predictive habitat mapping outlined in this document primarily proposes general habitat/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. In most cases, site derived species records were used to extrapolate preferred habitat by correlating with the underlying GIS layer. In these instances, mapped habitat will overlap with the predicted general habitat/potential habitat, which has not been elevated to the essential habitat/Important habitat level in accordance with that adopted under the VM Act. For these species, where a species point record and associated 1 km buffer intersect with areas of predicted general habitat, the area of overlap has been elevated to the essential habitat category. In instances where essential habitat is located within an area of protection, this is elevated to core habitat or Important habitat. The relationship between general habitat, species records, essential habitat, protected areas and core habitat, is outlined in Figure 5.1.
- 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. RE type). 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, Table 5.2 and Table 5.3). 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. RE 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 RE polygon size, etc.).

[1] 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 ha scale depending on how, where 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.

- Levels of habitat mapping – General habitat/ 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 general/predicted habitat category, these areas have been elevated to Essential or Important habitat in line with the information contained within the relevant species advice/guideline or policy.

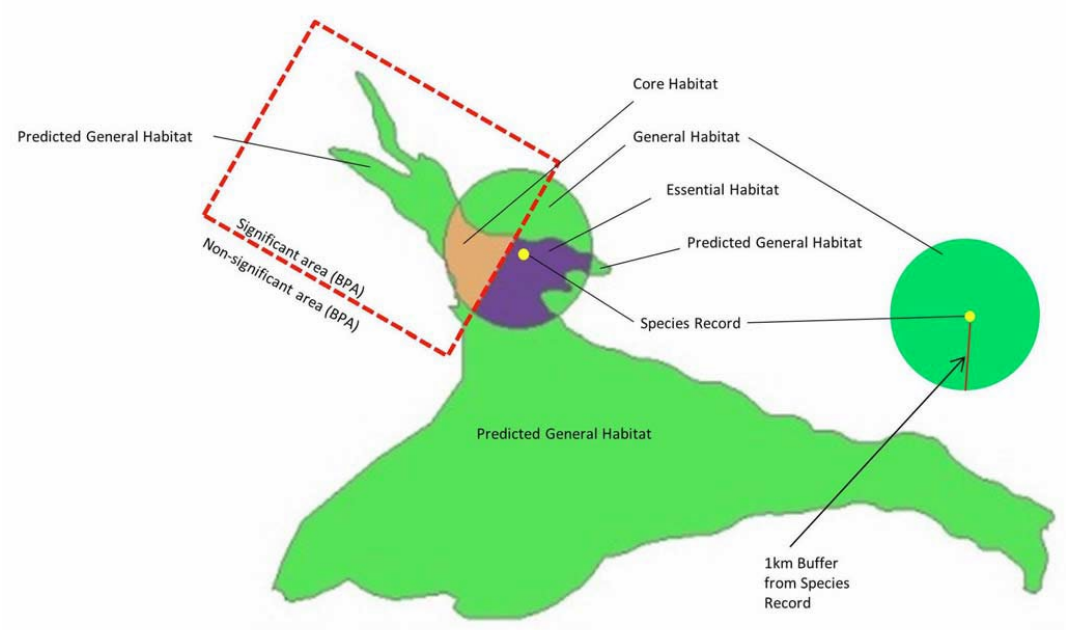

Figure 5.1 **Schematic indicating the relationship between specimen backed records, predicted general habitat, essential habitat and core habitat category designations for species listed under the NC Act**

Table 5.1 EPBC Act listed migratory species habitat assumptions used to map areas of occurrence within ecology study area

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions	
			NC Act	EPBC Act		Potential habitat	Important habitat
Birds	*Apus pacificus* (Fork-tailed swift)	Aerial migrant	SLC	M	Aerial insectivores, ubiquitous. Breeds only in the northern hemisphere.	All areas located outside of mapped remnant vegetation communities are potential habitat	All areas mapped as remnant vegetation (Category B regulated vegetation)
Birds	Oriental cuckoo (*Cuculus optatus*) Satin flycatcher (*Myiagra cyanoleuca*) Rufous fantail (*Rhipidura rufifrons*) Black-faced monarch (*Monarcha melanopsis*) Spectacled monarch (*Symposiachrus trivirgatus*)	Forest/ woodland migrants	SLC	M	This fauna group are typically found in complex habitats, including rainforests, vine thickets and wet sclerophyll forest gullies. However, during migration these species will utilise drier habitats such as riparian forests and woodlands, and larger open forest to woodland remnants with a dense understorey (Pizzey and Knight 2007).	The following is considered to be general habitat: *Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs identified as important habitat*	The following is considered to be important habitat: Remnant RE (Category C regulated vegetation) within 100 m of a waterway (stream order 3 or above) where they are greater than 200 ha in size: 11.8.5, 11.2.5, 11.5.2, 11.5.9, 11.7.1, 11.8.13, 11.8.15, 11.12.21, 12.3.3, 12.3.19, 12.9-10.11, 12.9-10.27, 12.11.3, 12.2.14 and 12.3.11
Birds	Yellow wagtail (*Motacilla flava*) Common sandpiper (*Actitis hypoleucos*) Sharp-tailed sandpiper (*Calidris acuminata*) Pectoral sandpiper (*Calidris melanotos*) Red-necked stint (*Calidris ruficollis*) Latham's snipe (*Gallinago hardwickii*) Caspian tern (*Hydroprogne caspia*) Red-necked phalarope (*Phalarops lobatus*) Glossy ibis (*Plegadis falcinellus*) Pacific golden plover (*Pluvialis fulva*) Common greenshank (*Tringa nebularia*) Marsh sandpiper (*Tringa stagnatilis*)	Wetland/ wader migrants	SLC	M	These are wetland species that associated with waterbodies, flooded paddocks and areas of inundation.	The following is considered to constitute general 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*	Non-breeding habitat only: mostly well-watered open grasslands and the fringes of wetlands. Roosts in mangroves and other dense vegetation. Therefore a 100 m buffer around the following is considered important 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

Class	Scientific name	Common name	Status		Habitat requirements that are the basis for the GIS assumptions (derived from references provided within the bibliography)	GIS habitat modelling instructions	
			NC Act	EPBC Act		Potential habitat	Important habitat
Birds	Osprey (*Pandion haliaetus*)	Waterway/ Marine migrant	SLC	M	The Osprey is found in coastal areas including beaches and estuaries. Nest trees are usually 1 km from the sea (NSW OEH).	The following is considered to constitute General 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*	Bays, estuaries, along tidal stretches of large coastal rivers, mangrove swamps, coral and rock reefs, terrestrial wetlands and coastal lands of tropical and temperate Australia and off shore islands. They feed primarily in the sea or nearby estuarine waters and nest in trees (often dead or with dead tops), rocky coastlines and on artificial structures such as telecommunication towers. Ospreys are generally found on or near the coast but also range inland along large rivers, mainly in northern Australia. As such all areas of potential habitat that intersect with a wetland are Important habitat

Table notes:

M = Migratory SL = Special least concern

Table 5.2 Listed NC Act conservation significant flora species habitat assumptions used to map areas of occurrence within ecology study area

Family	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	Habitat modelling assumptions		
					General habitat	Essential habitat	Core habitat
Poacae	*Digitaria porrecta*	Finger panic	NT	Occurs in communities dominated by *Eucalyptus orgadophila* on hills and slopes and *E. tereticornis* and *E. populnea* in drainage lines. Associated grasses and forbs include *Dichanthium sericeum, Panicum decompositum, Digitaria divaricatissima, Aristida leptopoda, Boerhavia dominii, Mentha satureioides, Psoralea tenax, Rhynchosia minima, Panicum queenslandicum, Paspalidium globoideum, Themeda avenacea, Ixiolaena brevicompta, Sclerolaena muricata* and *Tribulus micrococcus*. It usually occurs on dark and fine textured soils with some degree of seasonal cracking and often persists in disturbed habitats, such as fallow paddocks.	The following REs are considered to be General habitat for this species: 11.3.2, 11.3.4, 11.3.13, 11.3.21, 11.3.25, 11.4.11, 11.4.13, 11.8.5, 11.8.8, 11.8.11, 11.9.2, 11.9.3, 11.9.12, 11.11.11, 11.11.17 In addition to the above, any areas on the pre-clear REs that are of the following REs are considered to form general habitat when contained within a road reserve: 11.3.2, 11.3.4, 11.3.13, 11.3.21, 11.3.25, 11.4.11, 11.4.13, 11.8.5, 11.8.8, 11.8.11, 11.9.2, 11.9.3, 11.9.12, 11.11.11, 11.11.17 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside areas specified above*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as Essential habitat (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are Core habitat.
Cyperaceae	*Cyperus clarus*	A cyperus	V	Grows in grassland or open woodland, in heavy soils derived from basalt. Most often associates with *Aristida leptopoda* and *Panicum queenslandicum* occur on deep alluvial black clay; in *Eucalyptus melanophloia* woodland with mid-dense ground stratum of *Chrysopogon fallax*; and in *Dichanthium* grassland with *Cyperus bifax* and *Fimbristylis* spp.	The following REs are considered to be General habitat for this species: 11.8.4, 11.8.5, 11.8.8, 11.8.11, 11.9.2, 11.9.3, 11.9.12 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside areas specified above*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as Essential habitat (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are Core habitat.

Family	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	Habitat modelling assumptions		
					General habitat	Essential habitat	Core habitat
Cyperaceae	*Caustis blakei* subsp. *macrantha*		V	V	Inhabits tall open eucalypt forests with a sparse canopy, on sandstone ridges and soils derived from weathered sandstone (Wetland Info 2009)	The following Regional Ecosystems are considered to constitute general habitat: 12.3.2, 12.3.2a, 12.3.15, 12.5.1, 12.5.11, 12.9-10.5 In addition, the following Regional Ecosystems are considered to constitute general habitat when they are located within 200 m (ie create a buffer, which will be used to "cleave" larger REs to create 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 1 km radius) that fall outside of the REs identified above are considered to constitute General habitat*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*

Family	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	Habitat modelling assumptions		
					General habitat	Essential habitat	Core habitat
Cupressaceae	*Callitris baileyi*	Bailey's cypress	NT	*Callitris baileyi* grows on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, blue gum and spotted gum. (DEC 2005; Stanley & Ross 1983).	The following Regional Ecosystems are considered to be General habitat: 12.5.13, 12.5.13b, 12.8.16, 12.8.21, 12.9-10.2, 12.9-10.7, 12.9-10.8, 12.9-10.11, 12.9-10.15, 12.9-10.17, 12.9-10.18, 12.9-10.27, 12.11.5, 12.11.5a, 12.11.5e, 12.11.6, 12.11.14, 12.11.19, 12.12.3, 12.12.5, 12.12.7, 12.12.12, 11.7.16, 11.8.8, 11.8.9, 11.9.9, 11.10.1, 11.10.7, 11.11.3, 11.11.4, 11.12.3, 11.12.6, 11.12.19 *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*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Core habitat has not been mapped for this species
Apocynaceae	*Marsdenia coronata*	Slender Milkvine	V	*Marsdenia coronata* is restricted to southeast Queensland where it commonly grows in rainforest or moist areas of open forest, especially in eucalypt forest (Borsboom and Wang 1996). It has been observed on rainforest margins. Also recorded from an area of natural grassland on the top of Mt Kandanga, Imbil State Forest. The vine has been found between 40 and 780 m above sea level, and usually occurs on sandstone or stony soils (Borsboom and Wang 1996; Queensland Herbariums 2011).	The following REs are considered to be general habitat when they occur at an elevation of between 40 and 780 m above sea level: 12.3.18, 12,11.1, 12.11.3, 12.11.3a, 12.11.3b, 12.12.1 and 12.12.15 *Note: Any specimen backed records (buffered to a 1 km radius) that fall outside of the REs*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *general habitat* (refer previous column) constitute *essential habitat*	Core habitat has not been mapped for this species

Table notes:

E = Endangered V = Vulnerable NT = Near threatened

Table 5.3 Listed NC Act conservation significant fauna species habitat assumptions used to map areas of occurrence within the ecology study area

Class	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	GIS habitat modelling instructions		
					General habitat	Essential habitat	Core habitat
Reptile	*Hemiaspis damelii*	Grey snake	E	The Grey snake is found in woodland on heavier cracking clay soils	The following REs are considered general habitat: 11.3.1, 11.3.2, 11.3.4, 11.3.5, 11.3.25, 11.4.4, 11.4.7, 11.4.9, 11.9.1, 11.9.5, 12.8.16, 12.8.17 *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*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are *Core habitat*.
Birds	*Ninox strenua*	Powerful owl	V	The Powerful Owl requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. The species breeds and hunts in open or closed sclerophyll forest or woodlands and occasionally hunts in open habitats. It roosts by day in dense vegetation comprising species such as Turpentine (*Syncarpia glomulifera*), Black She-oak (*Allocasuarina littoralis*), Blackwood (*Acacia melanoxylon*), Rough-barked Apple (*Angophora floribunda*), Cherry Ballart (*Exocarpus cupressiformis*) and a number of eucalypt species.	The following Regional Ecosystems are considered to be General habitat: 11.3.4, 11.3.14, 11.3.23, 11.3.25, 11.3.39, 11.8.2, 11.8.8, 11.10.2, 11.10.2a, 11.12.13b, 12.2.4, 12.2.5, 12.2.14, 12.3.2, 12.3.2a, 12.3.15, 12.5.11, 12.8.1, 12.8.8, 12.9-10.1, 12.9-10.5, 12.9-10.14, 12.9-10.14a, 12.11.1, 2.11.2, 12.11.9x1, 12.12.1, 12.12.4, 12.12.6, 12.12.6x1, 12.12.14, 12.12.22,	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are *Core habitat*.

Class	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	GIS habitat modelling instructions		
					General habitat	**Essential habitat**	**Core habitat**
					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	*Calyptorhynchus lathami lathami*	Glossy black-cockatoo	V	Glossy black-cockatoo is found in open forest to woodland with *Allocasuarina littoralis, A. torulosa, A. luehmanni, Casuarina cristata*, and *C. equisetifolia (DSITI)*.	The following RE is considered general habitat: 11.3.14, 11.3.18, 11.3.26, 11.3.32, 11.5.1, 11.5.2, 11.5.3, 11.5.4, 11.5.5, 11.5.8, 11.5.14, 11.5.18, 11.5.21, 11.7.7, 11.8.1, 11.9.13, 11.10.9, 11.10.11, 11.11.3, 11.12.13, 11.12.15, 11.3.1, 11.3.17, 11.3.28, 11.4.1, 11.4.3, 11.4.7, 11.4.9, 11.4.10, 11.5.16, 11.7.1, 11.8.3, 11.8.5, 11.8.13, 11.9.14, 11.9.5, 11.9.10, 11.11.14, 11.2.2, 12.2.14, 12.2.19b, 12.8.23, 12.9-10.6, 12.12.26, 12.2.13, 12.5.4, 12.5.9, 12.8.14, 12.8.20, 12.9-10.4, 12.9-10.9, 12.11.9, 12.11.5, 12.11.21, 12.12.7, 12.12.9, 12.12.23, 11.10.4, 11.12.5. *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*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are *Core habitat*.

Class	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	GIS habitat modelling instructions		
					General habitat	**Essential habitat**	**Core habitat**
Mammals	*Ornithorhynchus anatinus*	Platypus	SLC	Platypus make their home in and near freshwater creeks, slow-moving rivers, lakes joined by rivers, and built water storages such as farm dams (DEHP).	The following is considered to constitute General habitat: All areas mapped as Water courses with a Stream order rating of 3 and above, and lacustrine water bodies with a buffer of 100 m *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* *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*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are *Core habitat*.

Class	Scientific name	Common name	NC Act	Habitat requirements that are the basis for the GIS assumptions	GIS habitat modelling instructions		
					General habitat	**Essential habitat**	**Core habitat**
Mammals	*Tachyglossus aculeatus*	Short-beaked echidna	SL C	The short-beaked echidna is found in forests, woodlands, heath, grasslands and desert	*The following is considered to be general habitat:* All RE habitat (with an additional 50 m into no-remnant areas) excluding land zones and 2 and RE 11.3.11, 11.3.40, 11.8.13, 11.10.8, 11.11.5, 11.4.1, 11.5.15, 11.7.1, 11.8.3, 11.9.4, 11.9.5, 11.10.8, 11.11.18, 11.11.21, 11.12.4, 11.12.7, 12.3.1, 12.3.16, 12.3.17, 12.3.21, 12.8.15, 12.11.1, 12.12.1, 12.5.13, 12.8.21, 12.8.22, 12.8.23, 12.9-10.15, 12.11.4, 12.11.13, 12.12.17, 12.12.18, 12.12.26 *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*	Any specimen backed records (buffered to a 1 km radius) that fall within areas mapped as *General habitat* (refer previous column) constitute *Essential habitat*	Any area identified as *Essential habitat* (refer previous column) that intersects with any area identified under the BPA mapping as 'H-Rating' (High or medium), 'J Rating' (Regional or State) or 'A Rating' (Very high, High or Medium), of any areas mapped as a national park, state forest or Nature refuge area or mapped as a voluntary Declaration (VDEC) are *Core habitat*.

Table notes:

V = Vulnerable SL = Special least concern

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APPENDIX

I

Terrestrial and Aquatic Ecology

Appendix B Species profiles

GOWRIE TO HELIDON ENVIRONMENTAL IMPACT STATEMENT

Inland Rail: Phase 2 - Gowrie to Helidon

Species Profiles

Australian Rail Track Corporation

Reference: 3200

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1 Flora species

1.1 Bailey's cypress pine (*Callitris baileyi*)

1.1.1 Status

EPBC Act – Not listed

NC Act – Near threatened

1.1.2 Biology and ecology

1.1.2.1 Characteristic

Bailey's cypress pine (*Callitris baileyi*) is a tree growing to 18 metres (m) tall, with spreading or erect branches and rough greyish bark. The foliage is green, rather than bluish as with many other cypress pines (refer Photograph 1.1). The adult leaves are 2 to 5 millimetres (mm) long and arranged in threes, parallel with the stem. A sharp keel runs down the back of each leaf. Male and female cones occur on the same tree. Male cones are 2 to 3 mm long and are on the ends of the branchlets. Female cones are solitary on slender fruiting branchlets and are waxy, greyish-blue during development. The oblong cones measure 10 to 13 mm in diameter and the alternate scales on the cones are shorter and narrower. The central stalk of the cone is short, narrow at the base and slightly angled (Stanley and Ross 1983; OEH 2018; Harden and Thompson 2008).

Photograph 1.1 Bailey's cypress pine (*Callitris baileyi*)

Source: Miles (2017)

1.1.2.2 Known distribution

Bailey's cypress pine is found sporadically in South-east Queensland (SEQ) and far north New South Wales (NSW). It is found from around Kumbia and Yarraman to west of Brisbane down across the NSW border near Tabulum (OEH 2018) (refer Figure 1.1).

Figure 1.1 **Distribution range of the Bailey's cypress pine**

Source: ALA (2018); OEH (2019)

1.1.2.3 Distribution in relation to the Project

Callitris baileyi has been predicted to occur within the ecology study area. Database records (i.e. AoLA and WildNet) indicate this species does not occur within the disturbance footprint as the nearest record in relation to the Project occurs approximately 5 kilometres (km) east of the eastern section of the alignment at the Lockyer Reserves dated 2019. The next nearest records occur to the north Highfield with two records dated 2019 within approximately 10 km of the disturbance footprint (refer Figure 1.2). Other records within a 50 km buffer of the Project disturbance footprint are sparse but occur in all directions account the Project with most records occurring to the south towards Main Range National Park and to the east near Marburg/Rosewood.

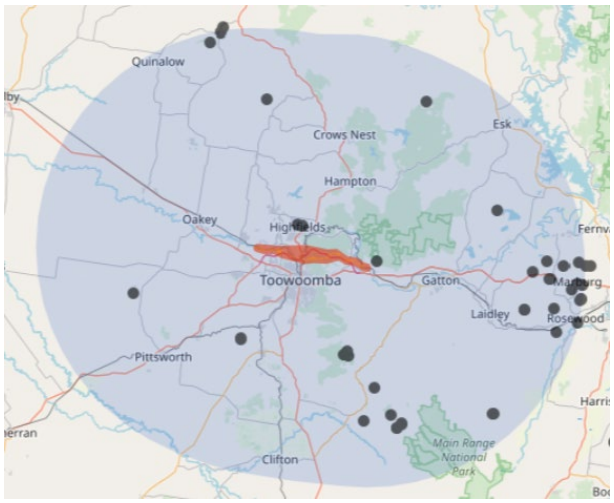

Figure 1.2 **Distribution range of the Bailey's cypress pine in relation to the Project**

Source: ALA (2020)

1.1.2.4 Biology and reproduction

Male and female cones occur on the same tree and are recorded all year round, however not much else is known about reproduction in Bailey's cypress pine (Stanley and Ross 1983).

1.1.3 Habitat

Bailey's cypress pine grows on rocky slopes, hilly or mountainous areas, in shallow and often clay soils. It is found in eucalypt woodland, commonly associated with ironbark, Blue gum and Spotted gum (OEH 2018; Stanley and Ross 1983).

1.1.4 Threatening processes

The following have been identified as potentially threatening processes to Bailey's cypress pine:

- Fire
- Risk of local extinction because population is small
- Trampling by livestock and people
- Clearing of habitat for agriculture
- Road and track maintenance works
- Grazing and disturbance by feral browsing animals (OEH 2018).

1.1.5 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.

1.1.6 Summary of threat abatement/recovery plan

The conservation strategy for Bailey's cypress pine identifies two priority management sites in NSW including:

- Trough Creek in Tenterfield local government area (LGA)
- Sandilands in Kyogle LGA.

Threats specific to Bailey's cypress pine identified in the strategy include:

- Current or potential future land management practices do not support conservation
- Trampling by stock
- Physical damage by campers and trail bikers
- Risk of local extinction because population is small.

Management actions outlined in the strategy include:

- Liaise with and encourage landholders to enter into agreements to maintain and enhance the species through voluntary management agreements
- In locations identified as being appropriate implement stock fencing to facilitate sustainable grazing in areas where this species occurs, particularly around cliff lines that drop to a creek
- Install locked gates providing landholder access to keep out recreational users of an area
- Survey suitable habitat and identify this species from aerial photography and historical records
- Conduct a census of the population during summer months mapping the extent of occurrence at the site and to determine if recruitment is occurring.

1.1.7 References

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Office of Environment and Heritage, NSW (2018). Callitris baileyi. Available from: https://www.environment.nsw.gov.au/threatenedSpeciesApp/profile.aspx?id=10131 [Accessed 31 August 2018].

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1.2 *Cyperus clarus*

1.2.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

1.2.2 Biology and ecology

1.2.2.1 Characteristic

Cyperus clarus is a slender tufted perennial. Its stems are erect and rigid, smooth to scabrous at the tip, 15 to 80 cm tall and 1 to 2.5 mm thick. The leaves are flat or folded and are 2 to 6 mm wide and shorter than the flowering stem. The flower head has 3 to 6 branches to 10 cm long (refer Photograph 1.2). Each branch consists of dense clusters made up of 8 to 20 short spikelets. The spikelets are flattened and are 7 to 18 mm long by 3 to 4.5 mm wide in side view. The glumes (scales enclosing the flower) are golden brown to brown and are 2.5 to 4 mm long with the sides having 3 to 4 nerves and an excurved tip to 0.8 mm long. The egg-shaped nuts are dusky brown to black in colour, 1.6 to 1.9 mm long and 0.6 to 0.8 mm diameter (Wilson 1991; Wilson 2008).

Photograph 1.2 **Cyperus clarus**

Source: Sharp (n.d.)

1.2.2.2 Known distribution

Specimens of *C. clarus* have been recorded in the Queensland Central Highlands, west of Brisbane near Toowoomba and in NSW near Inverell (ALA 2018) (refer Figure 1.3).

Figure 1.3 **Distribution range of the *C. clarus***

Source: ALA (2018)

1.2.2.3 Distribution in relation to the Project

Cyperus clarus has been predicted to occur within the ecology study area. Database records (i.e. AoLA and WildNet) indicate this species occurs within the ecology study area near the Toowoomba Waste Management Centre with a record dated 2018. The next nearest record occurs within 3 km west of the western section of the alignment however this record is from 1934. Other records from within a 50 km buffer of the disturbance footprint occur to the north-west near Oakey, to the south-west towards Pittsworth and south between Toowoomba and Clifton (refer Figure 1.4).

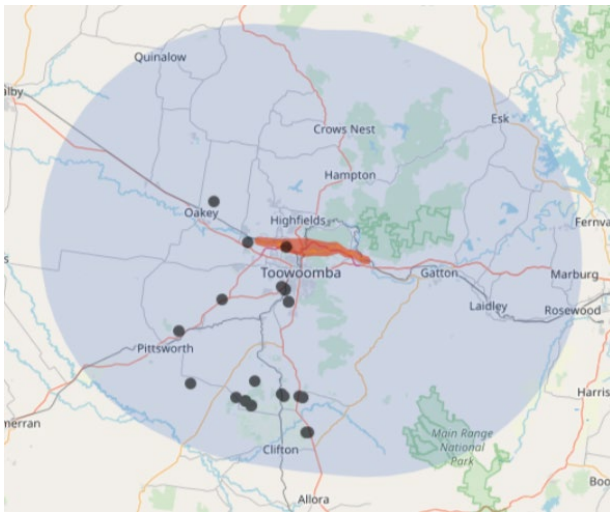

Figure 1.4 **Distribution range of the *Cyperus clarus* in relation to the Project**

Source: ALA (2020)

1.2.2.4 Biology and reproduction

Cyperus clarus flowers from spring to summer (Wilson 2008).

1.2.3 Habitat

Cyperus clarus grows in grassland or open woodland, in heavy soils derived from basalt. The species is associated with grasslands where *Aristida leptopoda* and *Panicum queenslandicum* occur on deep alluvial black clay; in *Eucalyptus melanophloia* woodland with mid-dense ground stratum of *Chrysopogon fallax*; growing with *Stemmacantha australis* in mountain coolibah woodland on basalt ridges; and in *Dichanthium* grassland with *Cyperus bifax* and *Fimbristylis* spp. (Queensland Herbarium 2011; Wilson 2008).

1.2.4 Threatening processes

The following have been identified as potentially threatening processes to *C. clarus*:

- Land clearing for agriculture and subsequent invasion of competitive weeds
- Mining activities which remove individuals and disrupts pollinator and disperser interactions (DERM 2010a)
- Grazing is also considered a threat in the south west management region (DERM 2010b).

1.2.5 Threat abatement/recovery plans

The following threat abatement/recovery plans have been identified as relevant for the species.

- Department of Environment and Resource Management (2010), Back on track actions for biodiversity: Taking action to achieve species conservation in the Border Rivers Maranoa-Balonne Natural Resource Management Region. Available from: https://qldgov.softlinkhosting.com.au/liberty/opac/search.do?queryTerm=Border%20Rivers%20Maranoa-Balonne%20Natural%20Resource%20Management%20Region%20Back%20on%20Track%20Actions%20for%20Biodiversity&mode=ADVANCED&=undefined&modeRadio=KEYWORD&operator=AND&activeMenuItem=false.

1.2.6 Summary of threat abatement/recovery plan

Cyperus clarus has been identified as a 'high priority' species of 'major' importance. Threats identified in this action plan for this species includes:

- Loss and removal of individual plants and habitat as a result of land clearing for agriculture and mining activities
- Competition with exotic invasive weeds
- Disruption of the pollinator and disperser interaction.

Management actions identified in this action plan for the species includes:

- Implement control measures for weed species in areas across the Border Rivers Maranoa-Balonne NRM region
- Provide input into impact assessments for mining activities within the region and encourage rehabilitation of abandoned mine sites
- Coordinate the Nature Refuges and Land for Wildlife Programs incentivising landholders to conserve and manage natural and cultural resources under a perpetual nature refuge agreement.

1.2.7 References

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Wilson K.L. (1991). Systematic studies in *Cyperus* section *Pinnati* (Cyperaceae). *Telopea* 4 (3): 480.

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1.3 Finger panic (*Digitaria porrecta*)

1.3.1 Status

EPBC Act – Not Listed

NC Act – Near threatened

1.3.2 Biology and ecology

1.3.2.1 Characteristics

Finger panic (*Digitaria porrecta*) is a perennial, loosely tufted, erect or ascending grass up to 60 centimetres (cm) tall. The nodes are pubescent and culms are branched. The leaf sheaths are smooth, or with a few hairs towards the base; the ligules are membranous, 2 to 3 mm long; the leaf blades are linear, the apex reinforced, 5 to 15 cm x 0.3 to 0.4 cm, pubescent or smooth (refer Photograph 1.3). The Finger panic has a loose branching cluster of several racemes up to 25 cm long. The lower racemes are mostly convoluted, branched divaricately 3 to 10 cm long. The upper racemes are individual with spikelet's in pairs, 5 to 7 mm long. The lower glume is approximately 1 to 1.5 mm long and the upper glume is known to be shorter than spikelet, covered with short soft hair between the outer nerves. Lower florets are known to be as long as the spikelet's, and smooth between the outer nerves but fibres at first appressed. When at length the Finger panic is woolly and upper florets are shorter than the spikelet's. The Finger panic has a similar appearance to the Hairy panic *(Panicum effusum)* and Queensland panic *(Panicum queenslandicum),* both of which are found in Queensland (DES 2018).

Photograph 1.3 Finger panic (*Digitaria porrecta*)

Source: readleaf environmental

1.3.2.2 Known distribution

The Finger panic is endemic to eastern Australia in Queensland and NSW (refer Figure 1.5). The species has been recorded in Queensland within the Brigalow Belt bioregion, Nebo district, southwest of Mackay, central highlands between Springsure and Rolleston, and from Jandowae south to Warwick. In Queensland, Finger panic occurs in communities dominated by *Eucalyptus orgadophila* on hills and slopes and and *E. tereticornis* and *E. populnea* in drainage lines (Halford 1995).

Figure 1.5 **Distribution range of Finger panic**

Source: ALA (2018)

1.3.2.3 Distribution in relation to the Project

Digitaria porrecta has been predicted to occur within the ecology study area. Database records (i.e. AoLA and WildNet) indicate this species occurs within the disturbance footprint to the north of Cotswold Hills dated 2010. Two records from 2015 occur within the ecology study area to the south of the disturbance footprint north of Cotswold Hills. A record from 2007 occurs within approximately 10 km north of the disturbance footprint near Highfields (refer Figure 1.6). Other records for this species within a 50 km buffer of the disturbance footprint are mostly to the west of the Toowoomba Range to the north-west, west, south-west and south of the alignment.

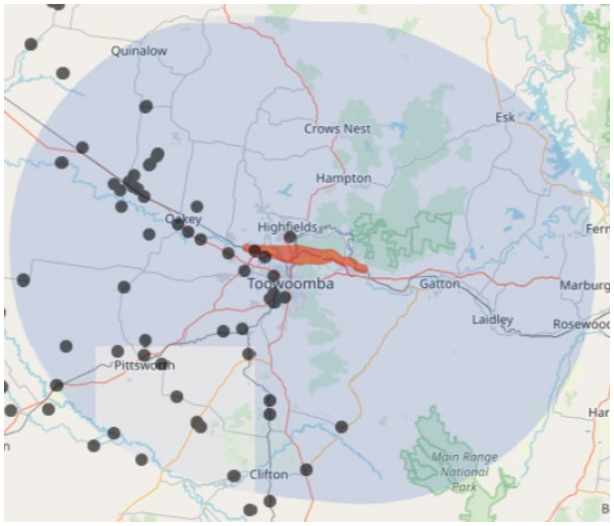

Figure 1.6 **Distribution range of Finger panic in relation to the Project**

Source: ALA (2020)

1.3.2.4 Biology and reproduction

The species flowers in late summer in a cylindrical cluster along a stalk and spread stiffly from the flowering stem, with the lower clusters arranged in a whorl of four to six, each up to 30 cm long. Finger panic seeds from March to April but also reproduces vegetative by dying back to the tussock base, from which it re-sprouts in summer. The species thrives in highly disturbed areas that have been cleared, including road reserves (Halford 1995, per sobs; Schell and Stark 2017).

1.3.3 Habitat

Finger panic is known to occupy dark and fine textured soils with some seasonal cracking and often persists in disturbed habitats, such as fallow paddocks, but its capability to maintain a viable population is unknown. The species is generally found in open woodland, tussock grasslands, box or forest red gum, alluvial plains and in areas with heavy cracking clays (DES 2018; Halford 1995).

1.3.4 Threatening processes

The following have been identified as potentially threatening processes to the Finger panic:

- Habitat loss from clearing and habitat fragmentation, disturbance and modification
- Invasive weeds compete with Finger panic for habitat resource
- Agriculture in terms of grazing impacts from livestock and physical disturbance from machinery are an identified threat (NSW DEC 2008).

1.3.5 Threat abatement/recovery plans

The following recovery plans have been identified as being relevant for this species:

- 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.
- Office of Environment and Heritage (2016), Saving our Species Program. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/project.aspx?ProfileID=10222. In effect under the BC Act 2016.

No threat abatement plan has been identified as being relevant for this species.

1.3.6 Summary of threat abatement/recovery plans

The *Save our Species* conservation strategy for *Digitaria porrecta* identifies six priority management sites:

- Bald Hills in Narrabri LGA
- Leard in Narrabri LGA
- Boggabri in Narrabri LGA
- Goolhi Road in Gunnedah LGA
- Mullaley in Gunnedah LGA
- Pine Ridge in Liverpool Plains LGA.

Threats identified at the management sites include:

- Heavy grazing my domestic stock
- Competition from invasive grasses (Johnson grass, African lovegrass and tall Rhodes grass)
- Lack of protected land at sites which the species has been recorded on.

Management activities to protect this species at the *Save our Species* sites are:

- Ensure grazing regimes are appropriate for the species/community by negotiating short and infrequent grazing, allowing for sufficient recovery periods and excluding stock from the site when the ground is wet
- Reduce and maintain weed densities through spot-spraying

- Track species abundance and condition over time through estimating total population size annually, assessing ground cover of invasive grasses and monitoring of ground condition for evidence of overgrazing.

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 Conservation Management Network (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.

1.3.7 References

Atlas of Living Australia (2018), *Digitaria porrecta,* Occurrence records map, viewed 18 August 2018, https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2920729.

Digitaria porrecta, WetlandInfo, Department of Environment and Science, Queensland, viewed 17 August 2018, https://wetlandinfo.des.qld.gov.au/wetlands/ecology/components/species/?digitaria-porrecta.

Nature Conservation Act (1992) (Queensland): Near Threatened species: May 2017 list) as *Digitaria porrecta*

New South Wales Department of Environment and Conservation (2008), NSW Threatened Species: Finger Panic Grass – profile, viewed 18 April 2008, <www.environment.gov.au/biodiversity/threatened/species/pubs/12768-conservation-advice.pdf.

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Redleaf environmental, Finger panic, viewed 18 August 2018, http://www.redleafenviro.com.au/news/vegetation-surveys.aspx.

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1.4 Koala fern (*Caustis blakei subsp. macrantha*)

1.4.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

1.4.2 Biology and ecology

1.4.2.1 Characteristic

Caustis blakei has rigid, erect, smooth stems up to 2 m tall and 2.5 to 5.0 mm in diameter. Mature leaves are reduced to dark brown, pointed scales. There are 10 to 18 vegetative nodes per stem, each having 1 to 6 lateral branches. The young flowering branches are short, narrow and wavy.

There are several to many flowering spikelets per inflorescence. Each spikelet is usually single-flowered and 6 to 11 mm long. The mature fruit is dark brown to black and 6 to 9 mm long, including a beak.

Caustis blakei subsp. macrantha has larger spikelets and fruit than the similar *Caustis blakei* subsp. *blakei*. (Johnston et al. 1997)

Photograph 1.4 ***Caustis blakei* subsp. *macrantha***

Source: Photographer: Martin Bennett, ALA (2019)

1.4.2.2 Known distribution

Caustis blakei subsp. *macrantha* is found inland near Murphys Creek and Helidon in south-eastern Queensland. Earlier records of this species are from Fernvale and Gatton, in the same inland area. The other subspecies, *Caustis blakei* subsp. *blakei*, is the more widespread coastal population, found from Toolara near Maryborough in Queensland, to Crowdy Bay, NSW and on the major islands off SEQ.

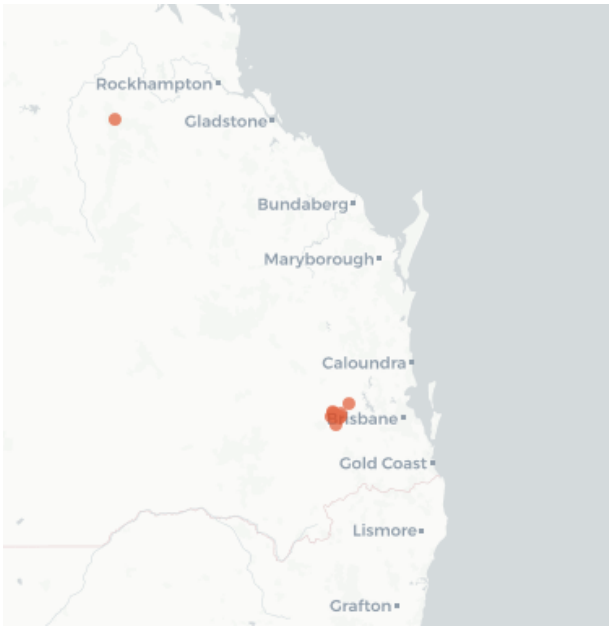

Figure 1.7 **Distribution range of *Caustis blakei* subsp. *macrantha***

Source: DES (2019)

1.4.2.3 Distribution in relation to the Project

Caustis blakei subsp. macrantha has been predicted to occur within the ecology study area. Database records (i.e. AoLA and WildNet) indicate this species occurs within approximately 3 km of the eastern section of the disturbance footprint however, this record is dated from 1964. More recent records (2016) occur within the Lockyer Reserves to the north east of the eastern section of the alignment where this species is mostly restricted to. These records extent approximately 35 km north-east of the alignment near Esk National Park (refer Figure 1.8).

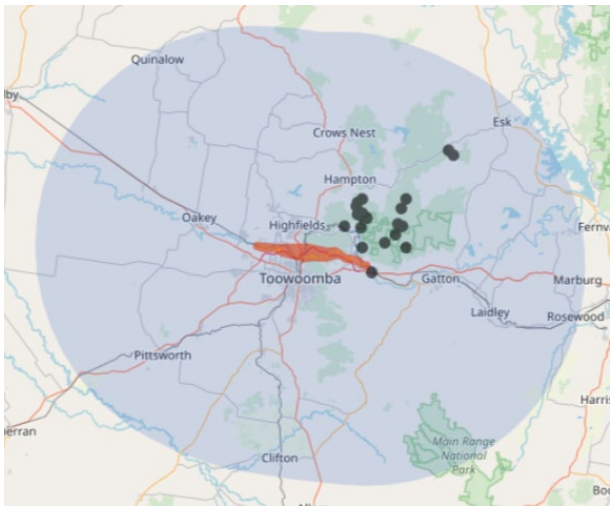

Figure 1.8 **Distribution range of Caustis blakei subsp. macrantha in relation to the Project**

Source: ALA (2020)

1.4.2.4 Biology and reproduction

Flowering in *Caustis blakei* subsp. *macrantha* is known to occur in the latter half of the year between August and December (PlantNET 2019).

1.4.3 Habitat

Caustis blakei subsp. *macrantha* inhabits tall open eucalypt forests with a sparse canopy, on sandstone ridges and soils derived from weathered sandstone. Regional Ecosystems 12.5.1 and 12.9/10.5 in the Helidon Hills (Johnston et al. 1997).

1.4.4 Threatening processes

The following have been identified as potentially threatening processes to the Koala fern:

- Loss or fragmentation of species populations or species habitat through vegetation clearing
- Inappropriate fire regimes. Frequent low-intensity burning to reduce fuel loads or promote grass growth for cattle grazing is likely to have a detrimental impact on this shrubby understorey species.
- Over-harvesting for flora trade.

1.4.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species (DoEE 2018).

1.4.6 References

Atlas of Living Australia (2018), Photo Caustis blakei subsp. macrantha, viewed 19 August 2019, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2920345#gallery

Atlas of Living Australia (2018), Caustis blakei subsp. macrantha, viewed 19 August 2019, available https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2920345#overview

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1.5 Slender milkvine (*Marsdenia coronata*)

1.5.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

1.5.2 Biology and ecology

1.5.2.1 Characteristic

Slender milkvine (*Marsdenia coronata*) is a herbaceous vine with tuberous roots. Its stems are cylindrical, up to 1.5 mm in diameter and exuding white latex when cut. Leaves are on stalks 2 to 7 mm long. The leaf blades are linear to lance-shaped, up to 5.5 cm long and 1 cm wide, wedge-shaped to rounded at the base with an acute apex. Flowers are on stalks 4.6 to 8 mm long, arising in a cluster at the end of a common stalk (refer Photograph 1.5). The corolla is shallowly bell-shaped, yellow to yellow-green, the basal part a tube 2.6 to 3 mm long, separating above the tube into triangular lobes 1.6 to 2 mm long and bent sharply downwards. Fruits are dry, spindle-shaped to egg-shaped, approximately 10 cm long (Forster 1995; 1996).

Photograph 1.5 Slender milkvine (*Marsdenia coronata*)

Source: Shields (2016)

1.5.2.2 Known distribution

Slender milkvine occurs in SEQ, where it is commonly found in eucalypt forest or, at Mount Coolum, in open grassland among rocks. Scattered populations occur from the Gunalda Range, north of Gympie, south to the Great Dividing Range near Killarney (Forster 1995; Halford 1998) (refer Figure 1.9).

Figure 1.9 Distribution range of the Slender milkvine

Source: ALA (2018)

1.5.2.3 Distribution in relation to the Project

Marsdenia coronata has been predicted to occur within the region and associated habitat within the ecology study area. Project associated field investigation detected this species within the ecology study area (ARTC 2017). However, there are no current records for this species within 50 km of the temporary and permanent project footprint. Database records (i.e. AoLA) indicate the nearest record of this species in relation to the Project is somewhat recent dated 1990 and occurs approximately 60 km east of the disturbance footprint. Database records including recent occur to the south-east of the Project from the Scenic Rim north-east to the Gunalda Range (refer Figure 1.10).

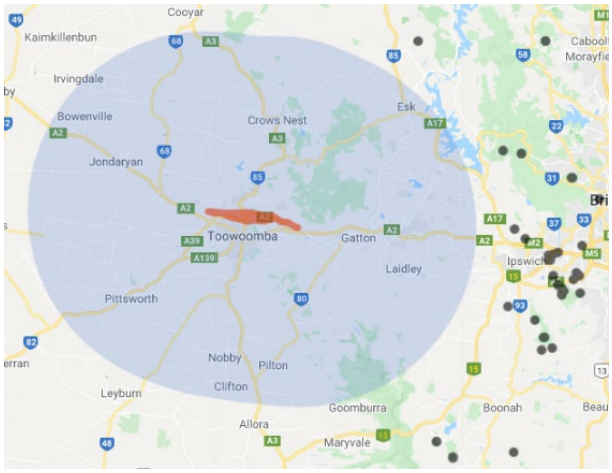

Figure 1.10 Distribution range of the Slender milkvine in relation to the Project

Source: ALA (2020)

1.5.2.4 Biology and reproduction

Flowering occurs from November to March, and fruiting occurs three to four months later (Forster 1996).

1.5.3 Habitat

Slender milkvine commonly grows in rainforest, rainforest margins or moist areas of open forest, especially in eucalypt forest. Also recorded from an area of natural grassland on the top of Mt Kandanga, Imbil State Forest. The vine has been found between 40 and 780 m above sea level, and usually occurs on sandstone or stony soils (Borsboom and Wang 1996).

1.5.4 Threatening processes

The following have been identified as potentially threatening processes to Slender milkvine:

- Destruction of habitat due to clearing and development and mining
- Inappropriate fire regimes (Borsboom and Wang 1996; Forster 1995).

1.5.5 Threat abatement/recovery plans

No threat abatement or recovery plans have been identified as being relevant for this species (DOEE 2018)

1.5.6 References

Atlas of Living Australia (2018). *Marsdenia coronata*. Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2901233#overview [Accessed 31 August 2018].

Borsboom, A. and Wang, J. (1996). *Marsdenia coronata* Species Management Profile, Department of Natural Resources, Queensland.

Forster, P.I. (1995). Circumscription of *Marsdenia* (Asclepiadaceae: Marsdenieae), with a revision of the genus in Australia and Papuasia. Australian Systematic Botany 8 (5): 784.

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Shields T. (2016). *Marsdenia coronata* (Image) [Online] Available from: https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2901233#gallery [Accessed 31 August 2018].

2 Fauna species – Conservation significant species – Invertebrates

2.1 Pale imperial hairstreak (*Jalmenus eubulus*)

2.1.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

2.1.2 Biology and ecology

2.1.2.1 Characteristic

The Pale imperial hairstreak (*Jalmenus eubulus*) is a medium-sized butterfly, with a wingspan of 32 mm for males and 37 mm for females. The iridescent central areas on the upperside of the wings are predominantly white with a very faint suffusion of green (particularly in the male) or sometimes blue (female) (refer Photograph 2.1). These iridescent areas are extensive, especially on the hind-wing where they extend close to the termen. The black markings on the underside of its wings are narrow and the short black bar at the end of the cell on the upperside of the forewing is narrow or absent. The chestnut-brown subterminal band on the underside of both wings is rich and pronounced and the termen and tornus of the forewing are generally rounded (Eastwood et al. 2008; OEH 2017)

Photograph 2.1 Pale imperial hairstreak (*Jalmenus eubulus*)

Source: Gillespie (2014)

2.1.2.2 Known distribution

In Queensland, the Pale imperial hairstreak is restricted to the seasonally sub-humid central and southern areas and in NSW it is found only in the northern brigalow-dominated open forests and woodlands (OEH 2017) (refer Figure 2.1).

Figure 2.1 **Distribution range of the Pale imperial hairstreak**

Source: ALA (2018)

2.1.2.3 Distribution in relation to the Project

Jalmenus eubulus has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that there are no records of *Jalmenus eubulus* within the ecology study area. The closest record is located approximately 1.5 km south of the disturbance footprint near Wilsonton Heights and is dated 2009. The next closest record is located approximately 30 km northwest of the alignment near Jondaryan and is dated 1992. No other records are present within a 50 km buffer of the disturbance footprint (refer Figure 2.2).

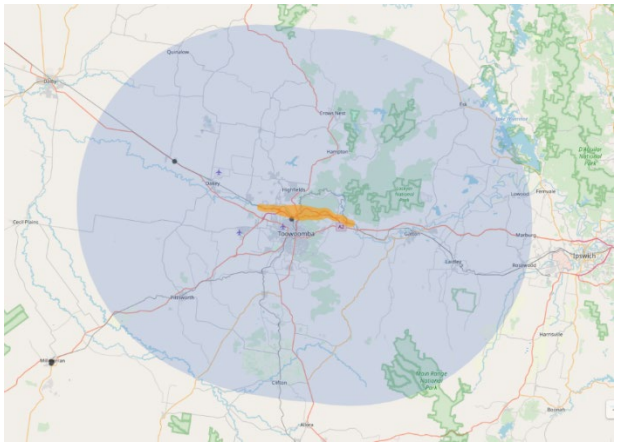

Figure 2.2 **Distribution range of the Pale imperial hairstreak in relation to the Project**

Source: ALA (2020)

2.1.2.4 Biology and reproduction

The larvae only feed on Brigalow (*Acacia harpophylla*) leaves (refer Photograph 2.2) and is an obligate myrmecophile with larvae attended by small black ants from the *Iridomyrmex* group of species (Braby 2000; Eastwood and Fraser 1999).

Photograph 2.2 Brigalow (*Acacia harpophylla*)

Source: Fagg (n.d.)

It is only known to breed in old-growth forests of Brigalow or woodland and does not appear to colonise regrowth brigalow habitats (OEH 2017).

2.1.3 Habitat

Suitable habitat is dominated by *Acacia harpophylla* and *Casuarina cristata* on clay soils on flat to gently undulating plains, usually with scattered emergent eucalypts such as Eucalyptus populnea and low trees of *Geijera parviflora* (OEH 2017). These areas are typically analogous to the Brigalow (*Acacia harpophylla*) dominant and sub-dominant threatened ecological community.

2.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Pale imperial hairstreak:

- Loss and disturbance to old growth brigalow communities
- The combined effects of habitat reduction with specific host plant and symbiotic ant interactions
- Lack of distributional information (OEH 2017).

2.1.5 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=520&ReportProfileID=10219. In effect under the BC Act 2016.

2.1.6 Summary of threat abatement/recovery plans

Jalmenus eubulus 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. As such, the objective of the strategy is to fill knowledge gaps in order to develop a targeted management strategy.

2.1.7 References

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Office of Environment and Heritage, NSW (2017). Pale Imperial Hairstreak. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=20123 [Accessed 3 September 2018].

3 Fauna species – Conservation significant species – Reptiles

3.1 Grey snake (*Hemiaspis damelii*)

3.1.1 Status

EPBC Act – Not listed

NC Act – Endangered

3.1.2 Biology and ecology

3.1.2.1 Characteristic

The Grey snake (*Hemiaspis damelii*) is typically uniform olive grey to grey above and their belly surfaces are white to cream, usually flecked with dark grey. The top of the head and the first few scale rows are black in juveniles. This dark patch reduces to a narrow bar in adults, or sometimes may disappear completely. They have large eyes and generally grow to a total length of about 0.7 m (refer Photograph 3.1) (DES 2017).

Photograph 3.1 Grey snake (*Hemiaspis damelii*)

Source: Zimny (2012)

3.1.2.2 Known distribution

Its distribution extends from central inland NSW, north to several isolated populations near Rockhampton in Queensland. Within Queensland, records are known from near Goondiwindi and the adjacent Darling-Riverine Plain, from the Darling Downs and from the Lockyer Valley (refer Figure 3.1). The core area for the Grey snake in the Brigalow Belt is south of the Great Dividing Range between Dalby and Glenmorgan (DES 2017).

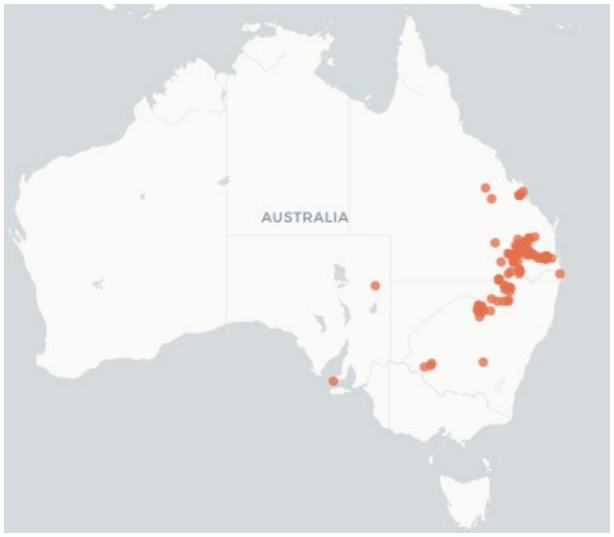

Figure 3.1 **Distribution range of the Grey snake**

Source: ALA (2018)

3.1.2.3 Distribution in relation to the Project

Hemiaspis damelii has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that no records of *Hemiaspis damelii* exist within the ecology study area. The closest record is located approximately 5 km northeast of the disturbance footprint in Lockyer State Forest and is dated 1996. The next closest record is located approximately 12 km south of the alignment near Westbrook (not dated). A number of records exist within a 50 km buffer of the disturbance footprint. The majority of these are located east of the alignment between Gatton and Lowood followed by the area between Oakey and Dalby (refer Figure 3.2).

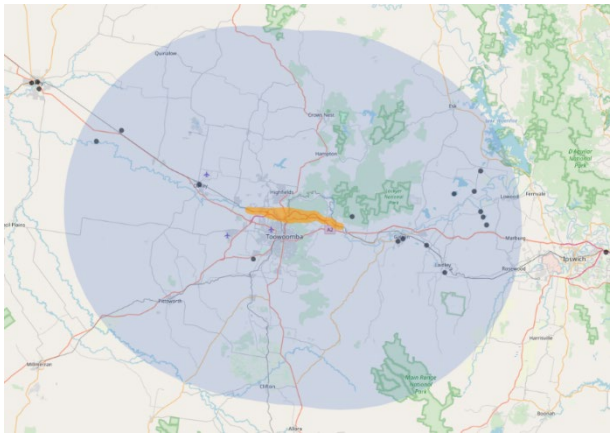

Figure 3.2 **Distribution range of the Grey snake in relation to the Project**

Source: ALA (2020)

3.1.2.4 Biology and reproduction

Grey snakes are active during the night when they feed on frogs and lizards (DES 2017).

They bear 4 to 16 live young, usually between January and March. Young are born fully formed and individuals take about 12 months to mature (DES 2017).

3.1.3 Habitat

The Grey snake favours woodlands, usually on heavier, cracking clay soils, particularly in association with water bodies or in areas with small gullies and ditches. It shelters under rocks, logs and other debris as well as in soil cracks (DES 2017).

3.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Grey snake:

- Pasture improvement and cultivation disrupts soil structure in cracking clay soils, potentially reducing the availability of shelter for the Grey snake
- Impacts from feral animals such as cats, foxes, canetoads and pigs
- Hydrological changes to waterways have the potential to impact on those species that rely on these types of habitats for survival (DES 2017).

3.1.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified for this species (DoEE 2018).

3.1.6 References

Atlas of Living Australia (2018). *Hemiaspis damelii*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:78a40c2c-23d8-45de-86e5-ad6f5441f276 [Accessed 10 October 2018].

Department of Environment and Science (2017). Grey snake. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/grey_snake.html [Accessed 10 October 2018]

Zimny, A. (2012). *Hemiaspis damelii* (Grey Snake). (Image) [Online] Available from: https://www.flickr.com/photos/zimny_anders/10403069974 [Accessed 10 October 2018].

4 Fauna species – Conservation significant species – Mammals

4.1 Platypus (*Ornithorhynchus anatinus*)

4.1.1 Status

EPBC Act – Not listed

NC Act – Special Least Concern

4.1.2 Biology and ecology

4.1.2.1 Characteristic

The male Platypus (*Ornithorhynchus anatinus*) is about 50 cm long and weighs about 1.5 kg while the female is typically 40 cm long, weighing 1 kg. However, size may vary with the smallest specimens found in the north and largest in the south. The Platypus has a leathery snout resembling a duck bill and broad flat tail. The snout is chocolate in colour and pliable (refer Photograph 4.1). Its streamlined body has uniform brown upperparts and pinkish brown underparts. It has short limbs and webbed feet with claws. Adult males are equipped with a 12 mm long spur on each hind ankle which can inject venom (DES 2018; Menkhorst and Knight 2011).

Photograph 4.1 Platypus (*Ornithorhynchus anatinus*)

Source: Wormleaton (2018)

4.1.2.2 Known distribution

The Platypus is found in bodies of freshwater in eastern Australia, from the Annan River in northern Queensland to the far south of Victoria and Tasmania (refer Figure 4.1). In Queensland, platypus live east of the Great Dividing Range, and in some western-flowing streams. In north Queensland, the range of the Platypus is closer to the coast (DES 2016; OEH 2018).

Figure 4.1 **Distribution range of the Platypus**

Source: ALA (2018)

4.1.2.3 Distribution in relation to the Project

Database records (i.e. AoLA and WildNet) indicated that *Ornithorhynchus anatinus* has been identified as potentially occurring within the Ecology Study Area. Database records (i.e. ALA) indicate that one record of *Ornithorhynchus anatinus* exists within the ecology study area. This record is located approximately 600 m from the disturbance footprint, northwest of Helidon, and is dated 1996. The next closest record is located approximately 3 km southeast of the disturbance footprint in Helidon and is dated 1876. A number of records exist within a 50 km buffer of the disturbance footprint to the north and east of the alignment. Most are concentrated to the north in the surrounds of Crows Nest National Park, followed by to the east in the area between Gatton and Laidley (refer Figure 4.2).

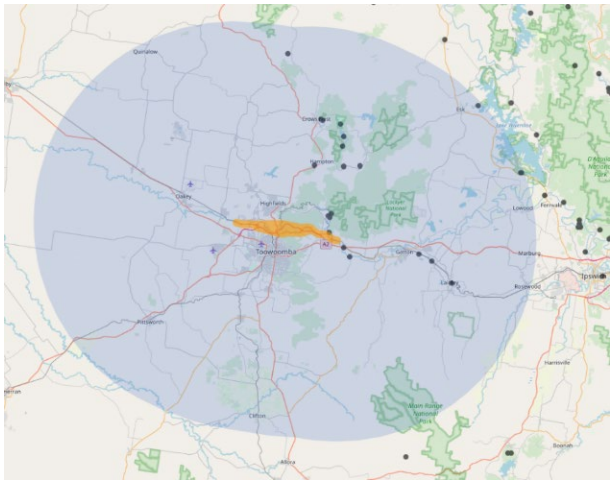

Figure 4.2 **Distribution range of the Platypus in relation to the Project**

Source: ALA (2020)

4.1.2.4 Biology and reproduction

The diet of the Platypus consists mainly of the benthic invertebrates, particularly insect larvae. They also known to feed on shrimps, water bugs, swimming beetles, tadpoles, worms, freshwater pea mussels and snails. Occasionally they will also catch cicadas and moths. Platypus are mainly crepuscular and rely on receptors in their sensitive bill to find and catch food (Australian Museum 2015; DES 2016).

In Queensland, Platypus mate in August, and about a month later in the south. After mating, the females build nesting burrows that can be up to 30 m long. After securing themselves within the burrow they lay two eggs which they incubate for about two weeks before they hatch. They are fed by their mother for a further 4 to 5 months before they leave the burrow and reach maturity at one year old (DES 2016; Menkhorst and Knight 2011).

4.1.3 Habitat

Found in freshwater streams, ranging from alpine creeks to tropical lowland rivers, lakes, shallow reservoirs and dams. They prefer areas with steep, vegetated banks for their burrows which are also concealed by vegetation (Menkhorst and Knight 2011).

4.1.4 Threatening processes

The following have been identified as potentially threatening processes to the Platypus:

- The biggest threat to the Platypus is the loss of habitat, especially land clearing and dams that disrupt the natural water flow
- Predation by introduced species such as foxes, cats and dogs and the entanglement in litter, such as fishing line and yabby traps are also threats to the Platypus
- Pollution, algal growths, siltation and destruction of creek banks are a threat to Platypus burrows (DES 2016; OEH 2018).

4.1.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

4.1.6 References

Atlas of Living Australia (2018) *Petrogale penicillata.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ac61fd14-4950-4566-b384-304bd99ca75f [Accessed 21 August 2018].

Australian Museum (2015). Platypus, *Ornithorhynchus anatinus*. Available from: https://australianmuseum.net.au/platypus [Accessed 21 August 2018].

Department of the Environment and Science (2016). Platypus. Available from: https://www.ehp.qld.gov.au/wildlife/animals-az/platypus.html [Accessed 21 August 2018].

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 (2018). Platypus. Available from: https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/platypus [Accessed 21 August 2018].

Wormleaton, S. (2018). Swimming platypus *(Ornithorhynchus anatinus).* (Image) [Online] Available from: https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/platypus [Accessed 21 August 2018].

4.2 Short-beaked echidna (*Tachyglossus aculeatus*)

4.2.1 Status

EPBC Act – Not listed

NC Act – Special Least Concern

4.2.2 Biology and ecology

4.2.2.1 Characteristic

The Short-beaked echidna (*Tachyglossus aculeatus*) is recognised by the extensive coverage of spines. It has a length of up to 450 mm and weighs up to 7 kg (females will usually weigh less). It also has hair present between the spines and they range in colour from light brown in the northern, hotter parts of Australia to darker in the south. The snout is 7 to 8 cm long and is rigid (refer Photograph 4.2). It has short, stout limbs and on the front feet they have five flattened claws which for digging. The back feet point backwards and help to push the soil away when the animal is burrowing (NPWS 1999; Queensland Museum 1995).

Photograph 4.2 Short-beaked echidna (*Tachyglossus aculeatus*)

Source: Edmonds (2015)

4.2.2.2 Known distribution

The Short-beaked echidna is found across all states and territories but appears to be most abundant in central and eastern Australia (ALA 2018) (refer Figure 4.3).

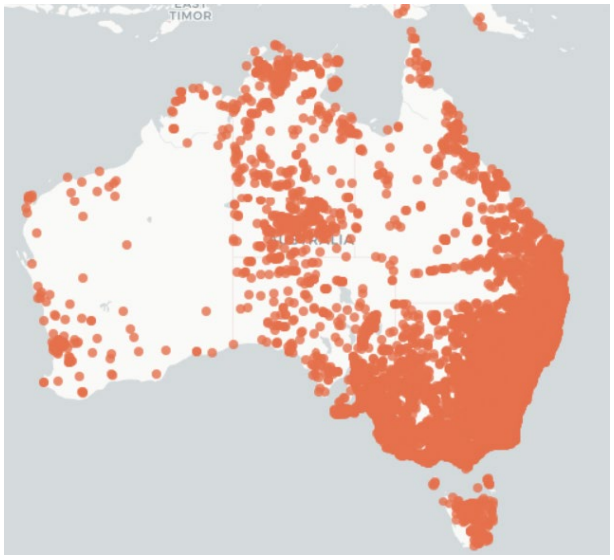

Figure 4.3 **Distribution range of the Short-beaked echidna**

Source: ALA (2018)

4.2.2.3 Distribution in relation to the Project

Database records (i.e. AoLA and WildNet) indicated that *Tachyglossus aculeatus* has been identified as potentially occurring within the temporary and permanent project footprint. Database records (i.e. ALA) indicate that two records of *Tachyglossus aculeatus* exist within the disturbance footprint and another two within the ecology study area. The two records within the disturbance footprint are located northwest of Helidon and are dated 2019. The two records within the ecology study are located approximately 2 km north of the alignment near Blue Mountain Heights and are dated 1978 and 2014. A number of records exist within a 50 km buffer of the disturbance footprint in all directions. Most are concentrated to the south of the alignment in the area between Toowoomba and Long Grass Nature Refuge, followed by the area between Crows Nest and Lockyer National Park (refer Figure 4.4).

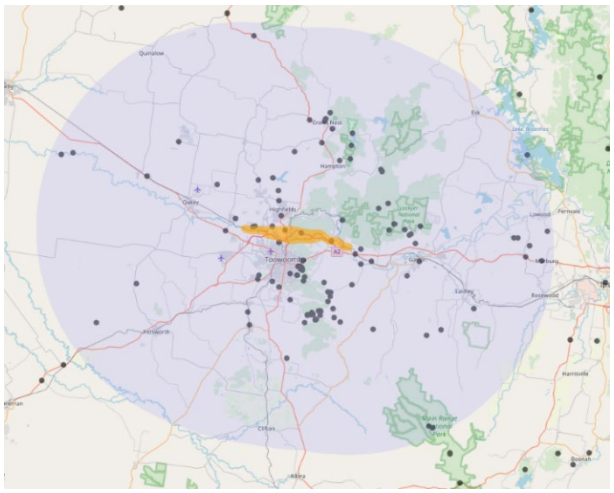

Figure 4.4 **Distribution range of the Short-beaked echidna in relation to the Project**

Source: ALA (2020)

4.2.2.4 Biology and reproduction

Termites and ants are its preferred food however it also eats earthworms, beetles and moth larvae.

Short-beaked echidnas breed from the end of June to early September. A particular characteristic displayed by echidnas during the breeding season is the formation of 'trains'. A female lays a single egg, which is incubated in the pouch and takes about ten days to hatch. The young echidna is suckled by its mother from mammary glands in the pouch, and is carried in the pouch for about three months. During this time the female will sometimes leave the young animal in a burrow, made by the female for its protection. The young echidna will leave the burrow at around 12 months of age. They have been known to live 10 to 16 years in the wild (Rismiller 1993; Rismiller and Seymour 1991; Strahan 1995).

4.2.3 Habitat

The distribution of the Short-beaked echidna ranges from undisturbed to disturbed habitats, and includes forests, woodlands, shrublands and grasslands, rocky outcrops and agricultural lands. Echidnas are usually found among rocks, in hollow logs, under vegetation or piles of debris, under tree roots or sometimes in wombat or rabbit burrows (Hyett and Shaw 1980).

4.2.4 Threatening processes

The following have been identified as potentially threatening processes to the Short-beaked echidna:

- Habitat loss – urban development
- Roadkill on roads
- Invasive predators, mostly domestic dogs (NPWS 1999).

4.2.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

4.2.6 References

Atlas of Living Australia (2018) *Tachyglossus aculeatus.* Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0d4c9c0c-51d3-44e0-a365-fe0f8b791c66#overview [Accessed 21 August 2018].

Edmonds A. (2015). *Tachyglossus aculeatus.* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0d4c9c0c-51d3-44e0-a365-fe0f8b791c66#gallery [Accessed 30 August 2018].

Hyett, J. and Shaw, N. (1980). *Australian Mammals: A Field Guide for NSW, Victoria, South Australia and Tasmania*, Thomas Nelson Australia, Melbourne.

National Parks and Wildlife Service (1999). Echidnas, Helping Them in the Wild. Hurstville, New South Wales: National Parks and Wildlife Service.

Queensland Museum (1995). *Wildlife of Greater Brisbane*. Brisbane: Queensland Museum Publications.

Rismiller, P. D. (1993). 'Overcoming a prickly problem', *Australian Natural History Magazine*, vol. 24, no. 6, pp. 22–29.

Rismiller, P.D. and Seymour, R.S. (1991). 'The echidna', *Scientific American*, vol. 264, no. 2, February, pp. 96– 103.

Strahan, R. (ed.) (1995). *The Mammals of Australia*, Reed Books, Sydney.

5 Fauna species – Conservation significant species – Birds

5.1 Glossy black-cockatoo (*Calyptorhynchus lathami lathami*)

5.1.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

5.1.2 Biology and ecology

5.1.2.1 Characteristic

The Glossy black-cockatoo (*Calyptorhynchus lathami lathami*) is a small black cockatoo that is approximately 46 to 51 cm in length with a wingspan of 90 cm, a tail 21 to 23 cm and an inconspicuous crest and broad bulbous bill. Adult males have solid bright red panels in the ventral surface of their tail feathers, while females have light orange-red panels with black barring (refer Photograph 5.1). Females also have irregular patches of yellow on the head and neck. Immature individuals also have irregular patches of yellow on the head and wing coverts. Tail barring in males is lost in successive moults as the panels become bright red (Pizzey and Knight 2007; Schodde et al. 1993).

The Glossy black-cockatoo is distinguished from the Red-tailed (*C. banksii*) and Yellow-tailed (*C. funereus*) black-cockatoo by its' smaller size, dull brown tinge to the head and breast, inconspicuous crest, and red rather than yellow panels in the tail (Glossy Black Conservancy 2010).

Photograph 5.1 **Glossy black-cockatoos (*Calyptorhynchus lathami lathami*)**

Source: Claridge (2016)

5.1.2.2 Known distribution

The Glossy black-cockatoo has a widespread distribution, ranging from Gympie to the southeast Queensland border, inland to Augathella and Tambo (refer Figure 5.1). The distribution continues south into NSW spreading inland to the Central Western Plains of NSW and also into eastern Victoria (Schodde et al. 1993).

Figure 5.1 **Distribution range of Glossy black-cockatoo**

Source: ALA (2018)

5.1.2.3 Distribution in relation to the Project

Calyptorhynchus lathami lathami has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that three records of *Calyptorhynchus lathami lathami* exist within the ecology study area. The closest record is located approximately 400 m east of the disturbance footprint near Helidon and is dated 1989. The other two records are located approximately 1.5 km north of the alignment, east of Mount Kynoch, and are both dated 1978. A number of other records are located within a 50 km buffer of the disturbance footprint in multiple directions. Most are concentrated to the southeast in the area between Toowoomba and Long Grass Nature Reserve, followed by to the north in the surrounds of Crows Nest National Park and Deongwar State Forest (refer Figure 5.2).

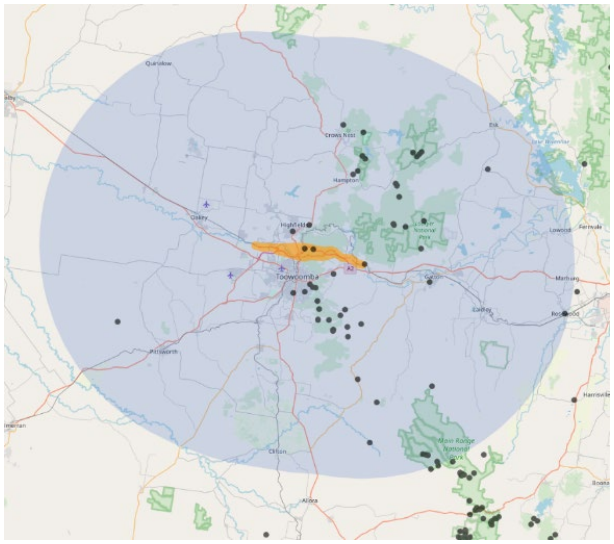

Figure 5.2 **Distribution range of Glossy black-cockatoo in relation to the Project**

Source: ALA (2020)

5.1.2.4 Biology and reproduction

The Glossy black-cockatoo feed almost exclusively on the seeds of species of *Allocasuarina* and *Casuarina* species throughout their range. In addition, within an area, feeding is often restricted to one or two individuals of a single species. This species also shows a strong fidelity to particular feed trees, returning to selected trees over consecutive years (Cameron 2005; Cameron and Cunningham 2006; Clout 1989).

Below are species that Glossy black-cockatoo's are known to feed on:

- *Allocasuarina torulosa*
- *Casuarina equisetifolia*
- *A. littoralis*
- *A. verticillata*
- *C. cristata*
- *C. pauper*
- *A. gymnanthera*
- *A. diminuta* (OEH 2017).

Glossy black-cockatoos are dependent on large hollow-bearing eucalypts for nesting. Hollows used for nests are typically located 10 to 20 m above the ground, in vertical or near vertical branches, stems, and spouts, or in trunk cavities. The same nest will be utilised in successive seasons, and they are known to often nest in close proximity to other nesting pairs. The peak breeding season occurs from March to August in southeast Queensland and northeastern NSW and clutch size is typically comprised of a single egg (Cameron 2006; Garnett et al. 1999; Glossy Black Conservancy 2010; Pizzey and Knight 2007).

5.1.3 Habitat

The Glossy black-cockatoo prefers woodland areas dominated by she-oak (*Allocasuarina* spp.), or open sclerophyll forests/woodlands with a stratum of *Allocasuarina* spp. beneath a canopy of *Eucalyptus* spp., *Corymbia* spp. or *Angophora* spp. Glossy black-cockatoos have also been recorded in mixed *Allocasaurina*, *Casuarina*, *Callitris* and *Acacia harpophylla* woodland assemblages. In southeast Queensland, west of the Great Dividing Range, they have been observed feeding in remnant Belah (*Casuarina cristata*) and Bulloak (*Allocasuarina luehmannii*) forests (Glossy Black Conservancy 2010).

5.1.4 Threatening processes

The following have been identified as potentially threatening processes to Glossy black-cockatoo:

- Reduction of suitable habitat through clearing for development
- Decline of hollow bearing trees over time due to land management activities
- Excessively frequent fire which eliminates she-oaks, depleting habitat and feed trees
- Limited information on the location of nesting aggregations and the distribution of high quality breeding habitat
- Disturbance from coal seam gas and open cut coal mining causing loss of foraging and breeding habitat as well as disturbing reproductive attempts
- Illegal bird smuggling and egg-collecting (OEH 2017).

5.1.5 Threat abatement/recovery plans

The following threat abatement/recovery plans have been identified as being relevant for this species.

- Office of Environment and Heritage (2017). Save Our Species: Help save the Glossy Black-Cockatoo. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=1178&ReportProfileID=10140. In force under the *Biodiversity Conservation Act 2016*.

5.1.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Loss of existing and future hollow-bearing trees
- Excessively frequent fires eliminating she-oaks from an area and preventing their development to maturity
- Reduced access to water in close proximity to foraging and nesting habitat
- Loss of habitat through clearing for development
- Global climate change impacting the spatial and temporal distribution of the species.

Management actions outline in the Saving our Species plan includes:

- Raise awareness around the importance of large old trees, which provide roosting habitat
- Protect large and small hollow bearing trees to facilitate regenerations of habitat trees
- Encourage the retention of she-oaks in the understorey and reduce impact caused by fire, slashing/underscrubbing and over-grazing
- Maintain accessibility to surface water or provide artificial sources of water ensuring vegetation cover is maintained between roosting/foraging sites and water sources
- Raise awareness among landholders on the importance of suitable habitat for the species
- Install nest boxes to provide artificial nesting sites for the species
- Enhance and restore corridors between woodland and forest habitat.

5.1.7 References

Atlas of Living Australia (2018). *Calyptorhynchus (Calyptorhynchus) lathami lathami*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:61461228-28c3-4174-ab6e-ac5a57daf4f9#overview [Accessed 3 September 2018].

Cameron, M. and Cunningham, R. B. (2006). Habitat selection at multiple spatial scales by foraging glossy black-cockatoos. *Austral Ecology* 31, 597-607.

Cameron, M. (2005). Group size and feeding rates of glossy black-cockatoos in central New South Wales. *Emu* 105, 299-304.

Cameron, M. (2006). Nesting habitat of the glossy black-cockatoo in central New South Wales. *Biological Conservation* 127, 402-410.

Claridge G. (2016). Glossy Black-Cockatoo (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:61461228-28c3-4174-ab6e-ac5a57daf4f9#gallery [Accessed 3 September 2018].

Clout, M.N. (1989). Foraging behaviour of glossy black-cockatoos. *Australian Wildlife Research* 16, 467-473.

Garnett, S. T., Pedler, L. P. and Crowley, G. M. (1999). The breeding biology of the glossy black-cockatoo *Calyptorhynchus lathami* on Kangaroo Island, South Australia. *Emu* 99, 262-279.

Glossy Black Conservancy (2010). *Glossy black-cockatoo Conservation Guidelines for Southeastern Queensland and far North-Eastern New South Wales*. Glossy Black Conservancy.

Office of Environment and Heritage, NSW (2017). Glossy Black-Cockatoo. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10140 [Accessed 3 September 2018].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Schodde, R., Mason, I.J. and Wood, J.T. (1993). Geographical differentiation in the glossy black-cockatoo *Calyptorhynchus lathami* (Temminck) and its history. *Emu* 93, 156-166.

5.2 Major Mitchell's cockatoo (*Lophochroa leadbeateri*)

5.2.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

5.2.2 Biology and ecology

5.2.2.1 Characteristic

Major Mitchell's cockatoo (*Lophochroa leadbeateri*) is smaller than the Sulphur-crested cockatoo but slightly larger than a Galah. It is salmon-pink below and white above with a large white-tipped crest that is banded in red and yellow. Its call is a distinctive stammering whinny (OEH 2017) (refer Photograph 5.2).

Photograph 5.2 Major Mitchell's cockatoo (*Lophochroa leadbeateri*)

Source: Montgomery (n.d.)

5.2.2.2 Known distribution

Major Mitchell's cockatoo is found across the arid and semi-arid inland areas of most states and territories. It has been recorded in southwestern Queensland and as far east as about Bourke and Griffith in NSW (refer Figure 5.3).

Figure 5.3 **Distribution range of Major Mitchell's cockatoo**

Source: ALA (2018)

5.2.2.3 Distribution in relation to the Project

Lophochroa leadbeateri 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 *Lophochroa leadbeateri* exist within the ecology study area. The closest record is located approximately 35 km southwest of the disturbance footprint in Pittsworth and is dated 1980. The next closest record is located approximately 40 km east of the disturbance footprint near Marburg and is not dated. No other records are located within a 50 km buffer of the disturbance footprint (refer Figure 5.4).

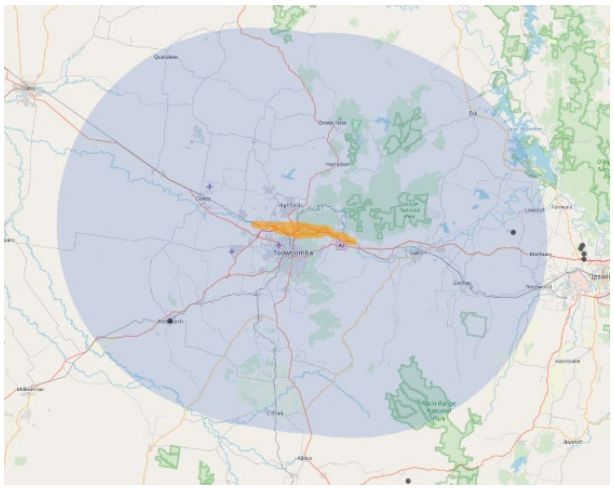

Figure 5.4 **Distribution range of Major Mitchell's cockatoo in relation to the Project**

Source: ALA (2020)

5.2.2.4 Biology and reproduction

Major Mitchell's cockatoo forages primarily on the ground, feeding on the seeds of native and exotic melons, saltbush, wattles and cypress pines (OEH 2017).

Major Mitchell's cockatoo typically breeds from May to August in Queensland. The nest is located within a tree hollow and is made of decayed debris, bark fragments and pebbles. On average, a clutch size is 2 to 4 eggs (Pizzey and Knight 2007).

5.2.3 Habitat

Major Mitchell's cockatoo inhabits a wide range of treed and treeless inland habitats, always within easy reach of water. This includes timbered watercourses, grasslands, acacia forests, native cypress stands and large mallee eucalypt woodlands (Pizzey and Knight 2007).

5.2.4 Threatening processes

The following have been identified as potentially threatening processes to Major Mitchell's cockatoo:

- Clearing of woodlands
- Heavy grazing of feeding areas
- Loss of existing and future hollow-bearing trees (OEH 2017).

5.2.5 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 Major Mitchell's Cockatoo. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=442&ReportProfileID=10116.

5.2.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Loss of existing and future hollow-bearing trees
- Heavy grazing of foraging areas by cattle resulting in the removal of grasses preventing the regeneration of food plants
- Illegal nest-robbing and trapping for the captive bird trade.

Management actions outline in the Saving our Species plan includes:

- Encourage landholders to enter into covenants or stewardship agreements that promote the retention of hollow-bearing trees, including paddock trees
- Implement revegetation efforts choosing tree species that would be suitable as future tree bearing hollows focusing planting efforts in areas where the species is known to occur
- Encourage landholders to implement sensitive grazing practices that minimised the removal of seeding grasses
- Promote awareness around the illegal harvesting of birds or nestlings from the wild along with the threatened status of the species
- Encourage reporting of suspected nest robbing and trapping to Environment Line (131 555).

5.2.7 References

Atlas of Living Australia (2018). *Lophochroa leadbeateri*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0217f06f-664c-4c64-bc59-1b54650fa23d# [Accessed 3 September 2018].

Montgomery I. (n.d.). Major Mitchell's Cockatoo (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:0217f06f-664c-4c64-bc59-1b54650fa23d# [Accessed 3 September 2018].

Office of Environment and Heritage, NSW (2017). Major Mitchell's Cockatoo. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10116 [Accessed 3 September 2018].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

5.3 Powerful owl (*Ninox strenua*)

5.3.1 Status

EPBC Act – Not listed

NC Act – Vulnerable

5.3.2 Biology and ecology

5.3.2.1 Characteristics

The Powerful owl (*Ninox strenua*) is the largest species of owl in Australia measuring 60 to 66 cm in total body length with a wingspan of 120 to 140 cm. The owl has large yellow eyes, no facial-disc with the upper body dark greyish-brown in colour with a mottled barred white lower body. The underside of the owl is whitist with dark grey-brown chevron markings (refer Photograph 5.3). Juvenile Powerful owls have a white crown and underpart contrasting its small, dark streaks and dark eye patches. Female Powerful owls have a smaller body size compared to the male, as well as a narrower head (OEH 2017; Pizzey and Knight 2007).

Photograph 5.3 Powerful owl (*Ninox strenua*)

Source: ALA (2018)

5.3.2.2 Known distribution

The Powerful owl is endemic to both eastern and southeastern Australia and inhabits the coastal side of the Great Dividing Range from Mackay to southwestern Victoria (refer Figure 5.5). In NSW the species exists in low densities through the eastern range and along the Murray River despite once being widely distributed throughout the eastern forests to the tablelands. In Queensland, the owl's possible known distribution extends from Bowen to the NSW border through southeast Queensland. Records have also suggested the species has been known to occupy suburban areas of Brisbane, Sydney and Melbourne (Birdlife International 2016; OEH 2017; Pizzey and Knight 2007).

Figure 5.5 **Distribution range of the Powerful owl**

Source: ALA (2018)

5.3.2.3 Distribution in relation to the Project

Ninox strenua has been identified as potentially occurring within the ecology study area. Database records (i.e. ALA) indicate that two records of *Ninox strenua* exist within the ecology study area. These are located approximately 1.5 km north of the disturbance footprint, east of Blue Mountain Heights, and are dated 1978. The next closest record is located approximately 3 km south of the disturbance footprint, east of Toowoomba, and is dated 2011. A number of records exist within a 50 km buffer of the disturbance footprint in multiple directions. Most are concentrated to the south of the alignment in the surrounds of Toowoomba, followed by to the northeast in Lockyer National Park (refer Figure 5.6).

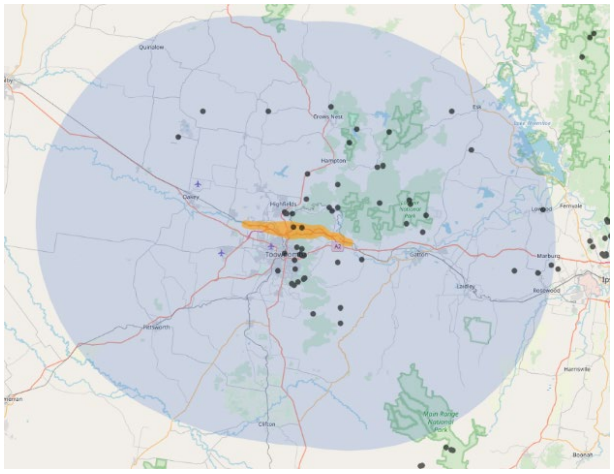

Figure 5.6 **Distribution range of the Powerful owl in relation to the Project**

Source: ALA (2020)

5.3.2.4 Biology and reproduction

The Powerful owl's main prey is dependent on habitat. However, medium-sized arboreal marsupials such as the Greater glider, Common ringtail possum and the Sugar glider constitutes much of its diet. Smaller bird species are an alternative prey to mammals for the owl species making up 10 to 50% of their diet (OEH 2017).

The Powerful owl forms long-lasting monogamous bonds which are maintained over the species lifetime, with new breeding bonds being formed only after the death of a mate. Breeding typically occurs from late autumn to mid-winter with pairs in northeastern NSW breeding earlier in late summer to mid-autumn. Nests are made in large tree hollows at least 0.5m deep usually in large eucalyptus trees which are at least 150 years old. Clutch size is typically two dull white coloured eggs with an incubation period lasting approximately 38 days. As the female and young remain in the nest, the male will roost nearby between 10 to 200 m away guarding them whilst concealed in trees (OEH 2017; Pizzey and Knight 2007).

5.3.3 Habitat

The Powerful owl inhabits a range of vegetation types, from woodland and open sclerophyll forest to tall open wet forest and rainforest. The species requires large tracts of forest or woodland habitat but can occur in fragmented landscapes as well. It roosts by day in dense vegetation comprising species such as Turpentine (*Syncarpia glomulifera*), Black she-oak (*Allocasuarina littoralis*), Blackwood wattle (*Acacia melanoxylon*), Rough-barked apple (*Angophora floribunda*), Scrub cherry (*Exocarpus cupressiformis*) and a number of Eucalypt species. Hollows and shrub layers are important habitat components for the Powerful owl who demonstrate high fidelity to a large territory with the size dependent on habitat quality and prey density (OEH 2017).

5.3.4 Threatening processes

The following have been identified as potentially threatening processes to the Powerful owl:

- Fragmentation of suitable habitats resulting from land clearing for rural and agricultural uses
- Inappropriate forest harvesting practices
- High frequency burning
- Predation of chicks by foxes, dogs and cats (OEH 2017).

5.3.5 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 Powerful Owl. New South Wales Government. Available from: https://www.environment.nsw.gov.au/savingourspeciesapp/ViewFile.aspx?ReportProjectID=712&ReportProfileID=10562. In force under the *Biodiversity Conservation Act 2016.*

5.3.6 Summary of threat abatement/recovery plan

Threats identified in the Saving our Species plan includes:

- Previous loss and fragmentation of woodland habitat for residential and agricultural development
- Habitat loss reducing the availability of prey species, particularly the Greater glider
- Prey availability reduced as a result of high frequency hazard reduction burns

Actions for this species outlined in the plan include:

- Compile available information, knowledge and assessment protocols to create a consensus of best practice guidelines
- Provide a single point resource for land managers to reference keeping it updated regularly
- Increase public interest through a novel educational framework
- Negotiate agreements with landholders to enter into stewardship agreements that promote retention of large old trees, riparian habitat, owl roost sites and other high value habitat

- Improve habitat quality and connectivity focusing on the restoration of arboreal habitat specific to mammalian prey
- Create wide corridors, particularly in areas such as riparian areas which are more productive for prey species due to abundant resources and soil fertility
- Install artificial hollows in high priority owl populations for both the owls and their prey. If effectiveness is demonstrated expand this as an education tool for the public highlighting the impact of the loss of hollow bearing trees
- Encourage the development of citizen science programs to increase community engagement in urban areas to create broader conservation awareness for powerful owls
- Identify known nests to ensure that no habitat degradation occurs within 100 m and facilitate the location of new nest sites.

5.3.7 References

Atlas of Living Australia (2018). Ninox (Rhabdoglaux) strenua. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:c303a58c-ffb9-4bf6-a71b-5e22299c5ee2#overview [Accessed 2 September 2018].

BirdLife International (2016). Ninox strenua. The IUCN Red List of Threatened. Available from: http://www.iucnredlist.org/details/22689389/0 [Accessed 22 August 2018].

Office of Environment and Heritage (2017). Powerful Owl - Profile. New South Wales Government. Available from: https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10562 [Accessed 2 September 2018].

Pizzey, G. and Knight, F. (2007). The Field Guide to the Birds of Australia. Harper Collins publishing. Sydney.

6 Fauna species – Conservation significant species – Migratory species

6.1 Fork-tailed swift (*Apus pacificus*)

6.1.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special Least Concern

6.1.2 Biology and ecology

6.1.2.1 Characteristic

The Fork-tailed swift (*Apus pacificus*) is a medium to large bird (30 to 40 g), with an approximate length of 18 to 21 cm, and a wingspan of 40 to 42 cm. It has a slim body, with long sickle-shaped wings that taper to finely pointed tips (refer Photograph 6.1). It is characterised by a long and deeply forked tail. The Fork-tailed swift is predominately blackish, with a white band across the rump, and a white patch on the chin and throat. The body, tail and upper wings are black-brown and they have a faint pale scaling to the saddle, and white scalloping to the underbody. The sexes are alike with no seasonal variation, juveniles are also indistinguishable in the field (DotEE 2018, Higgins 1999).

Photograph 6.1 Fork-tailed swift (*Apus pacificus*)

Source: Nicolson (2018)

6.1.2.2 Known distribution

The Fork-tailed swift is a non-breeding visitor to all states and territories of Australia (Higgins 1999) (refer Figure 6.1).

In Queensland, there are scattered records of the Fork-tailed swift in the Gulf Country, and a few records on Cape York Peninsula. In the northeast region there are many records east of the Great Divide from near Cooktown and south to Townsville. They are also widespread in much of the south southeastern region, more so west of the Great Divide, and are commonly found west of the line joining Chinchilla and Hughenden (DotEE 2018).

Figure 6.1 **Distribution range of the Fork-tailed swift**

Source: ALA (2018)

6.1.2.3 Distribution in relation to the Project

Fork-tailed swift is known from within the ecology study area with a record from 2003 to the south of the Toowoomba Waste Management Centre approximately 120 m from the Project disturbance footprint and a second dated 2013 east of the Withcott Seedling Farm approximately 15 m from the Project disturbance footprint. Most within a 50 km buffer of the Project disturbance footprint occur to the south of the alignment at the Toowoomba Range and north to Crows Nest (refer Figure 6.2). Other records exist near Oakey, Pittsworth and from Toowoomba to Marburg. Most records for this species occur closer to the coast as records are denser along the eastern seaboard of Australia.

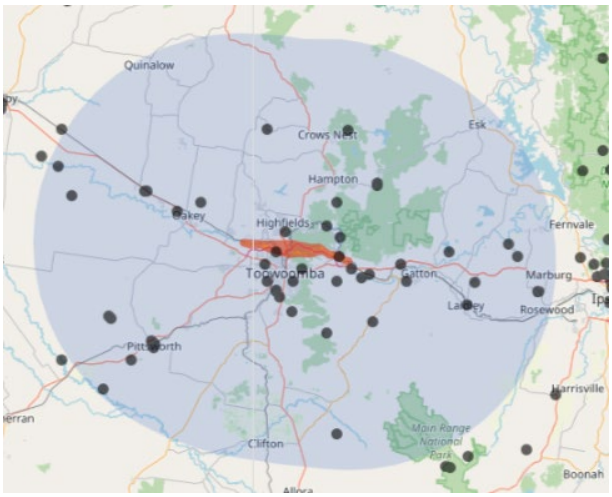

Figure 6.2 **Distribution range of the Fork-tailed swift in relation to the Project**

Source: ALA (2020)

6.1.2.4 Biology and reproduction

The Fork-tailed swift's diet is not well known within Australia. It is known, however, that this species is insectivorous. Studies have recorded the Fork-tailed swift eating small bees, wasps, termites and moths (DotEE 2018).

The Fork-tailed swift does not breed in Australia. It departs its breeding grounds in Siberia from August to – September, typically arriving in Australia in October. In April/May, the Fork-tailed swifts depart Australia, to continue its return trip to the breeding sites in Siberia (DotEE 2018).

6.1.3 Habitat

The Fork-tailed swift is an almost exclusively aerial species, flying from less than 1 m to at least 300 m above ground, and probably much higher. In Australia, Fork-tailed swifts predominately occur over inland plains, but sometimes occur above foothills, or in coastal areas. They often occur over cliffs, beaches, islands, and sometimes far out to sea. This species is also known to occur in the skies above settled areas, including urban areas and cities Sometimes, Fork-tailed swifts may feed among tree-tops in open forests (DotEE 2018, Higgins 1999).

6.1.4 Threatening processes

There are no significant threats to the Fork-tailed swift in Australia, but potential threats include habitat destruction and predation by feral animals (Birdlife International 2009).

6.1.5 Threat abatement/recovery plans

The following threat abatement plan 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.

6.1.6 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.

6.1.7 References

Atlas of Living Australia (2018). *Apus pacificus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:698f5cfc-4b81-4ed3-aebd-750d1f86a573 [Accessed 24 August 2018].

BirdLife International (2009). *Apus pacificus* **In:** IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. *Apus pacificus*. IUCN Red List.

Department of the Environment and Energy (2018). *Apus pacificus* 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=678 [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.

Nicolson, K. (2018). Fork-tailed swift (Apus pacificus). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=64c6d1c6-cbac-456e-9566-fd84d70cfa2b. [17 September 2019].

Pudwill, R 2008, Photograph: *Apus pacificus*, Available from: https://upload.wikimedia.org/wikipedia/commons/b/b5/ApusPacificus.jpg [Accessed 24 August 2018].

6.2 Black-faced monarch (*Monarcha melanopsis*)

6.2.1 Status

EPBC Act – Marine and Migratory (Bonn)

NC Act – SLC

6.2.2 Biology and ecology

6.2.2.1 Characteristic

The Black-faced monarch (*Monarcha melanopsis*) is approximately 16.5 to 19 cm long weighing in at about 21 to 29 grams (g). It has a pale bill with a black forehead and throat surrounding the bill. It has a grey upper breast that contrasts with the rich rufous underparts below and dark grey tail (refer Photograph 6.2). The immature form exhibits a darker bill lacking the black forehead and throat. The voice is a fussy, wheezy chattering with a main harsh call similar to 'Why-you, which-you' along with drawn out 'wheech you' and slurred 'r, r, rerr' or 'shsh-shsh-shirr' sounds (Pizzey and Knight 2007).

Photograph 6.2 Black-faced monarch (*Monarcha melanopsis*)

Source: Dew (2017)

6.2.2.2 Known distribution

The Black-faced monarch is widespread in eastern Australia (refer Figure 6.3) (Blakers et al. 1984). In Queensland, it is widespread from the islands of the Torres Strait and on Cape York Peninsula, south along the coasts and the eastern slopes of the Great Divide, to the NSW border (Beruldsen 1990; Blakers et al. 1984).

The Black-faced monarch is also recorded in Papua New Guinea and New Zealand (Coates 1990a).

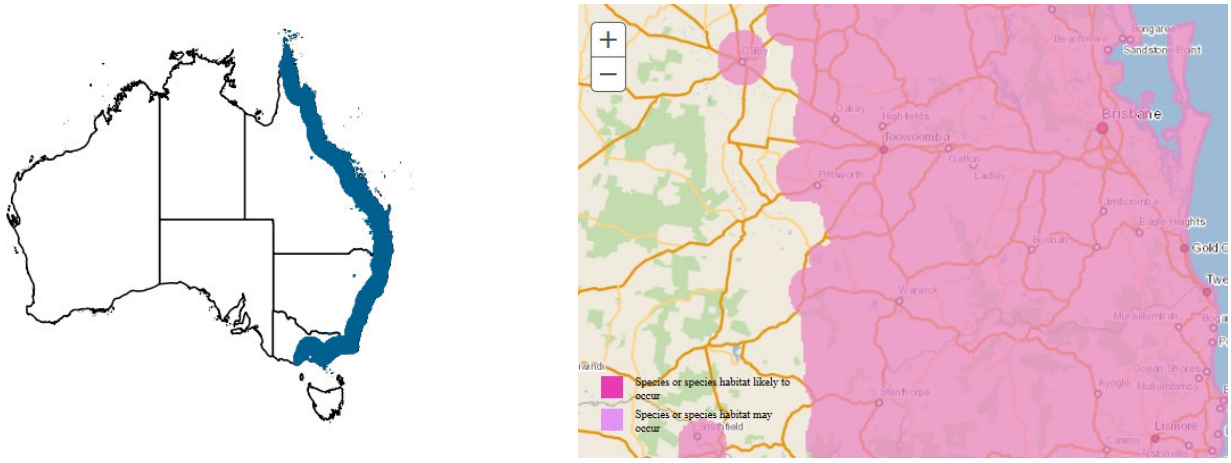

Figure 6.3 **Distribution range of the Black-faced monarch**

Source: ALA (2018), DotEE (2018)

6.2.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that a record of *Monarcha melanopsis* exists within the disturbance footprint. The record is located near Gowrie Junction and is not dated. Another record is located within the ecology study area approximately 500 m north of the alignment near Gowrie Junction and is not dated. The next closest record is located approximately 1 km south of the disturbance footprint, north of Prince Henry Heights, and is dated 1998. A number of other records exist within a 50 km buffer of the disturbance footprint in all directions of the alignment. Most are concentrated to the northeast near Ravensbourne National Park, followed by to the south in the surrounds of Toowoomba (refer Figure 6.4).

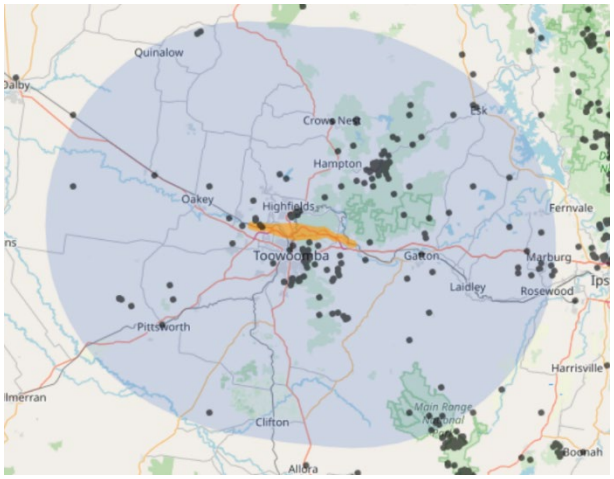

Figure 6.4 **Distribution range of the Black-faced monarch in relation to the Project**

Source: ALA (2020)

6.2.2.4 Biology and reproduction

The Black-faced monarch is known to eat a large variety of arthropods, including: spiders, beetles, grasshoppers, flies, moths etc. They forage at all vertical levels of the forest, though most often at low or middle levels, within 6 m of the ground (Blakers et al. 1984).

The Black-faced monarch breeds in rainforest habitat, and generally nests near the top of trees with large leaves, in the tops of small saplings, or in lower shrubs. They breed from October to March, with eggs recorded mostly from November to mid-January. There is a variation in egg-laying seasons with southeast Queensland eggs laid from October to December and possibly into January and in NSW eggs have been recorded from October to February. The incubation period is thought to be 13 to 15 days and the fledging period approximately 7 days or slightly more. The species appears to have a relatively high rate of fledging failure, with analyses of hatching and fledging success indicating that an average of 0.1 fledged young is yielded per nest per breeding event (BA NRS 2002, Marchant 1986).

6.2.3 Habitat

The Black-faced monarch mainly occurs in rainforest ecosystems, including semi-deciduous vine-thickets, complex notophyll vine-forest, tropical rainforest, subtropical rainforest, mesophyll thicket/shrubland, warm temperate rainforest, dry rainforest and cool temperate rainforest (Blakers et al. 1984).

The species also occurs in selectively logged and 20 to 30 years old regrowth rainforest and 'marginal' habitats during winter or during migration. Other areas include gullies in mountain areas or coastal foothills, softwood scrub dominated by Brigalow and coastal scrub dominated by Coast Banksia (Blakers et al. 1984; Laurance et al. 1996).

6.2.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Black-faced monarch.

6.2.5 Threat abatement/recovery plans

The following threat abatement plan 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.

6.2.6 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.

6.2.7 References

Atlas of Living Australia (2018). *Monarcha melanopsis*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21ebd2d3-f706-4997-b04a-79e5d023dcb3#overview [Accessed 27 August 2018].

BA NRS (2002). *Birds Australia Nest Record Scheme*. Available from: http://birdlife.org.au/projects/atlas-and-birdata/nest-record-scheme

Beruldsen, G.R. (1990). Cape York in the wet. *Australian Bird Watcher*. 13:209-217.

Blakers, M., Davies S.J.J.F. and Reilly P.N. (1984). *The Atlas of Australian Birds*. Melbourne, Victoria: Melbourne University Press.

Coates, B.J. (1990). *The Birds of Papua New Guinea Including the Bismarck Archipelago and Bougainville. Volume 2 Passerines*. Alderley, Queensland: Dove Publications.

Department of the Environment and Energy (2018). *Monarcha melanopsis* 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. [Accessed 24 August 2018].

Dew, S. (2017). Black-faced monarch (Monarcha melanopsis). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=84afdeb1-d20e-4b85-b6b1-d3a2e56416c3. [17 September 2019].

Laurance, W.F., Gordon C.E. and Perry E. (1996). Structure of breeding bird communities in rainforest and regrowth forest in tropical Queensland. *Sunbird*. 26:1-15.

Mansfield N. (2016). *Monarcha melanopsis* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21ebd2d3-f706-4997-b04a-79e5d023dcb3#gallery [Accessed 27 August 2018].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.3 Black-tailed godwit (*Limosa limosa*)

6.3.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – SLC

6.3.2 Biology and ecology

6.3.2.1 Characteristic

The Black-tailed godwit (*Limosa limosa*) is a large wader reaching 40 to 45 cm in length, a wingspan measuring 63 to 75 cm and adult weigh between 200 and 300 g. The species is graceful in its stance possessing a small head, long neck, a bill that is long and straight or slightly curved and legs that are considerably long (refer Photograph 6.3). They differ from the similar but smaller Bar-tailed godwit, *Limosa lapponica* with a bill that is straighter and more blunt, longer neck, shallower forehead, body that is slimmer and longer legs. There are slight differences between the sexes with females possessing a longer and larger bill and duller breeding plumage (Higgins and Davies 1996).

Photograph 6.3 Black-tailed godwit (*Limosa limosa*)

Source: Kasambe (2018)

6.3.2.2 Known distribution

For populations associated with the East Asian Australasia Flyway breeding locations are thought to be in far-east Russia. The species is also known to breed in Iceland and the Faeroes in the northern Atlantic, Europe, Russia and China (Higgins and Davies 1996). Outside of breeding locations the species is known to occur at all states and territories within Australia with most records occurring at locations along the coast. The largest congregations occur between Darwin and Weipa. Elsewhere records are spares with fewer, scattered records inland (Watkins 1993).

Figure 6.5 Distribution range of the Black-tailed godwit

Source: ALA (2020); DAWE (2020)

6.3.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of Black-tailed godwit from within the Project disturbance footprint or the ecology study area. The nearest records occur approximately 17 km west of the disturbance footprint at Oakey with three sightings at this location. Of the three only one is relatively recent (<20 years), the rest are old (>30 years) and one sighting has a large degree of spatial uncertainty. The location description for the reliable record is described as Oakey Abattoir Wetlands and is located north of Oakey Creek to the west of Oakey township (refer Figure 6.6). Another record occurs approximately 18 km to the east of the disturbance footprint at Gatton. This record is located south of Lockyer Creek at Lake Apex within the township of Gatton. This record has a degree of spatial uncertainty associated with it. Other records for the species occur at Laidley, Lake Clarendon and Atkinsons Lagoon.

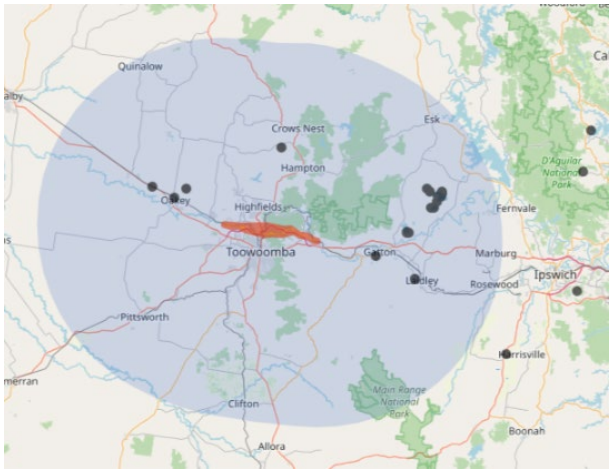

Figure 6.6 **Distribution range of the Black-tailed godwit in relation to the Project**

Source: ALA (2020)

6.3.2.4 Biology and reproduction

Black-tailed godwits consume an omnivorous diet, prey items in Australia are largely unknown. Observations have recorded the species consuming annelids, crustaceans, spiders, fish eggs, frog eggs, tadpoles and sometimes seeds (Higgins and Davies 1996).

The species does not breed in Australia during the Northern Hemisphere summer with eggs laid between April and June (del Hoyo et al. 1996).

6.3.3 Habitat

Black-tailed godwits inhabit coastal environments preferring sheltered bays, estuaries and lagoons consisting of large intertidal mudflats or sandflats, spits and mudbanks, sand or shell-grit, and sometimes on rocky coasts or coral islets. Tide heights can determine the use of suitable habitat. The species is also associated with inland wetlands, saltmarsh, saltflats, freshwater bodies and floodplains. The species will also utilise anthropogenic features such as bore over-flows, dams, sewage farms and saltworks (Higgins and Davies 1996).

6.3.4 Threatening processes

The following have been identified as potentially threatening processes to Black-tailed godwit:

- Loss and degradation of suitable habitat
- Disturbance from residential and recreational activity
- Exotic weed encroachment at intertidal mudflat habitat
- Hydrological changes in wetland habitat
- Chemical balance being impacted by exposure to acid sulphate soils (DEWHA 2009).

6.3.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and Marine Bioregional Plans have been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

- 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.

6.3.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Pacific golden plover 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.

6.3.7 References

Atlas of Living Australia (2018). *Limosa limosa*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ba17b534-ec3d-4ec3-8f9a-6c2c79ad4459. [Accessed: 5 May 2020].

del Hoyo, J., A. Elliott & J. Sargatal, eds. (1996). Handbook of the Birds of the World. Volume 3, Hoatzin to Auks. Barcelona: Lynx Edicions.

Department of Agriculture, Water and the Environment. (2020). Species Profiles and Threats Database, Black-tailed godwit – *Limosa limosa*. Available from: http://www.environment.gov.au/sprat. [Accessed: 5 May 2020].

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2009). Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html.

Higgins, P.J. and Davies, S.J.J.F. (1996). Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons. Melbourne, Victoria: Oxford University Press.

Watkins, D. (1993). A national plan for shorebird conservation in Australia. RAOU Report Series. 90.

6.4 Caspian tern (*Hydroprogne caspia*)

6.4.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – SLC

6.4.2 Biology and ecology

6.4.2.1 Characteristic

The Caspian tern (*Hydroprogne caspia*) is the largest tern species within Australia possessing long, slender wings and a tail that is slightly forked. The large-set bill is orange-red in colour with a dark grey to black tip (refer Photograph 6.4). There is no sexual dimorphism between males and females of the species (Higgins and Davis 1996). Caspian terns have a body that is white across the neck, chest and underside with grey across the wings with flight feathers darker. The short, shaggy crest is black with a white streak from the crown to the bill. Their legs are black and the eye dark brown (Higgins and Davies 1996). Breeding plumage consists of a black crown in adults whilst immature birds look similar to non-breeding birds (Birds Australia 2010).

Photograph 6.4 Caspian tern (*Hydroprogne caspia*)

Source: Daniels (2009)

6.4.2.2 Known distribution

The Caspian tern has a global distribution and can be found in North America, Europe, Africa, Asia, Australia and New Zealand (Higgins and Davies 1996). The Australasia birds are residents locally and otherwise disperse over short distances (Birdlife 2020). In Queensland the species is widespread throughout coastal regions from the southern Gulf of Carpentaria to the Torres Strait and eastern coastal region (refer Figure 6.7). The species also occurs inland in Queensland most frequently throughout the Lake Eyre Drainage Basin, Gulf Country north of Mount Isa and Cloncurry including central Queensland (Higgins and Davies 1996).

Figure 6.7 **Distribution range of the Caspian tern**

Source: ALA (2020); DAWE (2020)

6.4.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate two records within the ecology study area located at the eastern end of the alignment. The first record is from 2012 and is detailed to have occurred at Hoods Dam at the Lockyer Valley. The second record is from 2013 and detailed to have occurred at Lockyer Creek during tropical cyclone Oswald (refer Figure 6.8). The next nearest record within a 50 km buffer of the disturbance footprint occurs at Gatton approximately 15 km east of the Project. The record is from 2012 located at a small water body in the outskirts of the Gatton township to the west of the Gatton Racecourse. Further records occur with the Gatton township whilst other records from within a 50 km buffer of the disturbance footprint occur from Gatton to Laidley and north to Atkinsons Lagoon to the east of the Project. Several sparse records occur to the west, north-west and north of the Project.

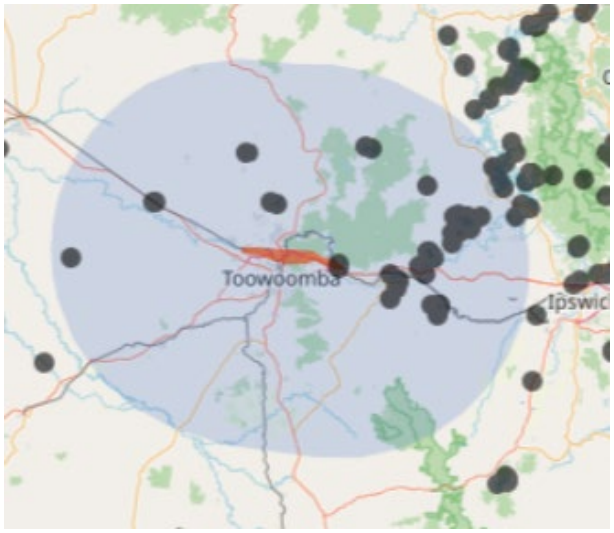

Figure 6.8 **Distribution range of the Caspian tern in relation to the Project**

Source: ALA (2020)

6.4.2.4 Biology and reproduction

The Caspian tern feeds predominantly on small to medium sized fish 5 to 25 cm in length. They will also feed opportunistically on the eggs and young of other birds, carrion and a range of terrestrial and aquatic invertebrates. They typically forage during the morning patrolling up to 15 m above the water shallow plunging from a hover when prey is spotted becoming fully submerged when doing so. Prey is eaten during flight (Higgins and Davies 1996). The species is thought to travel up to 60 km from nesting sites foraging for food (Birdlife International 2010).

Caspian terns reach sexual maturity between three to four years (Barlow 1991). The species will return to nesting ground in which they hatched to breed (Birdlife 2020). Breeding occurs between September and December in the Southern Hemisphere however this may vary geographically. Both parents will construct a nest consisting of a deep scrape on the ground as well as incubating the egg and caring for the young (Higgins and Davies 1996). One to three eggs are laid with an incubation period of 22 day with the chick fledging relatively quickly at 35 days (Birds Australia 2010).

6.4.3 Habitat

The Caspian tern is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It is found around large mudflats, saltmarsh, mangroves and seagrass. Habitats include embayments, harbours, river estuaries, deltas, lagoons, tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats. It will also use artificial wetlands including sewage farms, saltworks and dams. Offshore the species will stay close to islands that provide shelter and rarely venture beyond the reef (Higgins and Davies 1996).

6.4.4 Threatening processes

The following have been identified as potentially threatening processes to the Caspian tern:

- Degradation of suitable habitat from incursion of invasive flora (Birdlife International 2010)
- Sliver gulls (*Larus novaehollandiae*), feral cats (*Felis catus*) and Wild dogs (*Canus familiaris*) predating upon chicks
- Disturbance from human activity and livestock at breeding sites (O'Neill and Channels 1997)
- Young birds becoming entangled in recreational and commercial fishing equipment (Minton and Deleyev 2001)
- Exposure to avian diseases and bioaccumulation of toxins from prey and the environment (Birdlife International 2010, del Hoyo et al. 1996)
- Weather events and changing climatic conditions impacting nesting and breeding sites (Minton et al. 2002, Birdlife International 2010).

6.4.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and Marine Bioregional Plans have been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

- 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.

6.4.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Pacific golden plover 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.

6.4.7 References

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6.5 Common greenshank (*Tringa nebularia*)

6.5.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – SLC

6.5.2 Biology and ecology

6.5.2.1 Characteristic

The Common greenshank (*Tringa nebularia*) is a heavily built, elegant wader, 30 to 35 cm in length, with a wingspan of 55 to 65 cm and weight up to 190 g for both males and females (refer Photograph 6.5). During the nonbreeding period, the bill is long and slightly upturned and the legs are long and yellowish-green. In flight, all plumages show uniformly dark upperwing and contrasting white rump extending in a white wedge up the back. The sexes are alike. During the breeding season their head and neck is white with heavy black streaking and the interwing coverts are mostly brownish-grey with white fringes. The underbody is white with fine black streaks on chin and throat and there are bold black chevrons on the breast and flank. The underwing is white with faint brownish barring on the covers and the bill is bluish-greenish grey. The juvenile is like the adult non-breeding form but the head and neck are slightly darker with heavier, darker streaking (Higgins and Davies 1996).

Photograph 6.5 **Common greenshank (*Tringa nebularia*)**

Source: Matos (2017)

6.5.2.2 Known distribution

During the breeding season they are found in Eurasia, the northern British Isles, Scandinavia, east Estonia, northeast Belarus and Russia. In the nonbreeding season the species is widespread and found in Europe, Africa, Asia, Melanesia and Australasia. The species is found in most states and territories of Australia (refer Figure 6.9). In Queensland, it has been recorded in most coastal regions, possibly with a gap between north Cape York Peninsula and Cooktown. Inland, there have been a few records south of a line from near Dalby to Mt Guide, and sparsely scattered records elsewhere. In NSW, the species has been recorded in most coastal regions. It is widespread west of the Great Dividing Range, especially between the Lachlan and Murray Rivers and the Darling River drainage basin, including the Macquarie Marshes, and northwest regions (Higgins and Davies 1996).

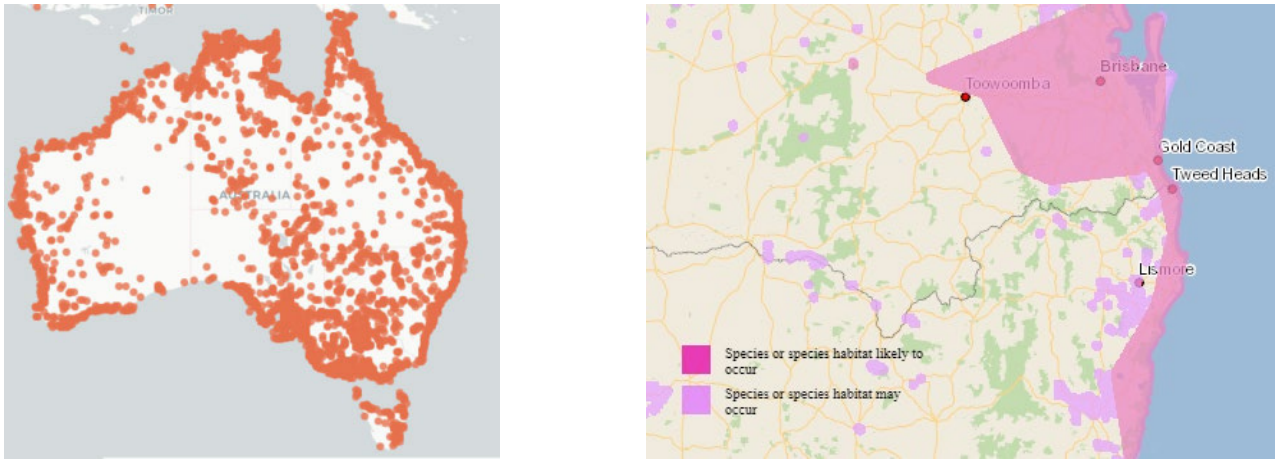

Figure 6.9 **Distribution range of the Common greenshank**

Source: ALA (2018); DOTEE (2018)

6.5.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Tringa nebularia* exist within the ecology study area. The closest record is located approximately 15 km northwest of the disturbance footprint at Oakey Army Aviation Centre and is not dated. The next closest record is located approximately 18 km northwest of the alignment near Oakey and is dated 2000. A number of other records are located within a 50 km buffer of the disturbance footprint to the north and east of the alignment. Most are concentrated at Seven Mile Lagoon and Atkinsons Lagoon, followed by in the surrounds of Gatton and Laidley (refer Figure 6.10).

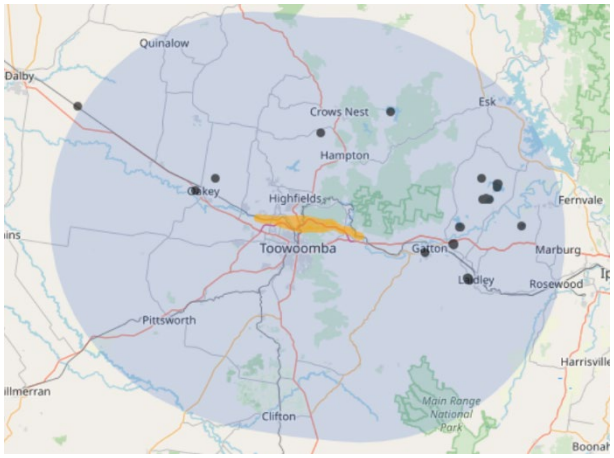

Figure 6.10 **Distribution range of the Common greenshank in relation to the Project**

Source: ALA (2020)

6.5.2.4 Biology and reproduction

The Common greenshank is carnivorous and has been recorded eating molluscs, crustaceans, insects, and occasionally fish and frogs.

The species does not breed in Australia. Common greenshanks migrate to breed in Eurasia, the northern British Isles, Scandanavia, east Estonia, northeast Belarus and Russia from April to June (Higgins and Davies 1996).

6.5.3 Habitat

The Common greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It is found around large mudflats, saltmarsh, mangroves and seagrass. Habitats include embayments, harbours, river estuaries, deltas, lagoons, tidal pools, rock-flats and rock platforms. The species uses both permanent and ephemeral terrestrial wetlands, including swamps, lakes, dams, rivers, creeks, billabongs, waterholes and inundated floodplains, claypans and saltflats. It will also use artificial wetlands including sewage farms, saltworks, dams, inundated rice crops and bores (Higgins and Davies 1996).

6.5.4 Threatening processes

The following have been identified as potentially threatening processes to the Common greenshank:

- Loss/modification of habitat (i.e.- Residential, farming, industrial and aquaculture/fishing activities) (Straw 1992)
- Increased silt in the water, pollution and weed or pest invasion of habitats can change the quality or quantity of food available from the sites or modify important biophysical aspects (Straw 1992)
- Disturbance (i.e.- fishing, power boating, four wheel driving, walking dogs, noise and night lighting) (DEH 2005).

6.5.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and Marine Bioregional Plans have been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.
- 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.

6.5.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Pacific golden plover 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.

6.5.7 References

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Department of the Environment and Energy (2018). *Hydroprogne caspia* (Caspian Tern) 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=808 [Accessed 7 September 2018].

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Matos, H. (2017). Common greenshank (Tringa nebularia). [image] [online] Available from: https://www.flickr.com/photos/145880133@N04/33210877622/in/photolist-SAJqSj-dJUAsX-7QBXDR-dJUDfp-qmyqQv-ExLPX6-EfWAAv-dJRkeU-278Vob5-V6GR9D-RVaMiZ-dJKUP2-dJRgfb-dJRmcC-dK14DE-dJRhj9-dJRj6Q-9H13Mz-U4MNNi-3ZFrhe-dJKTYn-oTCiPi-fY2cd4-3c7eCV-7dr6zo-oTmA5x-neQUm-4nUdQ1-Eubada-L7xRE8-q59v8z-f5vPxs-6x9orw-TTHgv9-ababct-6x5cXZ-rdQnrz-6x5dbM-222u7Q4-5Ks4m7-5wdtPT-EDeVEK-rhBHGt-rAQvwC-3cbEsE-dK15UC-dJUCE4-dhQSMh-g5RCgS-ayGuF4. [17 September 2019].

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6.6 Common sandpiper (*Actitis hypoleucos*)

6.6.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – SLC

6.6.2 Biology and ecology

6.6.2.1 Characteristic

The Common sandpiper (*Actitis hypoleucos*) is approximately 19 to 22cm long. It has a fine, brown bill with a buff base and whitish eyebrows and eye-rings. The legs are grey-green and tinged yellow. It is bronze-brown to grey-brown above with fine dark barring and distinct white hook around the bend of the closed wing leading to a white underside. The sides of the upper breast are washed brown (refer Photograph 6.6). Immature individuals have more distinct darker barring on the upper parts (Pizzey and Knight 2007).

Photograph 6.6 Common sandpiper (*Actitis hypoleucos*)

Source: Shah (2018)

6.6.2.2 Known distribution

The Common Sandpiper breeds in Europe and Asia. In Australasia it visits New Guinea and Australia. In Australia, the species is most commonly found in the north, east and west from August to May (refer Figure 6.11) (Pizzey and Knight 2007).

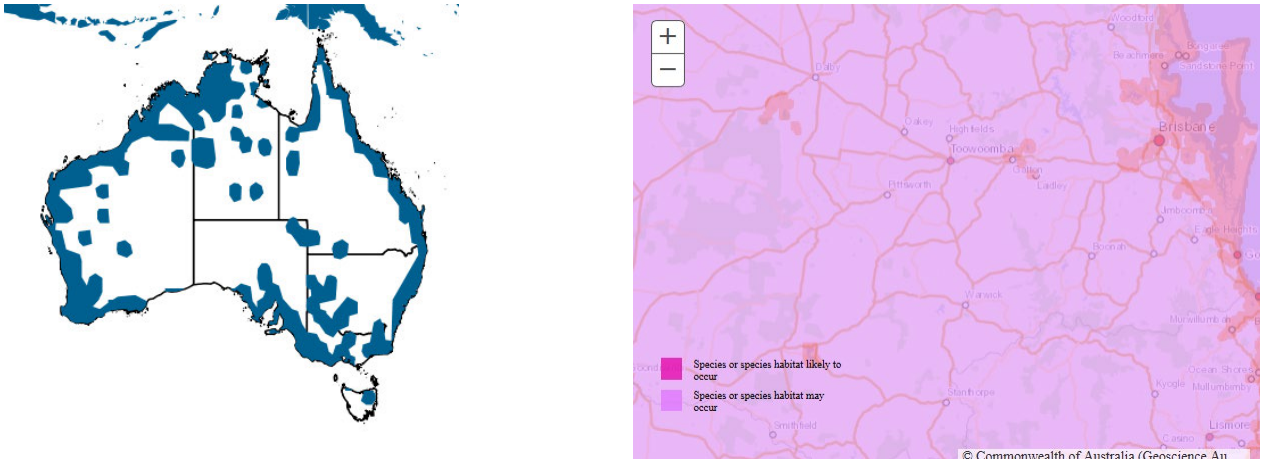

Figure 6.11 Distribution range of the Common sandpiper

Source: ALA (2018), DotEE (2018)

6.6.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Actitis hypoleucos* exist within the ecology study area. The closest record is located approximately 16 km east of the disturbance footprint near Gatton and is dated 1981. The next closest record is located approximately 17 km east of the disturbance footprint near Gatton and is dated 2016. A number of other records are located within a 50 km buffer of the disturbance footprint. Most are located in the area between Gatton and Atkinsons Lagoon (refer Figure 6.12).

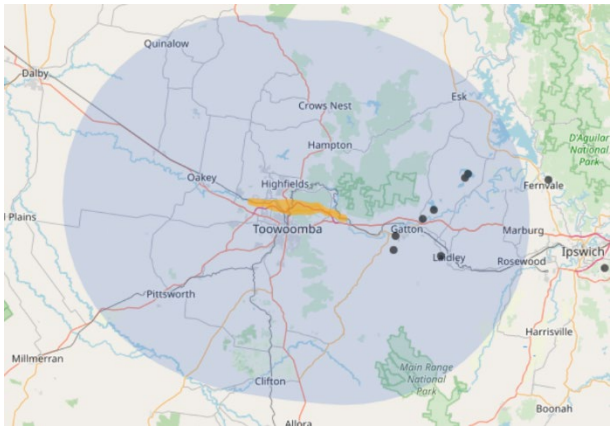

Figure 6.12 **Distribution range of the Common sandpiper in relation to the Project**

Source: ALA (2020)

6.6.2.4 Biology and reproduction

In Australia, the Common sandpiper is typically carnivorous, eating molluscs such as bivalves, crustaceans and a variety of insects (Higgins & Davies 1996).

This species does not breed in Australia. Breeding mostly occurs in the British Isles, Japan and eastern Siberia (Pizzey and Knight 2007).

6.6.3 Habitat

In Australia, Common sandpipers are found in shallow, pebbly, muddy or sandy edges of rivers and streams. They are found in coastal to inland areas, recorded in dams, lakes, sewage ponds, margins of tidal rivers, mangrove forests, saltmarshes, mudflats, beaches and drains (Pizzey and Knight 2007).

6.6.4 Threatening processes

The following have been identified as potentially threatening processes to the Common sandpiper:

- Habitat changes
- Regulation of rivers
- Pollution
- Use of pesticides (reducing prey abundance, especially in breeding periods) (Cramp & Simmons 1983).

6.6.5 Threat abatement/recovery plans

No recovery plan has been identified as being relevant for this species.

The following Wildlife Conservation Plan has been identified as being relevant for this species:

- Commonwealth of Australia (2015). Wildlife Conservation Plan for Migratory Shorebirds. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

6.6.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia

- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

6.6.7 References

Atlas of Living Australia (2018). *Actitis hypoleucos*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:920b5569-aa29-4311-9f33-13bac4512b1d#overview [Accessed 23 August 2018].

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6.7 Latham's snipe (*Gallinago hardwickii*)

6.7.1 Status

EPBC Act – Marine and Migratory (Bonn, JAMBA, ROKAMBA)

NC Act – SLC

6.7.2 Biology and ecology

6.7.2.1 Characteristic

Latham's snipe (*Gallinago hardwickii*) is a medium sized wader, and the largest snipe in Australia. This species typically measures 29 to 33 cm in length, and a 50 to 54 cm wingspan. It has a long straight bill, short broad pointed wings, a long tail, and short legs (DotEE 2018; Higgins and Davies 1996) (refer Photograph 6.7).

The Latham's snipe's plumage is intricately marked, with barring and chevrons of buff, black and various shades of brown. Blackish-brown stripes occur across the crown, and cream streaks occur down the back. The belly and parts of the head are white, and the tail is rufous, with a white tip. The sexes are similar in appearance, with no seasonal variation in the plumage. Non-breeding Latham's snipe have a plainer, less contrast colouring (Higgins and Davies 1996; Pizzey and Knight 1997).

Photograph 6.7 Latham's snipe (*Gallinago hardwickii*)

Source: Dunens (2018)

6.7.2.2 Known distribution

Latham's snipe breed in Japan, and far eastern Russia during the summer months of the Northern Hemispherehemisphere. They migrate south after the breeding season, travelling across Papua New Guinea to winter in eastern Australia. Latham's snipe has also been recorded as vagrants in New Zealand (DotEE 2018).

Latham's snipe is a non-breeding visitor to south-eastern Australia (refer Figure 6.13). It is a passage migrant through northern Australia (i.e. it travels through northern Australia to reach non-breeding areas located further south). The species has been recorded along the east coast of Australia from Cape York Peninsula, through to south-eastern South Australia. Its range extends inland over the eastern tablelands in SEQ, and to west of the Great Dividing Range in NSW (Barrett et al. 2003; Blakers et al. 1984; DotEE 2018; Higgins and Davies 1996).

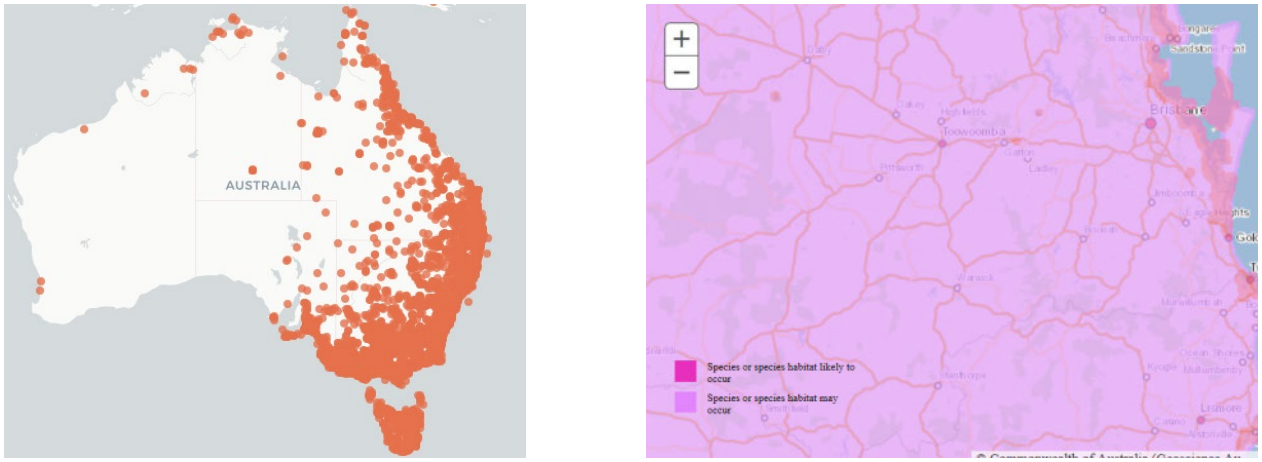

Figure 6.13 **Distribution range of the Latham's Snipe**

Source: ALA (2018), DotEE (2018)

6.7.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Gallinago hardwickii* exist within the ecology study area. The closest record is located approximately 1 km north of the alignment near Gowrie Junction and is not dated. The next closest record is located approximately 1.5 km south of the disturbance footprint near Helidon and is dated 2015. A number of other records exist within a 50 km buffer of the disturbance footprint in all directions. Most are concentrated in the surrounds of Gatton, followed by at Seven Mile Lagoon and Atkinsons Lagoon (refer Figure 6.14).

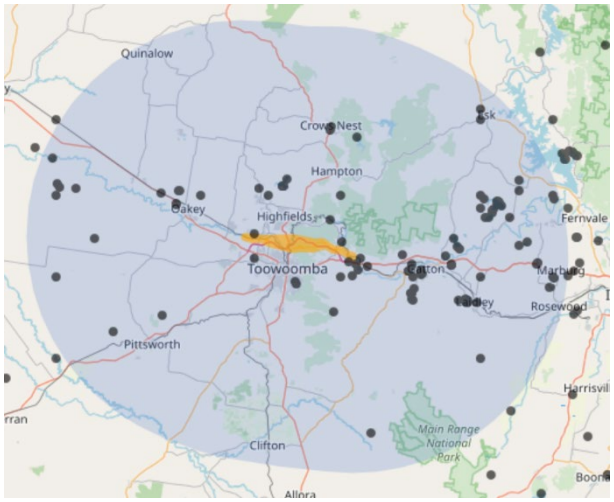

Figure 6.14 **Distribution range of the Latham's Snipe in relation to the Project**

Source: ALA (2020)

6.7.2.4 Biology and reproduction

Latham's snipe is an omnivorous species. It typically feeds on seeds and other plant material (mainly from *Cyperaceae, Poaceae, Juncaceae, Polygonaceae, Ranunculaceae* and *Fabaceae* families), and on invertebrates, including insects (mainly flies and beetles), earthworms and spiders, and occasionally molluscs, isopods and centipedes (DotEE 2018).

Latham's snipe does not breed in Australia; instead it breeds in Japan and eastern Russia (DotEE 2018).

6.7.3 Habitat

In Australia, Latham's snipe occurs in permanent and ephemeral wetlands up to 2,000 m above sea- level. They typically inhabit open, freshwater wetlands with low, dense vegetation (e.g. swamps, flooded grasslands or heathlands, around bogs and other water bodies. However, they are also known to occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (DotEE 2018).

The foraging habitats of Latham's snipe are typically characterised by areas of mud (either exposed or beneath a very shallow covering of water), and some form of cover (e.g. low, dense vegetation) (DotEE 2018).

The Latham's snipe roosts on the ground near (or sometimes in) their foraging areas, usually in sites that provide some degree of shelter (e.g. beside or under clumps of vegetation, among dense tea-tree, in forests, in drainage ditches or plough marks, among boulders, or in shallow water if cover is unavailable) (DotEE 2018).

Latham's snipe could potentially occur in Bluegrass (*Dichanthium*) dominant grasslands of the Brigalow Belt Bioregions (north and south), if this community is subject to flooding (DotEE 2018).

6.7.4 Threatening processes

The following have been identified as potentially threatening processes to the Latham's snipe:

- Loss of habitat caused by the drainage, modification of wetlands, agriculture and development of land (DotEE 2018)
- Easily disturbed by the intrusion of humans or cattle into their habitats (DotEE 2018)
- Pollution of wetlands.

6.7.5 Threat abatement/recovery plans

The following threat abatement plan and Wildlife Conservation Plan have been identified as being relevant for this species:

- Department of the Environment, Water, Heritage and the Arts (DEWHA) (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.
- Commonwealth of Australia (2015). Wildlife Conservation Plan for Migratory Shorebirds. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

6.7.6 Summary of threat abatement/recovery plan

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.

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

6.7.7 References

Atlas of Living Australia, (2018). *Gallinago hardwickii* – Latham's snipe, accessed 28 August 2018, available https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:6e718a65-6fec-44ec-a09a-ab2a0f2d464b.

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Dunens, E. (2018). Latham's snipe (Gallinago hardwickii). [image] [online] Available from: https://www.flickr.com/photos/blachswan/39986095442/in/photolist-jyK8z1-pBrUzW-bmFekY-JANDUp-qDak1C-iN5xUh-22AL3MQ-22bh6fR-Dq3z2q-JPsxEc-23At3Sg-K2mF9F-RpTFBC-22Tvciu-22sZ8Qm-21si5jo-22bh5Y8-28Fqu4J-FQkbtL-FGpjt2-23Vrc5E. [17 September 2019].

Garnett, S.T. and G.M. Crowley (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.

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Pizzey, G. and Knight, F. (1997). The Graham Pizzey and Frank Knight Field Guide to the Birds of Australia, Angus and Robertson: Sydney.

6.8 Marsh sandpiper (*Tringa stagnatilis*)

6.8.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special least concern

6.8.2 Biology and ecology

6.8.2.1 Characteristic

The Marsh sandpiper (*Tringa stagnatilis*) is a medium sized sandpiper approximating 22 to 26 cm in length with a wingspan of 40 to 45 cm and a weight approximating 70 g. They have a straight, black needle-like bill with a white face and proportionately larger, stilt-like legs of yellow-green colouring (refer Photograph 6.8). In all plumages, the species shows a contrasting outer-wing with black shoulders and flight feathers, a very pale whitish tail and a bold white wedge up the back (Higgins and Davies 1996, Pizzey and Knight 2007).

During breeding their upper body feathers have dark brown centres and buff-grey edges, notches and bars with dark streaks on the neck and v-bars on their flanks (Pizzey and Knight 2007).

Photograph 6.8 Marsh sandpiper (*Tringa stagnatilis*)

Source: Keats (2018)

6.8.2.2 Known distribution

The Marsh sandpiper is found on coastal and inland wetlands throughout Australia (refer Figure 6.15). The species is widespread in coastal Queensland, but few records exist north of Cooktown. They migrate through Africa, India, SE southeast Asia and Australasia from August to May but breed in the Northern Hemisphere near Austria through to Mongolia (DotEE 2018).

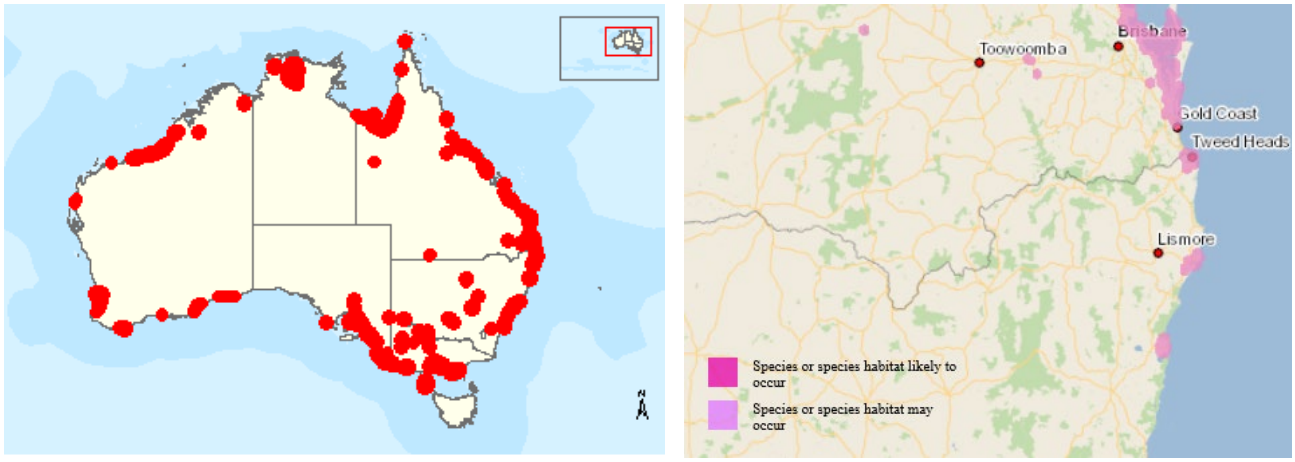

Figure 6.15 **Distribution range of the Marsh sandpiper**

Source: DotEE (2018)

6.8.2.3 Distribution in relation to the Project

No Marsh sandpiper records occur within the Project disturbance footprint. The nearest record occurs approximately 8 km north of the Project at Highfields and is dated 2003. Other records from within a 50 km buffer of the Project disturbance footprint occur at Oakey, Cooby Creek Reservoir, and between Gatton, Laidley and Atkinsons Lagoon (refer Figure 6.16). Records for this species occur along the coast and extensively across inland Australia. It is highly unlikely construction activities associated with the Project will have a significant residual impact on this species.

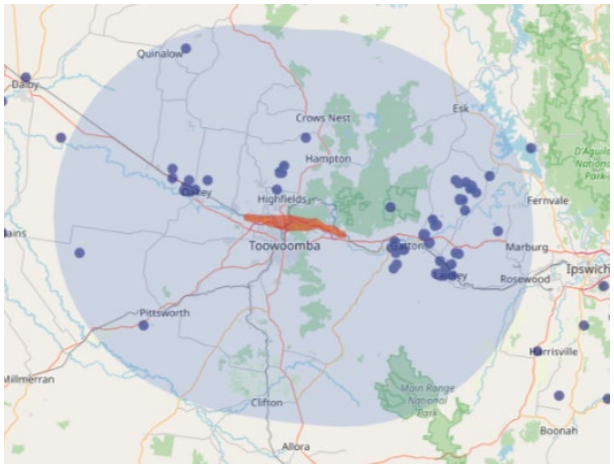

Figure 6.16 **Distribution range of the Marsh sandpiper in relation to the Project**

Source: ALA (2020)

6.8.2.4 Biology and reproduction

The Marsh sandpiper is carnivorous and feeds on insects, molluscs and crustacean. Plant material has been found in stomachs, but this may have been ingested incidentally (DotEE 2018, Higgins and Davies 1996).

The Marsh sandpiper does not breed in Australia. They breed in the Northern Hemisphere near Austria through to Mongolia (DotEE 2018).

6.8.3 Habitat

Preferred habitat of the Marsh sandpiper includes permanent or ephemeral wetlands of varying salinity, including swamps, lagoons, billabongs, saltpans, saltmarshes, estuaries, pools on inundated floodplains and intertidal mudflats and also regularly at sewage farms and saltworks. They are recorded less often at reservoirs, waterholes, soaks, bore-drain swamps and flooded inland lakes. They are found infrequently around mangroves (DotEE 2018, Higgins and Davies 1996, Pizzey and Knight 2007).

The Marsh sandpiper typically forages in shallow water at the edge of wetlands by probing wet mud of mudflats or feed among marshy vegetation (Higgins and Davies 1996).

6.8.4 Threatening processes

The following have been identified as potentially threatening processes to the Marsh sandpiper:

- Within Australia, there are a number of threats common to the Marsh sandpiper, including land clearing, inundation, infilling or draining and changes in water quality, hydrology or structural changes near roosting and foraging sites. Some sites are important all year round for juveniles who may stay in Australia throughout the breeding season until they reach maturity (DEWHA 2009).
- Other threats may be the invasion of intertidal mudflats by weeds, exposure of acid sulphate soils, hence changing the chemical balance at the site and direct human impacts like fishing, power boating, four-wheel driving, walking dogs, noise and night lighting (DEWHA 2009).

6.8.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

6.8.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia

- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

6.8.7 References

Department of the Environment and Energy (2018). *Tringa stagnatilis* 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=833 [Accessed 24 August 2018].

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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.

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Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Psylexic (2007). Photographic image of *Tringa stagnatilis*. [Accessed 24 August 2018].

6.9 Oriental cuckoo (*Cuculus optatus*)

6.9.1 Status

EPBC Act – Migratory (CAMBA)

NC Act – SLC

6.9.2 Biology and ecology

6.9.2.1 Characteristic

The Oriental cuckoo (*Cuculus optatus*) measures approximately 28 to 34 cm in length. The sexes are similar in appearance, the male being slightly larger than the female. The upper parts of the bird are grey, with a bronze gloss, and the tail is dark grey and black, spotted, and tipped white (refer Photograph 6.9). The flight feathers are grey, with pale bars. The chin, throat and upper breast is grey, and strongly barred with black (Schodde and Tidemann 2010).

Photograph 6.9 Oriental cuckoo (*Cuculus optatus*)

Source: eBird Australia (2015)

6.9.2.2 Known distribution

Oriental cuckoos are non-breeding migrants from Asia, wintering across northern Australia from the Kimberley region in Western Australia, to Brisbane in Queensland, and occasionally south to Narooma, NSW (Schodde and Tidemann 2010) (refer Figure 6.17).

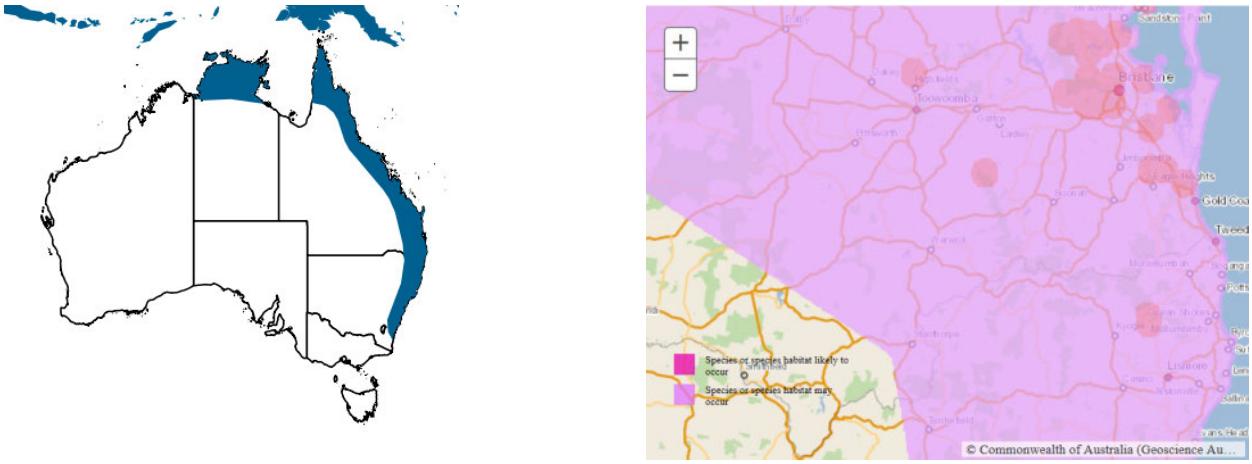

Figure 6.17 Distribution range of the Oriental cuckoo

Source: ALA (2018), DotEE (2018)

6.9.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Cuculus optatus* exist within the ecology study area. The closest record is located approximately 1.5 km south of the disturbance footprint near Helidon and is dated 2014. The next closest record is located approximately 2 km south-east of the alignment at Helidon and is dated 2014. A number of other records exist within a 50 km buffer of the disturbance footprint. Most are concentrated in the surrounds of Pittsworth, followed by in the west of Lockyer National Park (refer Figure 6.18).

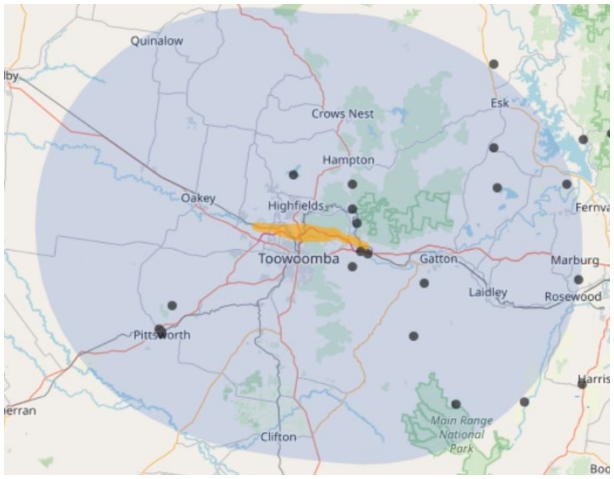

Figure 6.18 **Distribution range of the Oriental cuckoo in relation to the Project**

Source: ALA (2020)

6.9.2.4 Biology and reproduction

Oriental cuckoos feed predominately on caterpillars, stick insects, ants and beetles. They forage in trees, bushes, and the ground. Once the prey has been captured, this species typically flies to a tree branch to batter and consume its prey (Schodde and Tidemann 2010).

The Oriental cuckoo migrates from its breeding grounds in Eurasia each Autumn, to non-breeding winter grounds in southern Asia, Indonesia, New Guinea and Australia. It arrives along the northern Australian coast in November to December, departing again in April (Schodde, and Tidemann, 2010).

6.9.3 Habitat

Oriental cuckoos inhabit monsoon forests, wet sclerophylla forests, paperbark swamps, dense open forests, scrubby gullies, and mangroves and is also known to use rainforest edges, leafy trees in paddocks, river flats and roadsides. This species prefers dense vegetation with a closed canopy (Pizzey and Knight 2007; Schodde and Tidemann 2010).

6.9.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Oriental cuckoo.

6.9.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.9.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

6.9.7 References

Atlas of Living Australia (2018). *Cuculus optatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:b34cd2f6-79b3-4eee-9cf3-18a489d5d5fc [Accessed 24 August 2018].

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Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.10 Eastern osprey (*Pandion haliaetus*)

6.10.1 Status

EPBC Act – Marine and Migratory (Bonn)

NC Act – Special Least Concern

6.10.2 Biology and ecology

6.10.2.1 Characteristic

The Eastern osprey (*Pandion haliaetus*) is a medium-sized raptor with a total length of 50 to 65 cm and wingspan 145 to 170 cm. It should be noted that two species of *Pandion* have recently been identified based on distribution. The Easten osprey occurring in Australasia is now *P. cristatus* while the Western osprey occurring in Europe, Asia and the Americas is *P. haliaetus*. Typically, adults are mainly dark-brown to blackish-brown above and white below with a white head and neck, streaked blackish-brown, a dark-brown to blackish-brown crest, a black stripe across the eye and ear, a band of reddish-brown, brown or dark-brown streaking across the breast (sparse or absent in males), a white and pale greyish-brown underwing with black carpal patches and black trim, a white to pale greyish- brown undertail, yellow irides, a black bill and white to pale grey legs and feet (refer Photograph 6.10). The sexes are similar but females are typically larger than males (DotEE 2018; Marchant and Higgins 1993).

Photograph 6.10 Eastern osprey (*Pandion haliaetus*)

Source: Knight (2013)

6.10.2.2 Known distribution

The total species range (breeding plus non-breeding) around the northern coast of Australia, extending from Esperance in Western Australia to NSW, is more widespread than southern areas where records become scarcer (i.e. Victoria and Tasmania), where the species is a rare vagrant (refer Figure 6.19). The distribution of the species around the northern coast appears continuous except for a possible gap at Eighty Mile Beach (DotEE 2018).

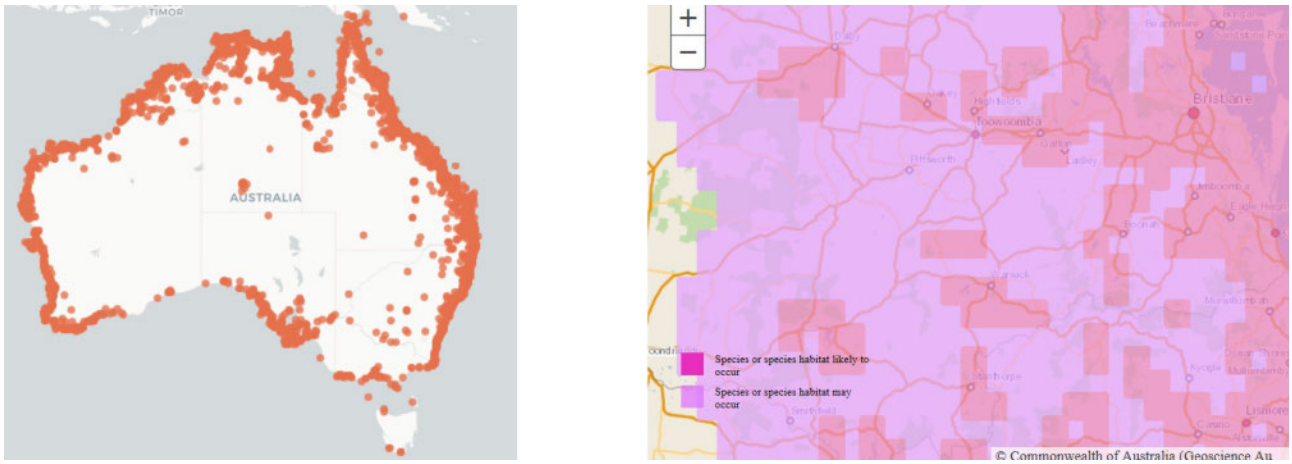

Figure 6.19 Distribution range of the Eastern osprey

Source: ALA (2018), DotEE (2018)

6.10.2.3 Distribution in relation to the Project

Eastern osprey has been predicted to occur within the region and associated habitat within the impact assessment area. Database records (i.e. AoLA, WildNet) are absent from the Project disturbance footprint area and the ecology study area. A number of records for the species occur from a single location approximately 5 km south-east of the Project to the south of Helidon along Lockyer Creek dated 2013. Other records within a 50 km buffer of the Project disturbance footprint occur at Cooby Creek Reservoir 12.5 km north of the Project, Crows Nest 30 km north of the Project, Atkinsons Lagoon and Gatton (refer Figure 6.20). Most records for this species are confined to the eastern seaboard, inland records are sparse and largely confined to waterways and watercourses.

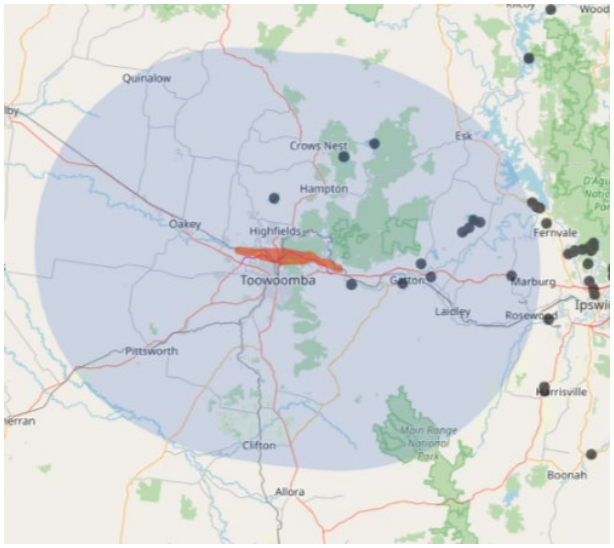

Figure 6.20 **Distribution range of the Eastern osprey in relation to the Project**

Source: ALA (2020)

6.10.2.4 Biology and reproduction

Eastern ospreys mainly feed on fish, especially mullet where available, and occasionally take molluscs, crustaceans, insects, reptiles, birds and mammals (DotEE 2018).

The Eastern osprey breeds from April to February in Australia and form monogamous pairs. Eastern osprey nests vary in size and shape but they are generally large and are mostly composed of sticks. They are constructed in a variety of natural and artificial sites. Nest sites may be used over many years by one or more pairs. Females lay clutches of one to four eggs which are incubated by both sexes, but mainly by the female, for a period of 33 to 38 days. The nestlings are generally brooded by the female but the male will take over when the female is absent from the nest. Pairs usually rear one brood but are capable of rearing two broods per season. Breeding attempts may be separated by periods of up to three years, as pairs do not typically breed each year (DotEE 2018; Hollands 2003; Marchant and Higgins 1993).

6.10.3 Habitat

Eastern ospreys occur in coastal habitats and terrestrial wetlands of tropical and temperate Australia. Typically, they are found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia. They frequent a variety of wetland habitats including inshore waters, beaches, estuaries, mangrove swamps, broad rivers, reservoirs and large lakes and waterholes. They may occur over atypical habitats such as heath, woodland or forest when travelling to and from foraging sites (DotEE 2018; Marchant and Higgins 1993).

6.10.4 Threatening processes

The following have been identified as potentially threatening processes to the Eastern osprey:

- Loss, degradation or alteration of habitat for urban or tourism development (DotEE 2018)
- Other lesser threats include ingestion of pollutants such as pesticides, heavy metals or fishing tackle as well as competition for food with commercial and recreational fisheries (DotEE 2018).

6.10.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.10.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat.

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

6.10.7 References

Atlas of Living Australia (2018). *Pandion cristatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:21464fca-984c-4103-ab72-5f6e9e7d5a2b [Accessed 24 August 2018].

Department of the Environment and Energy (2018). *Pandion cristatus* 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=82411 [Accessed 24 August 2018].

Hollands, D. (2003). *Eagles, Hawks and Falcons of Australia*. Second Edition. Melbourne: Bloomings Books.

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6.11 Glossy ibis (*Plegadis falcinellus*)

6.11.1 Status

EPBC Act – Marine and Migratory (Bonn)

NC Act – Special Least Concern

6.11.2 Biology and ecology

6.11.2.1 Characteristic

The Glossy ibis (*Plegadis falcinellus*) is the smallest Australian ibis. On average, the Glossy ibis is 55 to 65 cm long, with a wingspan of 80 to 95 cm and weighs approximately 500 to 800 g. The male is typically larger. It is characterised by a reddish-brown neck, a bronze-brown body and wings with a metallic, iridescent sheen. The Glossy ibis exhibits a distinctive long, downwards curved, bill. The facial skin is blue-grey that exhibits a white line, extending around the eyes (refer Photograph 6.11). Plumage in both sexes is similar, intensifying to a rich chestnut on the neck, mantle, shoulders and under parts during the breeding period. A purple-green sheen appears on the head, upperparts, tail and wings during this time. During the non-breeding period, Juveniles are characterised by a similar dark plumage to adults (DotEE 2018; Marchant and Higgins 1990).

Photograph 6.11 Glossy ibis (*Plegadis falcinellus*)

Source: Keats (2013)

6.11.2.2 Known distribution

Outside of its Australian distribution, the Glossy ibis is known from the eastern region of North America, Caribbean, Europe, Russia, Siberia, central Asia, sub-Saharan Africa, Pakistan, India, and Papua New Guinea. In Australia, it is found in all states and territories, but typically east of the Kimberley in Western Australia, and east of the Eyre Peninsula in South Australia (refer Figure 6.21). The Glossy ibis is known to have a patchy distribution in Western Australia and is considered a transient visitor to Tasmania (DotEE 2018; Marchant and Higgins 1990).

Figure 6.21 Distribution range of the Glossy ibis

Source: ALA (2018)

6.11.2.3 Distribution in relation to the Project

Glossy ibis records do not occur within the Project disturbance footprint however do occur within the ecology study area. Three recent (2009 – 2014) records occur at the eastern end of the ecology study area near Helidon. The majority of records within a 50 km buffer of the Project disturbance footprint occur between Gatton, Laidley, Rosewood and Coominya. Other scattered records occur at Oakey, Cooby Creek Reservoir and Pittsworth (refer Figure 6.22). Generally records for this species occur both along the eastern coastline and extensively throughout inland Australia.

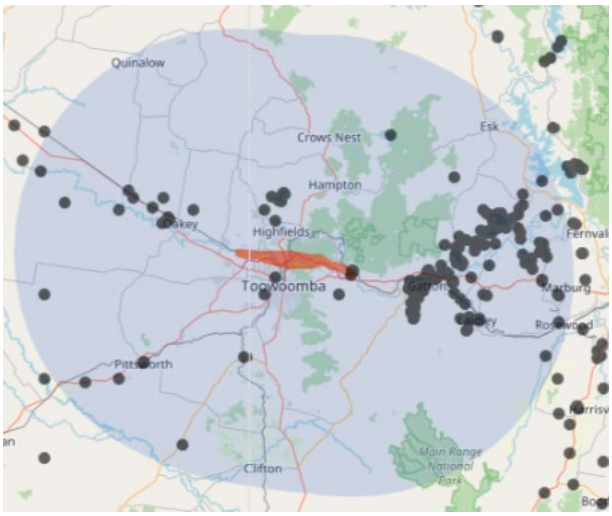

Figure 6.22 **Distribution range of the Glossy ibis in relation to the Project**

Source: ALA (2020)

6.11.2.4 Biology and reproduction

Glossy ibis typically feeds on a variety of aquatic invertebrates/insects. They may also eat fish, frogs, reptiles, and nestling birds (Marchant and Higgins, 1990).

Glossy ibis are known to live for approximately eight years and is matures by one or two years of age. Breeding season for Glossy ibis typically occurs mid-spring to the end of summer, though reproduction may extend from September to April, during favourable conditions (i.e. where there is plentiful food) at breeding sites. Breeding seasons have been recorded as coinciding with annual rain periods in some areas. The Glossy ibis builds a nest platform from twigs and aquatic vegetation. The nest is usually positioned less than one metre above water, in tall dense stands of vegetation. Three to six eggs are laid and both adults care for the young who fledge in approximately 25 to 28 days. Once fledged, adults remain feeding young for several weeks. The Glossy Ibis breeds at only a limited number of locations within Australia, including the Murray Darling Basin in northern NSW and Channel Country of Queensland/South Australia (wetlands of the Bulloo, Diamantina and Georgina River systems, occasionally also Cooper Creek) (Birds Australia 2010; DotEE 2018; Marchant and Higgins 1990; Scott 1997).

6.11.3 Habitat

Glossy ibis typically prefer aquatic habitats including water marshes at the edges of lakes and rivers, lagoons, flood-plains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields, and cultivated land with irrigation. Occasionally, Glossy ibis occur in coastal habitats (e.g. estuaries, deltas, saltmarshes and lagoons), and has been recorded within mangroves during breeding periods. During periods of drought, this species may retreat to permanent wetlands and/or coastal areas. Glossy ibis typically roost in canopy or shrubs, typically nearby water bodies (Marchant and Higgins 1990).

6.11.4 Threatening processes

Human disturbance is a potential threat but there are currently no known serious threatening processes that have been identified for the Glossy ibis (DotEE 2018).

6.11.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

6.11.6 References

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6.12 Pacific golden plover (*Pluvialis fulva*)

6.12.1 Status

EPBC Act – Marine and Migratory (Bonn/CAMBA/JAMBA/ROKAMBA)

NC Act – Special least concern

6.12.2 Biology and ecology

6.12.2.1 Characteristic

The Pacific golden plover (*Pluvialis fulva*) is a medium -sized bird, with long legs and a typical upright stance. This species measures approximately 23 to 26 cm in length and weighs approximately 120 to 175 g in weight. The sexes appear almost identical in their appearance. In non-breeding plumage, the Pacific golden plover's crown is dark brown, with golden streaks. Its nape and hindneck are slightly paler, and the forehead, lores, supercilium, chin, throat and sides of the head are all golden or creamy. The birds' upperparts are dark brown, are strongly pronounced with bright golden scaly-shaped spots. The secondary coverts exhibit white spots, which contrasts with the golden spots of both the mantle and scapulars. The foreneck and breast are both golden with grey-brown streaks, whilst the belly, flanks and undertail are white. The flanks have fine grey-brown streaks (refer Photograph 6.12). Adult breeding plumage displays bold golden spots on the crown and hindneck. This species also exhibits a white forehead, which extends as a broad supercilium, curving around the ear coverts to the sides of the neck. Its upperparts are brownish, and boldly spotted with gold. The tail is dark brown, with golden-buff bars (DotEE 2018; Marchant and Higgins 1993).

Photograph 6.12 Pacific golden plover (*Pluvialis fulva*)

Source: Kavanagh (2018)

6.12.2.2 Known distribution

The Pacific golden plover breeds mainly in northern Siberia and the western parts of Alaska. During the nonbreeding season, Pacific golden plovers are considered widespread in coastal habitats of Asia, Australasia, Melanesia and Polynesia. In Australia, the Pacific golden plover is widespread in coastal regions and recorded across all states and territories (refer Figure 6.23). Most Pacific golden plovers occur along the east coast and are considered widespread along the Queensland and NSW coastlines (DotEE 2018; Marchant and Higgins 1993).

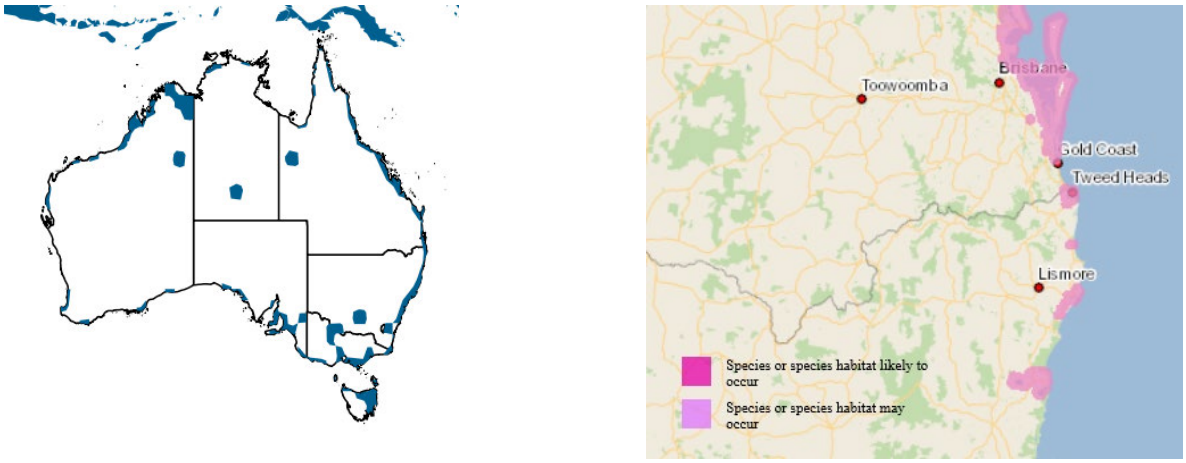

Figure 6.23 Distribution range of the Pacific golden plover

Source: ALA (2018); DotEE (2018)

6.12.2.3 Distribution in relation to the Project

Pacific golden plover records do not exist from within the Project disturbance footprint or from within the ecology study area. Records occur between Gatton and Atkinsons Lagoon including recent (2018). Several records exist from Cooby Creek Reservoir from 2018 approximately 13 km from the Project disturbance footprint (refer Figure 6.24). Whilst database records exist inland for this species, most occur along the eastern coastline.

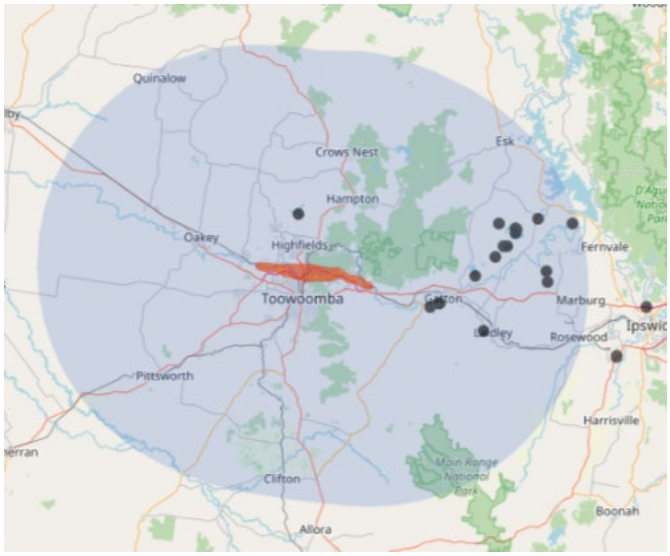

Figure 6.24 **Distribution range of the Pacific golden plover in relation to the Project**

Source: ALA (2020)

6.12.2.4 Biology and reproduction

Molluscs, polychaete worms, insects, larvae, spiders and crustaceans form the typical diet of a Pacific golden plover during the nonbreeding season (Evans 1975).

The species does not breed in Australia. Pacific golden plovers leave their breeding grounds in Siberia and Alaska in mid-July to October (Marchant and Higgins 1993).

6.12.3 Habitat

Pacific golden plovers typically occur in coastal habitats, though it is known to occasionally occur around inland wetlands. They usually occur on beaches, mudflats and sandflats, mainly in sheltered areas (e.g. harbours, estuaries, lagoons, evaporation ponds in saltworks). In a terrestrial setting, this species is known to inhabit short grassed paddocks, crops or airstrips, sewage ponds, sports fields, and ploughed or recently burnt areas (DotEE 2018; Marchant and Higgins 1993; Pizzey and Knight 2007).

6.12.4 Threatening processes

The following have been identified as potentially threatening processes to the Pacific golden plover:

- Pollution, with subsequent eutrophication, adversely affects food sources
- Accumulation of heavy metals, insecticides and herbicides
- Tourist visitation and urban development leading to increased levels of habitat loss and disturbance
- The spread of introduced plants (DotEE 2018).

6.12.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

- 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.

6.12.6 Summary of threat abatement/recovery plan

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for the Pacific golden plover 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.

6.12.7 References

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Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.13 Pectoral sandpiper (*Calidris melanotos*)

6.13.1 Status

EPBC Act – Marine and Migratory (Bonn, JAMBA, ROKAMBA)

6.13.2 Biology and ecology

6.13.2.1 Characteristic

The Pectoral sandpiper (*Calidris melanotos*) has a length of approximately 19 to 23 cm and males tend to be larger. They are similar to Sharp-tailed sandpiper (*Calidris acuminata*) (refer Section 6.18) but plainer, browner and with a longer neck. It has a straight or slightly decurved bill that is only just longer than its head. The legs are dull olive-yellow, yellow or olive-grey, that are usually brighter than the Sharp-tailed sandpiper. The long feathers of the upperparts have pointed dark centres with pale brown margins. The underparts are whitish buff and sparesly streaked with dark brown or black streaking/mottling on the neck and breast (refer Photograph 6.13) (Pizzey and Knight 2007).

Photograph 6.13 Pectoral sandpiper (*Calidris melanotos*)

Source: Cannizzaro (2016)

6.13.2.2 Known distribution

The Pectoral sandpiper breeds in northern Russia and North America. During the non-breeding season the species migrates south from August to May. In Australia, it is widespread but most common in eastern Queensland and south-eastern Australia (refer Figure 6.25) (Pizzey and Knight 2007).

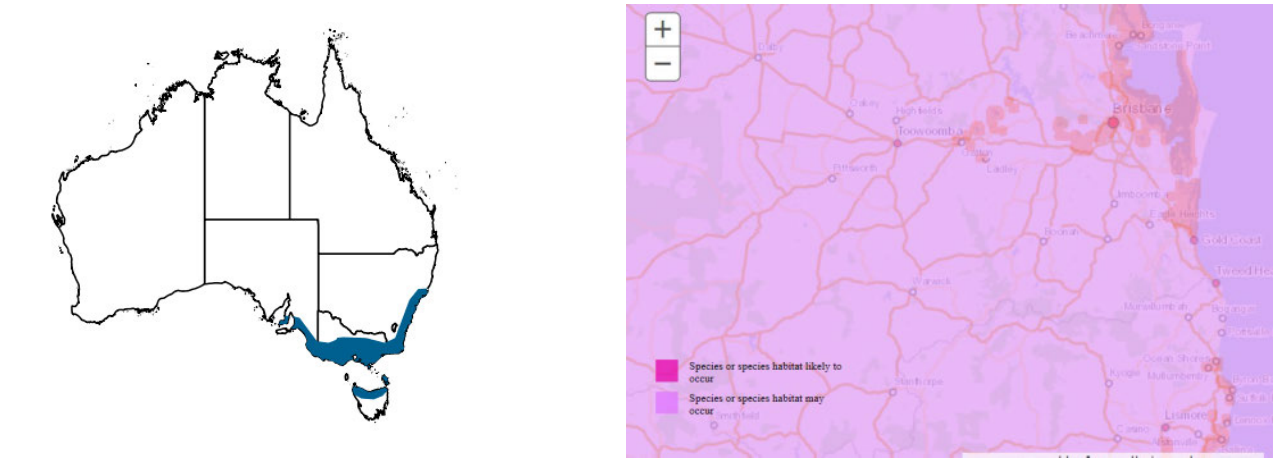

Figure 6.25 **Distribution range of the Pectoral sandpiper**

Source: ALA (2018), DotEE 2018

6.13.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Calidris melanotos* exist within the ecology study area. The closest record is located approximately 16 km northwest of the disturbance footprint at Oakey Army Aviation Centre and is not dated. The next closest record is located approximately 17 km northwest of the alignment at Oakey and is dated 1979 (refer Figure 6.26). A number of other records exist within a 50 km buffer of the disturbance footprint. Most are located in the area between Gatton and Lake Clarendon, followed by at Lowood.

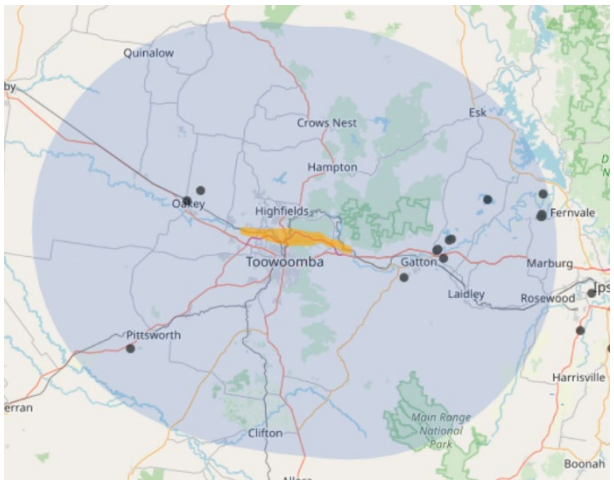

Figure 6.26 **Distribution range of the Pectoral sandpiper in relation to the Project**

Source: ALA (2020)

6.13.2.4 Biology and reproduction

In Australia, the Pectoral sandpiper is omnivorous, consuming algae, seeds, crustaceans, arachnids and insects (Higgins and Davies 1996).

This species does not breed in Australia and they migrate to north-eastern Siberia and North America to breed and nest (Higgins and Davies 1996).

6.13.3 Habitat

In Australia, the Pectoral sandpiper prefers shallow fresh to saline wetlands. The species is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands. It is occasionally found further inland within wetlands and inundated vegetation (Higgins & Davies 1996).

6.13.4 Threatening processes

The following have been identified as potentially threatening processes to the Pectoral sandpiper:

- Habitat loss reducing the availability of foraging and roosting sites
- Habitat degradation including loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds, water pollution and changes to the hydrological regime and exposure of acid sulphate soils
- Disturbance from residential and recreational activities (DEWHA 2009).

6.13.5 Threat abatement/recovery plans

No abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: **http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016**. In effect under the EPBC Act from 15-Jan-2016.

6.13.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

6.13.7 References

Atlas of Living Australia (2018). *Calidris melanotos*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:186ec2cd-8267-4162-8c0a-7c6bc51262c2 [Accessed 20 September 2018].

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6.14 Red-necked stint (*Calidris ruficollis*)

6.14.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

6.14.2 Biology and ecology

6.14.2.1 Characteristic

The Red-necked stint (*Calidris ruficollis*) is approximately 13 to 16 cm in length, weighs 25 g and has a wingspan between 29 and 33 cm. The legs are short and dark and the bill is straight or slightly decurved, with a bulbous tip. In non-breeding plumage, the upper parts are brown and grey-brown, with most feathers pale-edged, giving a mottled effect (refer Photograph 6.14). It also has a pale eye-stripe. The rump and tail are black and the outer tail-feathers and sides of the rump are white. The underparts are white with some grey on the sides of the breast. In breeding plumage, it has a deep salmon-pink on the head and nape suffusing into pink on the mantle and wing-coverts. Immature birds are similar to non-breeding adults but browner and the crown is dull rufous (Birdlife Australia 2018).

Photograph 6.14 Red-necked stint (*Calidris ruficollis*)

Source: Kavanagh (2018)

6.14.2.2 Known distribution

The Red-necked stint breeds in Siberia and sporadically in north and west Alaska. During the nonbreeding season they are found in Southeast Asia and Australasia (refer Figure 6.27). It is distributed along most of the Australian coastline and is found inland in all states when conditions are suitable (Watkins 1993).

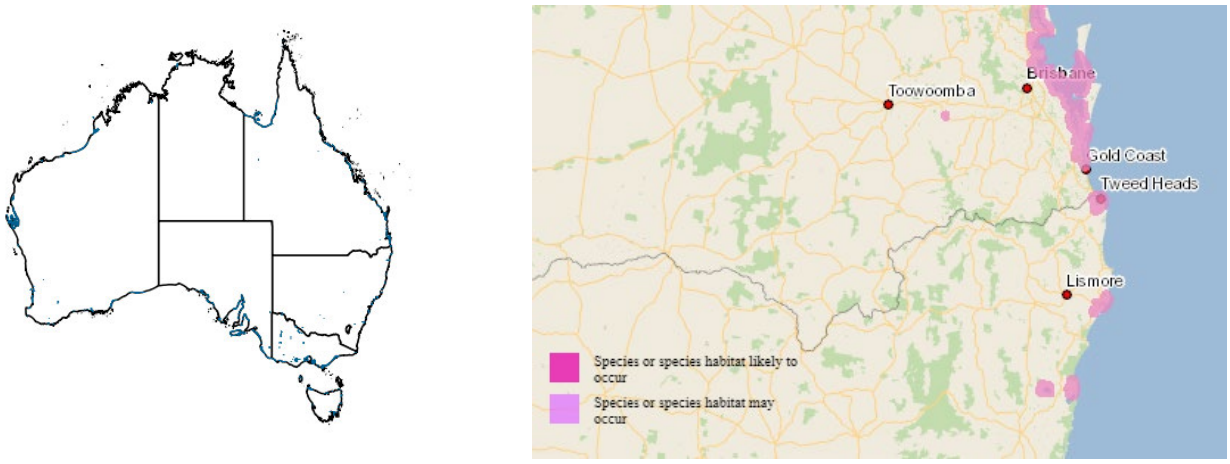

Figure 6.27 **Distribution range of the Red-necked stint**

Source: ALA (2018); DOTEE (2018)

6.14.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that No Red-necked stint records exist within the ecology study area. The closest record is located approximately 15 km north of the Project disturbance footprint at Cooby Creek Reservoir and is dated 2018. The next closest record is located approximately 18 km to the east near Gatton and is not dated. A number of records exist within a 50 km buffer of the Project disturbance footprint in multiple directions. Most are concentrated to the east in the surrounds of Atkinsons Dam, followed by the surrounds of Gatton and Laidley (refer Figure 6.28).

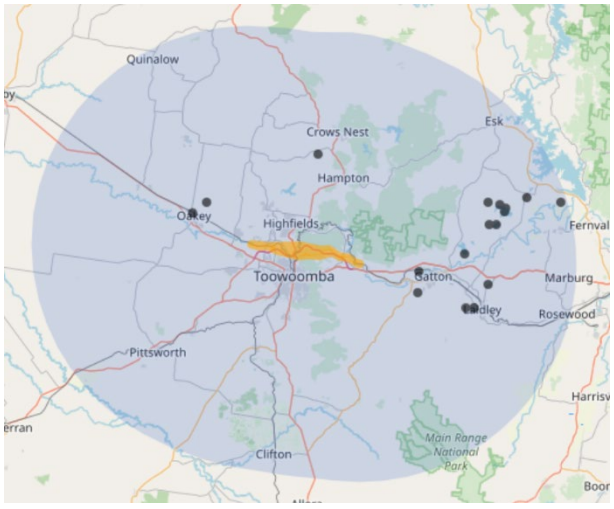

Figure 6.28 **Distribution range of the Red-necked stint in relation to the Project**

Source: ALA (2020)

6.14.2.4 Biology and reproduction

The Red-necked stint forages on plant seeds (such as from *Ruppia* spp. and *Polygonum* spp.) and on a range of invertebrates such as marine worms, molluscs, shrimps, spiders, insects. It will also eat grit (Higgins and Davies 1996).

Red-necked stints do not breed in Australia. They breed in Siberia and west Alaska, laying eggs in June. They migrate to Australia from August to April (Pizzey and Knight 2007).

6.14.3 Habitat

In Australasia, the Red-necked stint is mostly found in coastal areas, including sheltered inlets, bays, lagoons and estuaries with intertidal mudflats. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland (Higgins & Davies 1996).

6.14.4 Threatening processes

The following have been identified as potentially threatening processes to the Red-necked phalarope:

- Habitat loss (i.e.- land clearing, inundation and infilling or draining)
- Habitat degradation (i.e.- loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds such as cord grass, water pollution and changes to the water regime, changes to the hydrological regime and exposure of acid sulphate soils)
- Disturbance - (i.e. fishing, power boating, four wheel driving, walking dogs, noise and night lighting)
- Direct mortality (DEWHA 2009).

6.14.5 Threat abatement/recovery plans

No threat abatement/recovery plans were identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan were identified as being relevant for this species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.
- 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.

6.14.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon

- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

In terms of the Marine bioregional plan for the North-west Marine Region, the relevant management strategies for Red-necked stint include:

- Increase the support from research organization
- Establish and manage a Commonwealth marine reserve network to provide protection and conservation of the biodiversity
- Provide regional advice determining the significance of potential impact
- Develop targeted collaborative programs to coordinate species recovery and environmental protection efforts
- Improve monitoring, evaluation and reporting on ecosystem health.

6.14.7 References

Atlas of Living Australia (2018). *Calidris ruficollis*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ba624e08-5847-4c34-96cf-c3b414f00117 [Accessed 16 October 2018].

Birdlife Australia (2018). Red-necked Stint. Available from: http://www.birdlife.org.au/bird-profile/red-necked-stint [Accessed 16 October 2018].

Department of the Environment and Energy (2018). *Calidris ruficollis* (Red-necked Stint) 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=860. [Accessed 24 August 2018].

Department of the Environment, Water, Heritage and the Arts (2009). *Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html [Accessed 16 October 2018].

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.

Kavanagh, P. (2018). Red-necked stint (*Calidris ruficollis*). [image] [online] Available from: https://www.flickr.com/photos/patrick_k59/47255157842/in/photolist-q7W5xh-pdsrhP-pde1yN-bpWu2W-2cuHRTj-pSE1WQ-CCL9hJ-2eZM35J-mZuD2a-2de3Q8U-28Tdmo9-4UwQxJ-8FDNru-8FDNi7-pddXjw-pSDdbU-pddRsb-q9qwu4-pSEbdW-YnUDKN-mZuzh6-291YB8f-5aqD9C-Ds1Bjg-22td3yU-8FDNoq-TjC2XC-2emUzX1-291YAnC-DnvyPK-291YAJj-ditXU4. [17 September 2019].

Nicolson, K. (2018). *Calidris ruficollis* (Image) [Online] Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:ba624e08-5847-4c34-96cf-c3b414f00117 [Accessed 16 October 2018].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

Watkins, D. (1993). A national plan for shorebird conservation in Australia. RAOU Report Series. 90.

6.15 Red-necked phalarope (*Phalaropus lobatus*)

6.15.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – Special least concern

6.15.2 Biology and ecology

6.15.2.1 Characteristic

The Red-necked phalarope (*Phalaropus lobatus*) has a length of 18 to 19 cm, a wingspan of 31 to 34 cm and a weight of 34 g. It has a small head, slender neck, short straight needle-like bill, short legs and feet with lobed toes. All plumages show a bold white wing-bar with white sides to a dark-centred rump and uppertail coverts (refer Photograph 6.15). The species has white underwings with a contrasting dark trailing edge and markings on the coverts. It also has a black mark that curves through the eye onto the ear-coverts. During the breeding season they have a rust-colored throat patch with the female being somewhat more brightly colored than the male. The juvenile form is darker than the nonbreeding adult form with a dark forehead that connects to the black eye marks, a pinkish buff breast and neck and golden-buff fringing on the upperparts (Higgins and Davies 1996).

Photograph 6.15 Red-necked phalarope (*Phalaropus lobatus*)

Source: Shah (2018)

6.15.2.2 Known distribution

The Red-necked phalarope breeds in the Arctic and subarctic North America, Europe and Russia. During the nonbreeding season they are found in northern South America, southern Arabian Peninsula, SE Asia and Australia. In Australia, they are found across all states and territories (refer Figure 6.29). In Queensland the species has been found near Lake Moondarra, Mount Isa, Hood's Lagoon and Helidon and near Guyra in NSW (Higgins and Davies 1996).

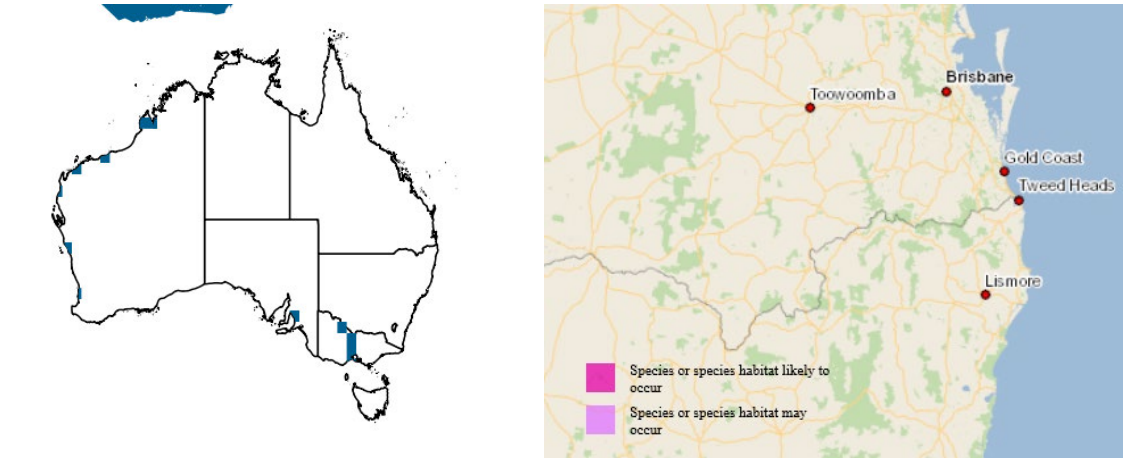

Figure 6.29 **Distribution range of the Red-necked phalarope**

Source: ALA (2018); DotEE (2018)

6.15.2.3 Distribution in relation to the Project

Phalaropus lobatus has been identified as potentially occurring within the ecology study area. Two database records (i.e. AoLA) indicate this species occurs within the ecology study area to the west of the disturbance footprint at Helidon. A single record also occurs at Helidon within approximately 2 km south of the disturbance footprint. All of these records are dated 1988 and are not recent. No other records exist for this species from within a 50 km buffer of the disturbance footprint (refer Figure 6.30). The next closest record outside of 50 km buffer occurs to the east approximately 100 km from the disturbance footprint.

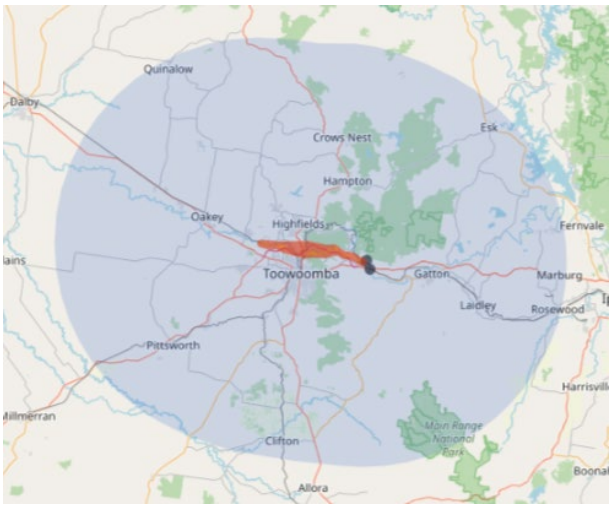

Figure 6.30 **Distribution range of the Red-necked phalarope in relation to the Project**

Source: ALA (2020)

6.15.2.4 Biology and reproduction

There is limited information on the feeding habits of the Red-neck phalarope. The species is known to eat invertebrates in the open water, and very rarely on mudflats (Higgins and Davies 1996).

Red-necked phalaropes do not breed in Australia. They breed in the Arctic and subarctic North America, Europe and Russia. They migrate to Australia from mid-October to early-April (Higgins and Davies 1996).

6.15.3 Habitat

During non-breeding period the Red-necked phalarope occurs mainly at sea. In Australia it is recorded at both inland and coastal lakes/swamps, including highly saline waters and artificial wetlands (Higgins and Davies 1996).

6.15.4 Threatening processes

The following have been identified as potentially threatening processes to the Red-necked phalarope:

- Habitat loss (i.e.- land clearing, inundation and infilling or draining)
- Habitat degradation (i.e.- loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds such as cord grass, water pollution and changes to the water regime, changes to the hydrological regime and exposure of acid sulphate soils)
- Disturbance (i.e. fishing, power boating, four-wheel driving, walking dogs, noise and night lighting)
- Direct mortality (DEWHA 2009).

6.15.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

6.15.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

6.15.7 References

Atlas of Living Australia (2018). *Phalaropus lobatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:8f9d4df2-c40d-4bee-b676-f5c52c8c2688#overview [Accessed 29 August 2018].

Department of the Environment, Water, Heritage and the Arts (2009). *Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21*. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html [Accessed 24 August 2018].

Department of the Environment and Energy (2018). *Phalaropus lobatus* 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=838. [Accessed 24 August 2018].

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.

Shah, I. (2018). Red-necked phalarope (*Phalaropus lobatus*). [image] [online] Available from: https://www.flickr.com/photos/gilgit2/32377651848/in/photolist-29dtJwj-RSK92b-BQr4ft-Ts2diV-2aLo1ce-Rk6VSG-Y82KVC-2czorkX-LLVv9B-JrutvK-222shQ8-DUS6tc-BZTCtd-CzBiXk-212q5o3-zeHrGa-a38CM2-YkuCnz-oUXior-a9X2v2-fHL1oE-aba6dB-6WKZuA-5kSEBs-fUJbox-7XPdT7-QWYDee-7XKWzF-NuZFxE-7XKWsD-M9t9CE-eogBuB-MZy4pV-7XKWR4-P1jVkL-mwywse-8Ak86R-4PhM5D-pzvaVi-5hpMgm-eogEvD-ajgGMH-fw4kjF-fHL3ro-v6YAZ9-nwwCWR-vb6czu-wHLquq-nH2Gan-34wvXt. [17 September 2019].

6.16 Rufous fantail (*Rhipidura rufifrons*)

6.16.1 Status

EPBC Act – Marine and Migratory (Bonn)

NC Act - SLC

6.16.2 Biology and ecology

6.16.2.1 Characteristic

Adult Rufous fantail (*Rhipidura rufifrons*) are medium sized birds, typically ranging in size from 14.5 to 18.5 cm in length, with a wingspan averaging of 21 cm. Both male and female specimens appear identical except for size, with males being slightly larger than females. The forehead is a rich reddish-brown colour across the eyes. The eyes have a white arc underneath. The top of the head, back of the neck and the upper back, transition from an olive to reddish-brown colour, which then blends into a blackish-brown, long, fan-shaped tail. This blackish-brown tail, contrasts with the base of the tail, which is tipped with a paler colour, often white (DotEE 2018; Higgins et al. 2006) (refer Photograph 6.16).

The Rufous fantail has black feathers over the ears and the throat is white. A black bar is present across the upper breast, below which the lower breast is off-white with black scale-like spots which transitions into an off-white colour towards the centre of the abdomen. The eyes, bill and feet of the bird are all a brown colour. The plumage in the immature birds is similar to that of adults. Adults moult annually prior to the breeding season, and this basic plumage does not vary (Higgins et al. 2006).

Photograph 6.16 Rufous fantail (*Rhipidura rufifrons*)

Source: Lostandcold (2009)

6.16.2.2 Known distribution

The Rufous fantail occurs in coastal and near coastal districts of northern and eastern Australia. They also migrate north into much of SE Asia (Lindsey 1992) (refer Figure 6.31).

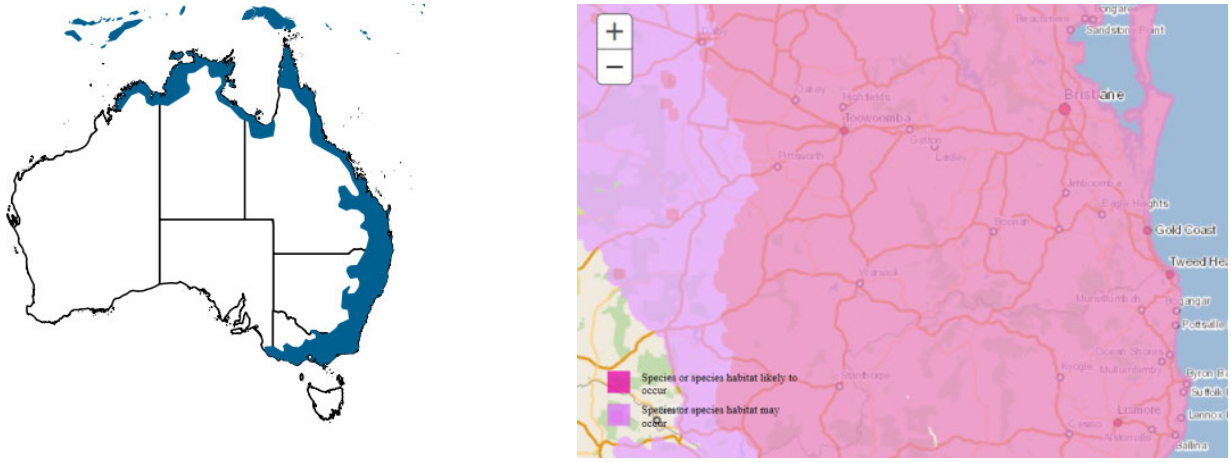

Figure 6.31 Distribution range of the Rufous fantail

Source: ALA (2018), DotEE (2018)

6.16.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that *Rhipidura rufifrons* has been recorded within the Project disturbance footprint to the east of Mount Kynoch dated 2000. Several records occur within the ecology study area to the north of the disturbance footprint to the east of Mount Kynoch and Blue Mountain Heights dated. Two of these records are old (1978) and two are dated from 2000 and 2001. Records for this species from within a 50 km buffer of the Project disturbance footprint occur to the north and south of the alignment along the range from Toowoomba to Crows Nest. Records to the west and east of the range are largely scattered and sparse (refer Figure 6.32).

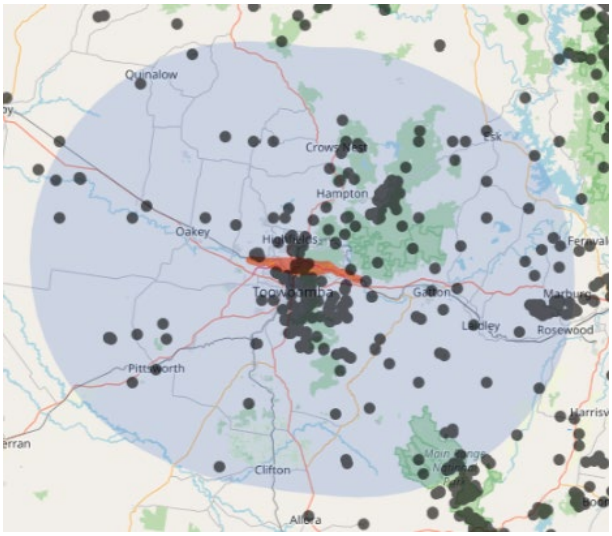

Figure 6.32 **Distribution range of the Rufous fantail in relation to the Project**

Source: ALA (2020)

6.16.2.4 Biology and reproduction

The Rufous fantail is an insectivorous species and typically gleaning and sallying in the low to middle strata of forests (Higgins et al., 2006).

The Rufous fantail is usually seen singly or in pairs, but occasionally in small groups. On winter passage, they have been observed in small flocks. The Rufous fantail generally breeds between September to February, with most individuals producing clutches between November to December. Clutch size approximates between two or three eggs, but as many as four have been recorded. Eggs are laid in a small cup-shaped nest which is usually constructed from grass, roots, fine strips of bark, plant-fibre, decayed wood, moss and spider web. The nest is placed in a tree, shrub or vine about 1.6 m above the ground (Higgins et al. 2006).

6.16.3 Habitat

In east and southeast Australia, the Rufous fantail typically inhabits wet sclerophyll forests, often in gullies dominated by Eucalypts such as Tallowwood (*Eucalyptus microcorys*), Mountain grey gum (*E. cypellocarpa*), Narrow-leaved peppermint (*E. radiata*), Mountain ash (*E. regnans*), Alpine ash (*E. delegatensis*), Blackbutt (*E. pilularis*) or Red mahogany (*E. resinifera*). These areas usually have a dense shrubby understorey often including ferns. The species also occasionally occurs in secondary regrowth, following logging or disturbance in forests or rainforests. This species has also been recorded from parks and gardens during movement events (DotEE 2018).

6.16.4 Threatening processes

The following have been identified as potentially threatening processes to the Rufous fantail:

- Fragmentation
- Loss of core moist forest breeding habitat through land clearing and urbanisation; especially forest remnants and corridors along the species' migration routes.

6.16.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.16.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

6.16.7 References

Atlas of Living Australia (2018). *Rhipidura rufifrons*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:025b08d1-0e50-4723-b581-9be91d8d09ed [Accessed 27 August 2018].

Department of the Environment and Energy (2018). *Rhipidura rufifrons* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=592 [Accessed 27 August 2018].

Higgins, P.J. Peter J.M. and Cowling S.J. (2006). Handbook of Australian, New Zealand and Antarctic Birds. **In:** *Part A. Boatbill to Larks*. Volume 7. Melbourne, Victoria: Oxford University Press.

Lindsey, T.R. (1992). Encyclopedia of Australian Animals: Birds. Page(s) 313. Collins-Angus and Robertson Publishers Pty Ltd.

Lostandcold. (2009). Rufous fantail (*Rhipidura rufifrons*). [image] [online] Available from: https://www.flickr.com/photos/lostandcold/4065996836/in/photolist-7ciicJ-bzzXAH-RGE7Zm-Hi6Ykc. [17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.17 Satin flycatcher (*Myiagra cyanoleuca*)

6.17.1 Status

EPBC Act – Marine and Migratory (Bonn)

NC Act – Special Least Concern

6.17.2 Biology and ecology

6.17.2.1 Characteristic

The Satin flycatcher (*Myiagra cyanoleuca*) ranges in size from 15 to 17 cm. This species is blue-black and white bird with a small crest. The sexes are dimorphic. Males are glossy blue-black dorsally, with a blue-black chest and white below. Females are duskier blue-black dorsally, with an orange-red chin, throat and breast, and white underparts and pale-edged wing and tail feathers. Immature birds are dark brown-grey above, with pale streaks and buff edges to the wing feathers, and a mottled brown-orange throat and chest (DotEE 2018; Pizzey and Knight 2007) (refer Photograph 6.17).

Photograph 6.17 Satin flycatcher (*Myiagra cyanoleuca*)

Source: Musser (2014), Harris (2016)

6.17.2.2 Known distribution

The Satin flycatcher occurs along the east coast of Australia from far northern Queensland to Tasmania, including southeastern South Australia (refer Figure 6.33). In Queensland, it is widespread but scattered in the east. The Satin flycatcher is a migratory species, moving northwards in winter to northern Queensland and Papua New Guinea, returning south to breed in spring (BirdLife Australia 2012; Pizzey and Knight 2007).

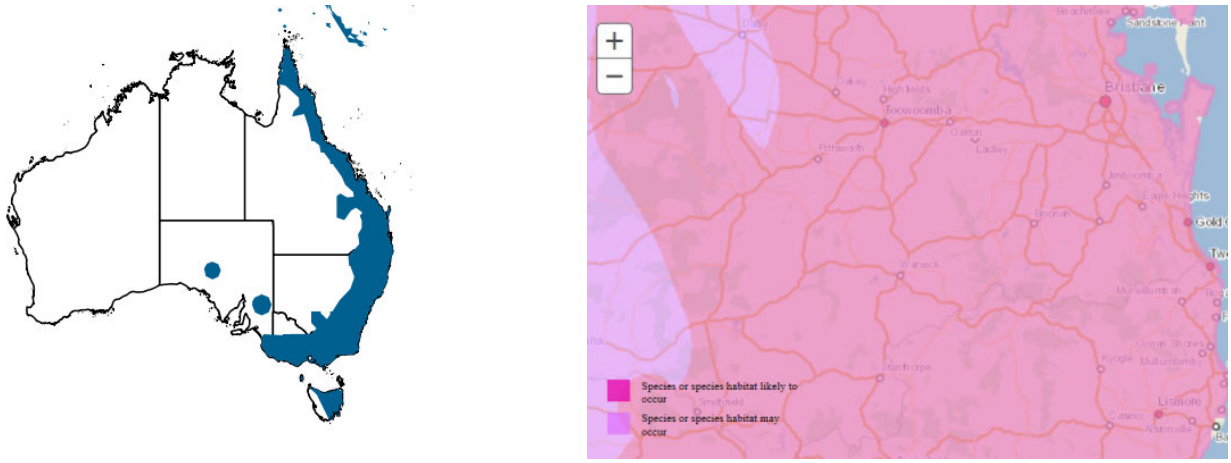

Figure 6.33 Distribution range of the Satin flycatcher

Source: ALA (2018), DotEE (2018)

6.17.2.3 Distribution in relation to the Project

Satin flycatcher was observed in the ecology study area during field investigations for the Project. The next nearest records occur approximately 1.5 km south of the Project disturbance footprint to the east of Toowoomba with four records at this located dated between 2000 and 2001. Other records within a 50 km buffer of the Project disturbance footprint occur throughout the Toowoomba Range, Lockyer Reserves, Crows Nest, Pittsworth and Oakey. Records are largely confined to forested reserves and national parks (refer Figure 6.34).

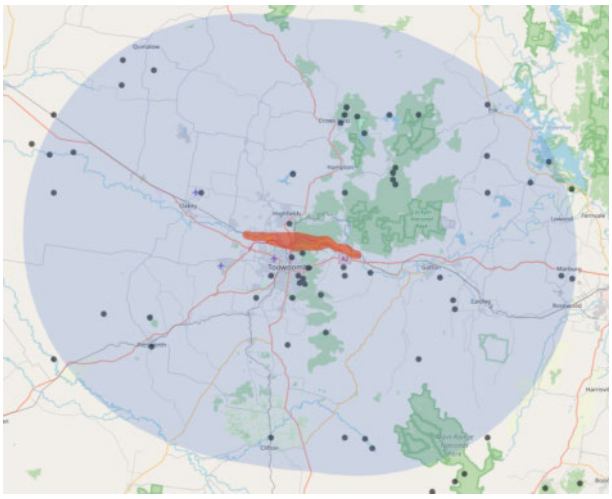

Figure 6.34 **Distribution range of the Satin flycatcher in relation to the Project**

Source: ALA (2020)

6.17.2.4 Biology and reproduction

Satin flycatchers are mainly insectivorous although very occasionally they will also eat seeds.

The Satin flycatcher builds a neat cup of bark strips, moss and spiders webs on a horizontal dead branch located 5 to 25 m above the ground under living foliage. This species has been reported to nest in loose groups with each individual pair spaced between 20 to 50 m apart. Both sexes build the nest, incubate the eggs and feed the young. Clutch size ranges from two to three eggs and breeding occurs between October and February (Pizzey and Knight 2007).

6.17.3 Habitat

The Satin flycatcher is found in tall forests, preferring wetter habitats such as heavily forested gullies, but not rainforests. This species is known to inhabit heavily vegetated gullies in Eucalypt dominated forests and taller woodlands usually above the shrub layer. On migration, this species occurs in coastal forests, woodlands, mangroves and drier woodlands and open forests as well as trees in open country and gardens (BirdLife Australia 2012; Blakers et al. 1984; Pizzey and Knight 2007).

6.17.4 Threatening processes

The following have been identified as potentially threatening processes to the Satin flycatcher (Blakers et al. 1984):

- Clearing and logging of forests, particularly mature forests, in south-eastern Australia (Blakers et al. 1984).

6.17.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.17.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat.

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

6.17.7 References

Atlas of Living Australia (2018). *Myiagra cyanoleuca*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:77929aae-e7de-48dd-aac9-ba1080d28783 [Accessed 27 August 2018].

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Birds Australia (2010). *Birds in Backyards- Satin flycatcher factsheet*. [Online]. Available from: http://www.birdsinbackyards.net/species/Myiagra-cyanoleuca

Blakers, M., Davies S.J.J.F. and Reilly P.N. (1984). *The Atlas of Australian Birds*. Melbourne, Victoria: Melbourne University Press.

Department of the Environment and Energy (2018). *Myiagra cyanoleuca* 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=82411 [Accessed 27 August 2018].

Harris, K. (2016). Satin flycatcher (*Myiagra cyanoleuca*). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=e294aee2-7cf5-4d47-af1d-0e8740369565. [17 September 2019].

Musser, A. (2017). Satin flycatcher (Myiagra cyanoleuca). [image] [online] Available from: https://images.ala.org.au/image/details?imageId=c6460cde-1d8a-4cca-95de-f0450bf2963d. [17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.18 Sharp-tailed sandpiper (*Calidris acuminata*)

6.18.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – SLC

6.18.2 Biology and ecology

6.18.2.1 Characteristic

The Sharp-tailed sandpiper (*Calidris acuminata*) grow to 17 to 21 cm long, with males being usually larger. It has a small straight or slightly decurved bill that is longer than its head. The legs are dull olive-yellow, yellow or olive-grey. It has a dull chestnut crown with dark eyelines that becomes browner on ear-coverts. The long feathers of the upperparts have pointed dark centres with pale brown margins. The underparts are whitish buff and sparsely streaked (refer Photograph 6.18). During the breeding season the upperparts are rufous with buff-white edges and they have an upperbreast which is buffish and heavily streaked on the flanks (Pizzey and Knight 2007).

Photograph 6.18 Sharp-tailed sandpiper (*Calidris acuminata*)

Source: Kavanagh (2019)

6.18.2.2 Known distribution

The Common sandpiper breeds in northern Siberia, from the delta of the Lena River, east to Chaun Gulf and east of the Kolyma River delta. It visits Australia from August to May and commonly found in the south-east but widespread across Australia in both inland and coastal locations (refer Figure 6.35) (Higgins & Davies 1996).

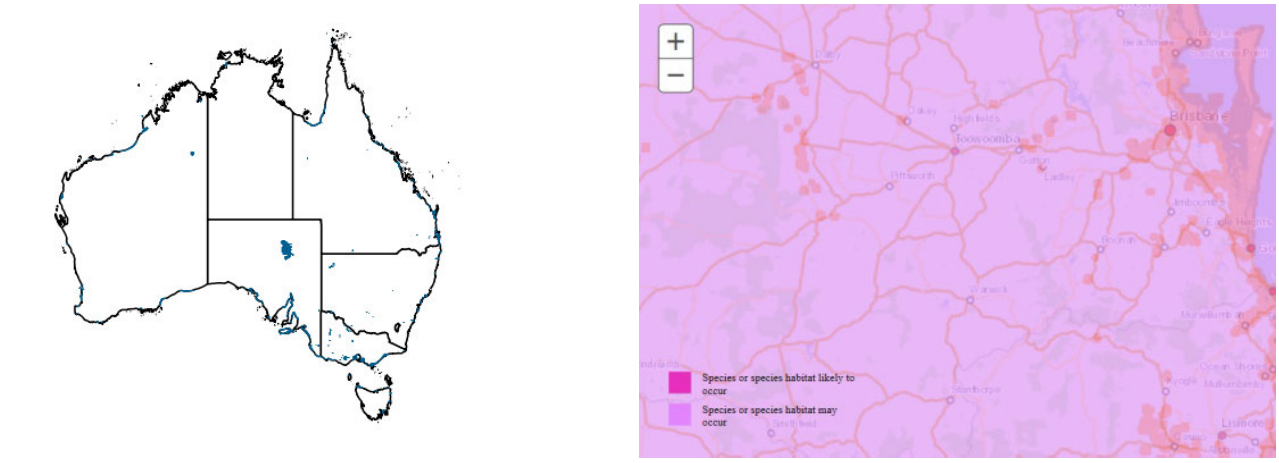

Figure 6.35 **Distribution range of the Sharp-tailed sandpiper**

Source: ALA (2018), DotEE (2018)

6.18.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Calidris acuminata* exist within the ecology study area. The closest record is located approximately 10 km north of the disturbance footprint near Highfields and is not dated. The next closest record is located approximately 12 km south of the alignment at Flagstone Creek and is dated 1995. A number of other records exist within a 50 km buffer of the disturbance footprint in multiple directions. Most are concentrated to the east in the area between Gatton and Atkinsons Lagoon, followed by to the east in the surrounds of Laidley (refer Figure 6.36).

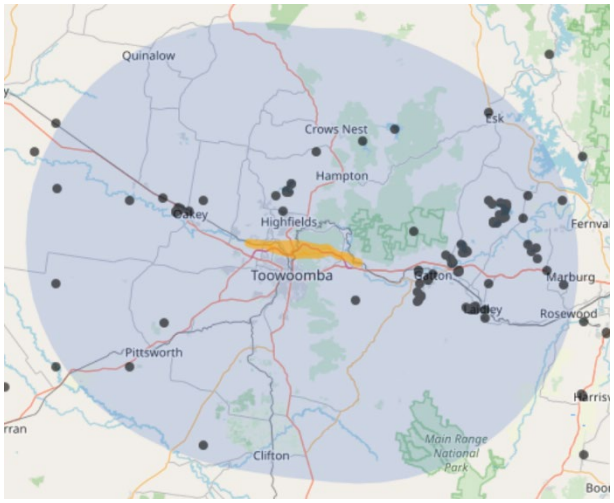

Figure 6.36 **Distribution range of the Sharp-tailed sandpiper in relation to the Project**

Source: ALA (2020)

6.18.2.4 Biology and reproduction

In Australia, the Sharp-tailed sandpiper forages on seeds, worms, molluscs, crustaceans and insects (Higgins & Davies 1996).

This species does not breed in Australia and they migrate to northern Siberia to breed and nest (Higgins & Davies 1996).

6.18.3 Habitat

In Australia, the Sharp-tailed sandpiper prefers muddy edges of shallow fresh or brackish wetlands, with inundated or emergent sedges, grass, saltmarsh or other low vegetation including lagoons, swamps, lakes and pools near the coast, and dams, waterholes, soaks, bore drains and bore swamps, saltpans and hypersaline saltlakes inland. They use flooded paddocks, sedgelands and other ephemeral wetlands, but leave when they dry. They use intertidal mudflats in sheltered bays, inlets and estuaries or seashores (Higgins & Davies 1996).

6.18.4 Threatening processes

The following have been identified as potentially threatening processes to the Sharp-tailed sandpiper:

- Habitat loss reducing the availability of foraging and roosting sites
- Habitat degradation including loss of marine or estuarine vegetation, invasion of intertidal mudflats by weeds, water pollution and changes to the hydrological regime and exposure of acid sulphate soils (DEWHA 2009).

6.18.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species.

The following Wildlife Conservation Plan and marine bioregional plan have been identified as relevant for the species:

- Commonwealth of Australia (2015). *Wildlife Conservation Plan for Migratory Shorebirds*. Canberra, ACT: Department of the Environment. Available from: http://www.environment.gov.au/biodiversity/publications/wildlife-conservation-plan-migratory-shorebirds-2016. In effect under the EPBC Act from 15-Jan-2016.

6.18.6 Summary of threat abatement/recovery plans

The threats to migratory shorebirds outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Habitat loss as a result of infrastructure and coastal development in Australia
- Modification of important habitat through chronic and acute pollution, invasive species and altered hydrological regimes
- Anthropogenic disturbance
- Climate variability and change
- Harvesting of shorebird prey
- Fisheries by-catch
- Hunting.

Objectives and actions outlined in the Wildlife Conservation Plan for Migratory Shorebirds include:

- Protection of important habitat for migratory shorebirds that occurs throughout the East Asia-Australasian Flyway
- Protect and conserve wetland habitats on which migratory shorebirds are dependent upon
- Minimise or eliminate anthropogenic impacts to migratory shorebirds in Australia
- Identify and address knowledge gaps in migratory shorebird ecology to better inform decision makers, land managers and the public.

6.18.7 References

Atlas of Living Australia (2018). *Calidris acuminata*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:75106fa7-7d65-4724-814d-dce6306c79d9 [Accessed 20 September 2018].

Department of the Environment and Energy (2018). *Calidris acuminata* 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=874 [Accessed 27 August 2018].

Department of the Environment, Water, Heritage and the Arts (2009). Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html.

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.

Kavanagh, P. (2019). Sharp-tailed sandpiper (*Calidris acuminata*). [image] [online] Available from: https://www.flickr.com/photos/patrick_k59/46301707304/in/photolist-2dxwmsm-2f7Wpc2-2cRpB6V-2fzddoG-254uhk9-21RS3AD-J5pVor-Dnv4mM-RPUPCq-21Wxs4h-DnvAzZ-J5q4k8-2327Qcz-21xdmw8-XKp6ZK-DpvVqo-21usDbS-XFVjNK-DTHCUp-bDBKME-21xeaer-Zs78j9-21usx2Y-21xdLZX-21si5af-21Fxk46-2ghF6bq-RGryGt-23uUAdu-21usrf7-21xd7sg. [17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.19 Spectacled monarch (*Symposiachrus trivirgatus*)

6.19.1 Status

EPBC Act – Migratory (Bonn)

NC Act – SLC

6.19.2 Biology and ecology

6.19.2.1 Characteristic

The Spectacled monarch (*Symposiachrus trivirgatus*) approximates 15 cm in size and is blue-grey above, with a black face mask that extends across both eyes. The breast is rufous in colour and the underparts are pale. The tail is black with white outer tips. Immature birds lack the black face and have a grey throat (Pizzey and Knight 2007) (refer Photograph 6.19).

Photograph 6.19 Spectacled monarch (*Symposiarchrus trivirgatus*)

Source: Mike's Birds (2017)

6.19.2.2 Known distribution

The Spectacled monarch is found in coastal north-eastern and eastern Australia, including coastal islands, from Cape York, Queensland to Port Stephens, NSW (refer Figure 6.37). It is much less common in the south. It is also found in Papua New Guinea, the Moluccas and Timor (Blakers et al. 1984; DotEE 2018).

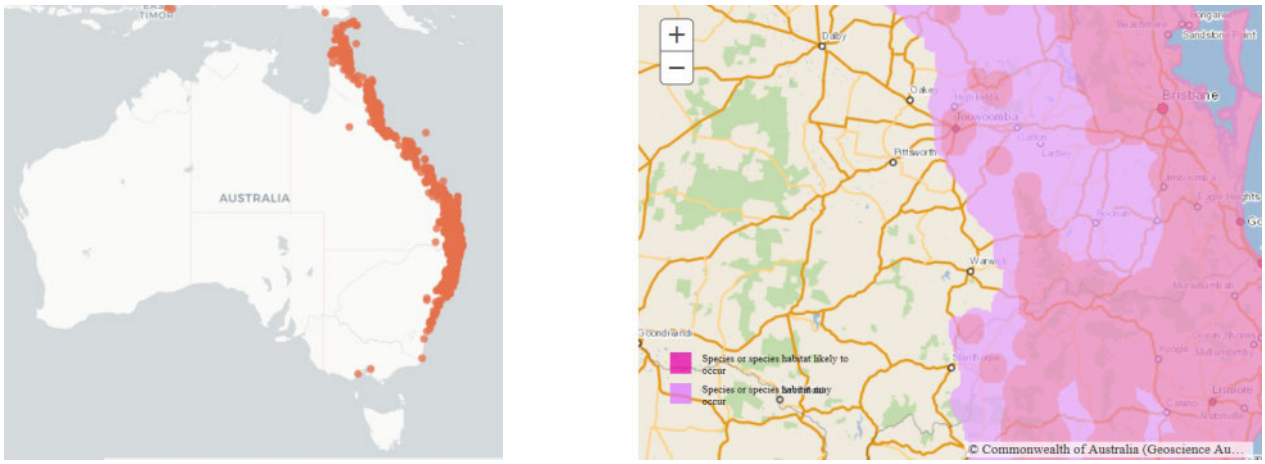

Figure 6.37 Distribution range of the Spectacled monarch

Source: ALA (2018), DotEE (2018)

6.19.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Symposiachrus trivirgatus* exist within the ecology study area. The closest record is located approximately 3 km south of the disturbance footprint near Prince Henry Heights and is dated 2006. The next closest record is located approximately 3.5 km south of the alignment, also near Prince Henry Heights, and is dated 2014. A number of other records exist within a 50 km buffer of the disturbance footprint. Most are concentrated south of the alignment in the surrounds of Prince Henry Heights and to the northeast in Ravensbourne National Park (refer Figure 6.38).

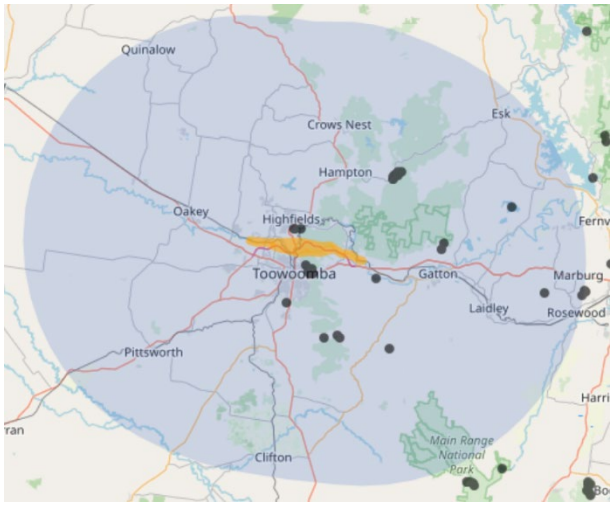

Figure 6.38 **Distribution range of the Spectacled monarch in relation to the Project**

Source: ALA (2020)

6.19.2.4 Biology and reproduction

The Spectacled monarch forages for insects among foliage, or catches flying insects on the wing (Pizzey and Knight 2007).

The Spectacled monarch is a resident in the north of its range (i.e. from Rockhampton in Queensland northward), but is a summer breeding migrant to coastal south-eastern Australia, arriving in September and returning northwards in March. It may also migrate to Papua New Guinea in autumn and winter. The Spectacled monarch builds a small cup nest of fine bark, plant fibres, moss and spider web generally in a tree fork or in hanging vine 1 to 6 m above the ground. Nests are often located near water. Only the female builds the nest, but both sexes incubate the eggs and feed the young. Clutch size consists of two eggs. Reproduction occurs between October and February (DotEE 2018; Pizzey and Knight 2007).

6.19.3 Habitat

The Spectacled monarch inhabits both dense low vegetation and habitats with fairly open understoreys. The species prefers the understorey of mountain and lowland rainforests, thickly wooded gullies and waterside vegetation (Pizzey and Knight 2007).

6.19.4 Threatening processes

There are currently no known serious threatening processes that have been identified for the Spectacled monarch.

6.19.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.19.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals

- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat

Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline.

6.19.7 References

Atlas of Living Australia (2018). *Symposiachrus trivirgatus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:025b08d1-0e50-4723-b581-9be91d8d09ed [Accessed 27 August 2018].

Blakers, M., Davies S.J.J.F. and Reilly P.N. (1984). *The Atlas of Australian Birds*. Melbourne, Victoria: Melbourne University Press.

Department of the Environment and Energy (2018). *Symposiachrus trivirgatus* in Species Profile and Threats Database, Department of the Environment and Energy, Canberra. Available from: https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=592 [Accessed 27 August 2018].

Mike's Birds. (2017). Spectacled monarch (Symposiarchrus trivirgatus). [image] [online] Available from: https://www.flickr.com/photos/pazzani/32674373086/in/photolist-cbDuRN-248Bv1h-RMjGL7-p2uuuJ-7ubegy-LDPfDX-rARt3W-2hczLX3-XAz8D2-QnWzZW. [17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

6.20 Whimbrel (*Numenius phaeopus*)

6.20.1 Status

EPBC Act – Marine and Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)

NC Act – SLC

6.20.2 Biology and ecology

6.20.2.1 Characteristic

The Whimbrel is type of curlew of a medium size reaching a length of 40 to 45 cm, wingspan of 76 to 90 cm and weight of 350 g. The overall colouration is brown with dark brown on the top part of the body with a paler underside streaked with brown and pale fringes. The colour of the legs is grey to blueish grey. Adult birds have a distinctive pattern across the head consisting of a dark brown crown and stripe across the eye (refer Photograph 6.20) (Higgins and Davies 1996).

Photograph 6.20 Whimbrel (*Numenius phaeopus*)

Source: Trepte (2011)

6.20.2.2 Known distribution

In Australia Whimbrels are largely associated with coastal regions in their distribution. Most regions of Australia encounter scattered records including inland. They are more commonly encountered in the north of the country (refer Figure 6.39). They are also encountered at offshore island throughout Australia and in New Zealand (DAWE 2020). The species breeds in the Northern Hemisphere in north America, Iceland, Eurasia, Scandinavia, Russia, Estonia with the Arctic Circle comprising on the northern limit of their breeding distribution (Higgins and Davies 1996).

Figure 6.39 Distribution range of the Whimbrel

Source: ALA (2020), DAWE (2020)

6.20.2.3 Distribution in relation to the Project

Database records (i.e. AoLA, WildNet) do not indicate occurrences of Whimbrel from within the Project disturbance footprint, ecology study area or within a 50 km buffer of the disturbance footprint. The nearest record occurs inland of the Project approximately 75 km from the disturbance footprint. The record is more than 30 years old (1990) and is located at the Lake Broadwater Conservation Park. The next nearest record, approximately 80 km east of the Project is more recent (2007) and is located at Fig Tree Pocket in Brisbane to the north of the Brisbane River (refer Figure 6.40). Records for the species are largely restricted to the eastern coastal region near Brisbane and few records occur inland where the Project is located.

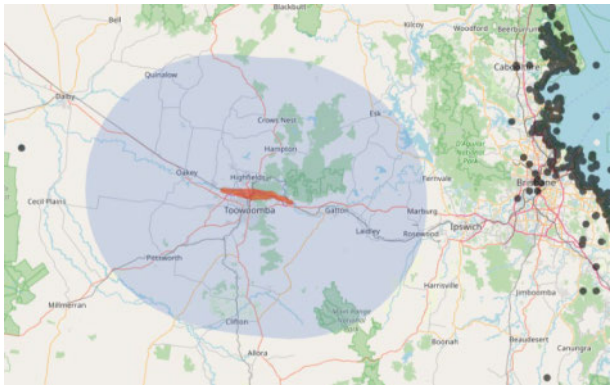

Figure 6.40 **Distribution range of the Whimbrel in relation to the Project**

Source: ALA (2020)

6.20.2.4 Biology and reproduction

A Whimbrel's diet is predominantly carnivorous feeding on annelids, crustaceans and occasionally vertebrates including fish and Little tern (*Sterna albifrons*) nestlings. The species has also been observed feeding on berries, shellfish, arthropods and reptiles (Higgins and Davies 1996).

This species does not breed within Australia. Breeding occurs in the Northern Hemisphere during the summer months between May and June. The species will either nest in mangroves on the fringes of mudflats and estuaries or in a depression on the ground. Two to three eggs are laid with a 22 to 28 day incubation period. Chicks remain in the nest for 35 to 40 days once hatched (del Hoyo et al. 1996).

6.20.3 Habitat

Whimbrels are typically found in habitat associated with coastal areas including mudflats and sheltered coasts, harbours, lagoons, estuaries and river deltas. Most often they will occupy these areas where mangroves are present but are also present at bare mudflats. They can occasionally be found at sandy or rocky beaches on mainland, islands and reefs (Higgins and Davies 1996).

6.20.4 Threatening processes

The following have been identified as potentially threatening processes to the Whimbrel:

- Habitat loss and degradation
- Disturbance of resting and roosting sites
- Direct mortality (DEWHA 2009).

6.20.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.20.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia
- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat
- Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline

6.20.7 References

Atlas of Living Australia (2020). *Numenius phaeopus*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:1ef65ebd-d888-45e1-88f8-75ce5a3fd0ed. [Accessed: 6 May 2020].

del Hoyo, J., Elliott, A., Christie, D.A. and Sargatal J. (1996). Handbook of the Birds of the World: Hoatzin to Auks. Barcelona: Lynx Edicions.

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2009). Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21. Canberra, ACT: Commonwealth of Australia. Available from: http://www.environment.gov.au/epbc/publications/migratory-shorebirds.html.

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.

Trepte, A. (2011). [Image] Whimbrel (*Numenius phaeopus*) Available from: https://en.wikipedia.org/wiki/File:Whimbrel_Numenius_phaeopus.jpg. [Accessed: 6 May 2020].

6.21 Yellow wagtail (*Motacilla flava*)

6.21.1 Status

EPBC Act – Marine and Migratory (CAMBA, JAMBA, ROKAMBA)

NC Act – SLC

6.21.2 Biology and ecology

6.21.2.1 Characteristic

The Yellow wagtail (*Motacilla flava*) is approximately 16.4 to 18 cm long with dark legs and uniform grey-green rump. In the nonbreeding season adults have greyish brown upperparts with white or yellowish eyebrows, dark ear-coverts and a buff-white breast. They have dark wings with white or yellow margins in a netted pattern on the upper wings (refer Photograph 6.21). In breeding plumage, they have bright yellow underparts from breast to vent. Juvenile forms are browner than the nonbreeding form with bolder spotted necklaces or yellow patches. They also make a high pitched 'sweet' or 'tzeep' sound (Pizzey and Knight 2007).

Photograph 6.21 Yellow wagtail (*Motacilla flava*)

Source: Pestana (2011)

6.21.2.2 Known distribution

They breed from Europe to Siberia and migrate south to Africa, SE Asia and Australia. In Australia, they are found in mostly coastal northern areas but also further south in NSW and southern WA Western Australia from November to April (Pizzey and Knight 2007) (refer Figure 6.41).

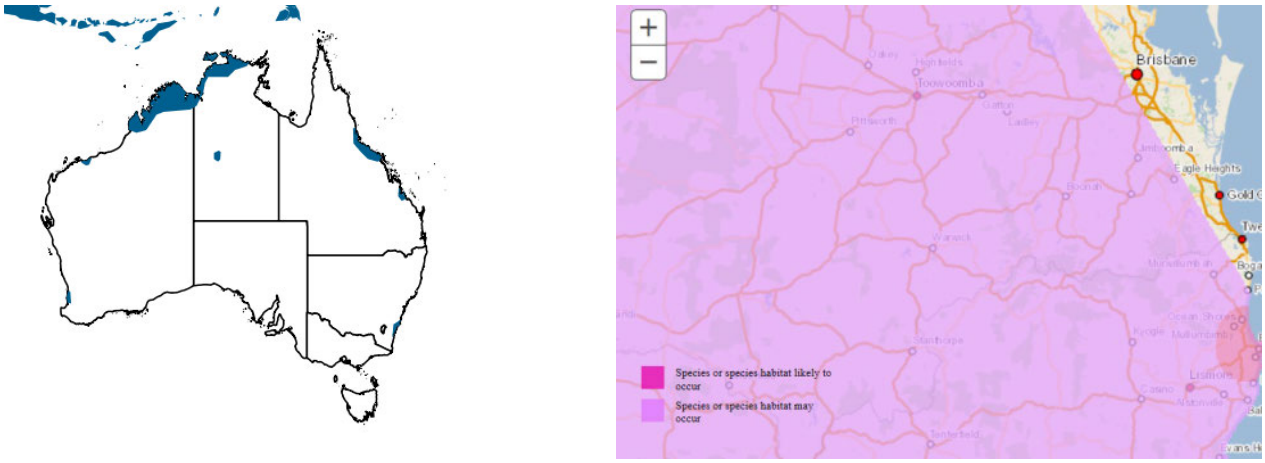

Figure 6.41 Distribution range of the Yellow wagtail

Source: ALA (2018), DotEE (2018)

6.21.2.3 Distribution in relation to the Project

Database records (i.e. ALA) indicate that no records of *Motacilla flava* exist within the ecology study area or within a 50 km buffer of the disturbance footprint. The closest record is located approximately 100 km to the east of the alignment, north of Brisbane, and is dated 2013 (refer Figure 6.42).

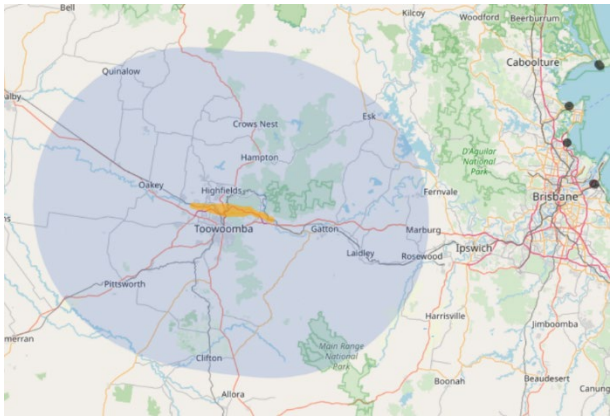

Figure 6.42 **Distribution range of the Yellow wagtail in relation to the Project**

Source: ALA (2020)

6.21.2.4 Biology and reproduction

It feeds on a wide variety of terrestrial and aquatic invertebrates as well as some plant material, particularly seeds (BirdLife International (2017).

Yellow wagtails do not breed in Australia and migrate north from April to August (Pizzey and Knight 2007).

6.21.3 Habitat

Yellow wagtails can be found in and around short grass, bare ground, swamp margins, sewage ponds, saltmarshes, sports fields, airfields, ploughed land and urban lawns (Pizzey and Knight 2007).

6.21.4 Threatening processes

The following have been identified as potentially threatening processes to the Yellow wagtail (BirdLife International (2017):

- Agricultural intensification
- Wetland drainage
- Use of pesticides (BirdLife International 2017).

6.21.5 Threat abatement/recovery plans

No threat abatement/recovery plans have been identified as being relevant for this species. The following referral guideline has been identified for this species:

- Referral guideline for 14 birds listed as migratory species under the EPBC Act.

6.21.6 Summary of threat abatement/recovery plans

The actions considered to have a significant impact on migratory birds include:

- Substantial loss or modification of important habitat for the species
- Actions that cause serious disruptions to an ecologically significant proportion of a population impacting annual mortality rates or the breeding cycles of individuals
- Establishment of invasive species harmful to migratory species in areas of important habitat.

Objectives and actions outlined in the referral guideline include:

- Retain the necessary habitats and resources required for the listed migratory birds to successfully migrate and, where appropriate successfully breed throughout their natural range in Australia

- Provide parameters for assessing the significant impacts based on actions that are likely to seriously disrupt the lifecycle of an ecologically significant portion of any migratory species' population or an action that will result in invasive species harmful to migratory species becoming established in an area of important habitat
- Upper thresholds have been outlined for the impact related to the disruption of habitat or to an ecologically significant proportion of the population for each species listed in the referral guideline

The Yellow wagtail is one of the five non-breeding species outlined in the referral guideline. As they are considered to be extremely uncommon migrants the number of individuals at any one site are so small relative to their global population that no small group of individuals is likely to be significant for the species in Australia or the ecological attributes for a site. For these species it is sufficient to lodge records with the Commonwealth to satisfy the recommendation.

6.21.7 References

Atlas of Living Australia (2018). *Motacilla flava*. Available from: https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:5b193d88-79d6-4a38-9c11-1385bace84c8#overview [Accessed 29 August 2018].

BirdLife International (2017). *Motacilla flava* (amended version of 2017 assessment). The IUCN Red List of Threatened Species 2017: e.T103822349A119286241. Available from: http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T103822349A119286241.en. [Accessed 29 August 2018]

Pestana, F. (2011). Yellow wagtail (Motacilla flava). [image] [online] Available from: https://www.flickr.com/photos/ferranp/5652899418/in/photolist-9BwA45-HRgKqh-gR7PEB-fqKQ16-o1PHy5-fqKQjV-gR7PRD-fqKQdF-nmAZEj-QJYupF-o1PHxd-nsA7DR-nYSZa3-29bQGXw-QPEsnm-RkvQME-J6aFCJ-4Gy77j-k732Zo-RxsJbL-eKmW48-nuDpMn-nqQ8ZW-2dXB6Bd-s7mLvg-9T9Y7S-9T7afH-2nhuTx-9JQHoM-o1PHD5-cSUaUY-9T9ZRQ-aLjuZe-9Ec8xC-o1CfSD-qbdtXd-nhXMG3-gR6SDW-gUkByF-o1PHKC-aD92DN-o1CfKK-nJr6Eq-DRXEbo-9T9Z4W-p9jAnR-nYSZqy-9E3tPb-eujvUb-dJQUtZ. [17 September 2019].

Pizzey, G. and Knight, F. (2007). *The Field Guide to the Birds of Australia*. Harper Collins publishing, Sydney.

APPENDIX I

Terrestrial and Aquatic Ecology

Appendix C Herbarium confirmation letters

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