Rockhampton Ring Road

Report - Preliminary Documentation (EPBC 20208628)

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Department of Transport and Main Roads

Rockhampton Ring Road

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Project Manager:	Darren Leeson
Author:	M. Zulpo, K. McPherson, D. Weller, J. Diflo, A. Marsden, C. Vaughan
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159 Denison St
Rockhampton QLD 4700

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Definitions

Reference	Definition
The Client or the Principal	Department of Transport and Main Roads
Project or RRR	Rockhampton Ring Road
AEP	Annual exceedance probability
ARI	Average Recurrence Interval
Alluvium	Clay, silt, sand, gravel, or similar material deposited by running water
Aquifer	Body of porous rock or sediment (such as the alluvium across the floodplain) saturated with water, with the top of an aquifer referred to as the water table
AS/NZS ISO	Joint Australian/New Zealand Standards International Organization for Standardization
Benthic	Associated with or occurring on the bottom of a body of water
B Act	*Biosecurity Act 2014*
CAMBA, JAMBA, ROKAMBA	Bilateral migratory bird agreements with Japan (JAMBA), China (CAMBA) and the Republic of Korea (ROKAMBA)
CBD	Central Business District
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLR	Contaminated Land Register
Confined aquifer	Aquifer (underground water) that is overlain by a low permeability layer, so it does not receive direct vertical recharge and is less responsive to surface conditions. Water in a confined aquifer is typically under pressure.
Critically endangered	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
DAWE	Department of Agriculture Water and the Environment
DD	Detailed Design
DDS	Detailed Design Stage
Design Documentation	Design deliverables prepared by the project team to specify the design
Design Package	Collation of Design Documents for submission for an element or aspect of the Works at a Design Stage
Design Package Number	Number assigned to the Item Codes by the JSDJV, to assist with the delivery of items in the Functional Specification. Relates to document numbering and delivery workflows
Design Stage	Defined stages in the development of the design as follows: 1) Preliminary Design Stage (PDS) 50% 2) Detailed Design Stage (DDS) 100% 3) Issued for Construction (IFC) Certified 100% Design
DES	Department of Environment and Science
Dispersive soils	A soil type defined by a process by which clay particles are repelled by electrostatic forces and mechanical forces and separate from each other forming a suspension of clay particles in water.
DIWA	Directory of Important Wetlands of Australia
DO	Dissolved oxygen
Drawdown of an aquifer	Change in groundwater level due to an applied stress

Reference	Definition
Ecological community	A naturally occurring group of native plants, animals and other organisms that are interacting in a unique habitat. Its structure, composition and distribution are determined by environmental factors such as soil type, position in the landscape, altitude, climate and water availability.
EMP(C)	Environmental Management Plan (Construction)
EMR	Environmental Management Register
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Endangered	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
ESCP	Erosion and Sediment Control Plan
FFMP	Flora and Fauna Management Plan
FTE	Full-time equivalent
Groundwater	Water that is underground and saturates soil and fills spaces in rock
HES wetland	High ecological significance wetland
HEV wetland	High ecological value wetland
IAAF	Infrastructure Australia's Assessment Framework
IFC	Issued for Construction
ISCA	Infrastructure Sustainability Council of Australia
JSDJV/DJV	Jacobs SMEC Design Joint Venture. An organisation preparing Design Documents for the project on behalf of the Department of Transport and Main Roads
KBA	Key Biodiversity Area
Lacustrine wetland	Lacustrine wetlands or lakes may have fringing vegetation, although the majority of the wetland area is open water. Natural lacustrine systems are generally over 8 ha in size and have deep, standing or slow-moving water.
Listed migratory species	Listed migratory species include any native species identified in an international agreement approved by the Minister. The Minister may approve an international agreement for this purpose if satisfied that it is an agreement relevant to the conservation of migratory species.
Loam	Soil with a mix of clay and sand with organic matter
Migratory species	Migratory species are those animals that migrate to Australia and its external territories, or pass through or over Australian waters during their annual migrations.
the Minister	The Australian Government environment minister
MNES	Matters of national environmental significance
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NC Act	*Nature Conservation Act 1992*
NTU	Nephelometric turbidity units
Palustrine wetland	Heavily vegetated, non-riverine or non-channel systems that are generally less than 8 ha in overall size. They can include billabongs, swamps, bogs, springs, soaks and marshes and typically have more than 30% emergent vegetation.
PDS	Preliminary Design Stage

Reference	Definition
Periphyton	A complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged substrate
Pile cap	A concrete slab approximately 1.5 m thick that sits on top of underground piles and provides the foundations for the aboveground bridge piers
Project Area	The Project Area generally aligns with the gazetted road corridor. It is the area proposed to be disturbed, altered, or used for the construction or operation of the Rockhampton Ring Road. Relocation of Public Utility Services may occur outside of the Project Area as well as other flood mitigation works.
Project Footprint	The Project Footprint is located within the Project Area. It is the area proposed to be used for the operation of the Rockhampton Ring Road.
Putrescible waste	Liable to decay or purification
Quaternary site	As defined in Queensland Herbarium, Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Neldner, Dillewaard, Butler, 'Ryan, & Wilson, 2017).
Ramsar wetland	Ramsar wetlands are wetlands that meet criteria set by the Convention on Wetlands of International Significance. These wetlands are also referred to as Wetlands of International Importance. Ramsar wetlands are placed under protection due to their international and ecological significance.
RE	Regional ecosystem
Regional ecosystem	A vegetation community in a bioregion that is consistently associated with a particular combination of geology, landform and soil.
Remnant vegetation	Defined under the *Queensland Vegetation Management Act 1999 – Schedule* as vegetation— (c) that is— (i) an endangered regional ecosystem; or (ii) an of concern regional ecosystem; or (iii) a least concern regional ecosystem; and (d) forming the predominant canopy of the vegetation— (i) covering more than 50% of the undisturbed predominant canopy; and (ii) averaging more than 70% of the vegetation's undisturbed height; and (iii) composed of species characteristic of the vegetation's undisturbed predominant canopy.
Riverine waterbodies	Freshwater systems contained within a channel (e.g. river, creek) and the vegetation on the banks, which can be natural or artificial, and can connect to lacustrine, palustrine, estuarine and marine wetlands.
RFI	Request for Information
Riffle	Areas of broken water with rapid current
Riparian	Relating to or inhabiting the banks of a natural course of water
RRC BP	Rockhampton Regional Council Biosecurity Plan for Pest Management
RRC	Rockhampton Regional Council
Salinity	The presence of soluble salts in soil or water
Scour	The potential for scour in relation to bridges is the result of the erosive action of water, excavating and carrying away material from the bed and banks of streams and from around the piers and abutments due to contraction, pressure and localised vortices against the bridge elements.
Scupper	An outlet on a bridge to drain water from the bridge surface

Reference	Definition
Secondary site	As defined in Queensland Herbarium, Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Neldner, Dillewaard, Butler, 'Ryan, & Wilson, 2017).
SIE	Social Impact Evaluation
Significant impact	An impact which is important, notable, or of consequence, having regard to its context or intensity
SPRAT	Species Profile and Threats Database
State	State of Queensland
Survey program	The survey program refers to the culmination of all ecological field surveys undertaken for the Project
TEC	Threatened Ecological Communities
Temporary Works	Works required for the purpose of constructing the Project that do not form part of the permanent Works or in-service loading. Design for Temporary Works includes design for construction configurations whether or not the design results in additional works being specified.
TMR	Department of Transport and Main Roads
Transmissivity of the aquifer	The rate at which groundwater flows horizontally through an aquifer
Tunnel erosion	If not compacted properly during construction, air voids occur in dispersive soils and water can easily get into these void spaces and cause dispersion of the surrounding soil and small 'pipes' can form which quickly develop into 'tunnels'
Unconfined aquifer	Water table aquifer (underground water), which receives recharge from the land surface
Vulnerable	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
Water table	The upper surface of an area saturated with water (i.e. an aquifer)
WONS	Weeds of National Environmental Significance
WQO	Water quality objective

Preamble

This Preliminary Documentation Report has been prepared in direct response to additional information requested by the Department of Agriculture Water and the Environment (DAWE) as part of the “Controlled Action: Preliminary Documentation” determination for the Rockhampton Ring Road made on 16 June 2020 (EPBC Reference: 2020/8628). The Controlled action decision is based on DAWE’s assessment of the project as potentially resulting in a Significant Impact on the following Matters of National Environmental Significance:

- listed threatened species and communities (Sections 18 and 18A)
- listed migratory species (Sections 20 and 20A).

Information provided within this report is in response to an information request from DAWE received on 23 July 2020. As per the Request for Further Information, outlined below is a table that cross-references the information requested with the corresponding section of the Preliminary Documentation Report.

Summary of information requirements and corresponding document section

Comment	Corresponding section of PD Response
The Preliminary Documentation, which includes the referral documentation and the additional information described below, must be a stand-alone document containing sufficient information to avoid the need to search out previous or supplementary reports.	All
The Preliminary Documentation should take into consideration the EPBC Act Significant Impact Guidelines 1.1 and EPBC Act Significant Impact Guidelines 1.2, available at: www.environment.gov.au/epbc/guidelines-policies.html.	Sections 6-7
The document must enable interested stakeholders and the Minister to easily understand the consequences of the project on matters of national environmental significance (MNES). Information provided in the document should be objective, clear, succinct, avoid technical jargon and, where appropriate, be supported by maps, plans, diagrams, data or other descriptive detail.	All
Detailed technical information, studies or investigations necessary to support the information in the stand-alone document must be included as appendices. It is recommended that any additional supporting documentation and studies, reports or literature not normally available to the public, from which information has been extracted, be made available at appropriate locations during the period of public display of the Preliminary Documentation. The proponent should also make sure the Preliminary Documentation is made available on the Internet.	Appendix B
If it is necessary to make use of material that is considered to be of a confidential nature, the proponent should consult with the Department of the Agriculture, Water, and Environment (the Department) on the preferred presentation of that material before submitting it to the Minister for approval for publication for public comment.	Not applicable
The level of analysis and detail in the stand-alone document should reflect the level of significance of the expected impacts on MNES. Any and all unknown variables or assumptions made in the assessment must be clearly stated and discussed. The extent to which the limitations, if any, of available information may influence the conclusions of the environmental assessment must be discussed.	Section 7
The document should be written so that any conclusions reached can be independently assessed. To this end, all sources must be appropriately referenced using the Harvard standard of referencing. The reference list should include the address of any Internet webpages used as data sources.	Section 11

Comment	Corresponding section of PD Response
The Preliminary Documentation must include a list of persons and agencies consulted and the names of, and work done by, the persons involved in preparing the Preliminary Documentation.	Section 1.3
Maps, diagrams and other illustrative material should be included in the Preliminary Documentation. The document should be produced on A4 size paper capable of being photocopied, with maps and diagrams on A4 or A3 size and in colour. The proponent should consider the format and style of the document appropriate for publication on the Internet. The capacity of a website to store data and display the material may have some bearing on how the document is constructed.	All
The stand-alone document must include a copy of this request for information and a cross-reference table indicating where the information fulfilling this request is included in the Preliminary Documentation.	Preamble and Appendix C
All construction, operational, rehabilitation and decommissioning components of the action must be described in detail. This must include the details of the final ring road design, construction methodologies, geotechnical field investigation results, no-go zones, road length, and updated maps. The description of the action must discuss flooding immunity of the ring road and describe the flood consideration in the design.	Section 4
Provide the total size (in hectares) of the Project Area and the total size (in hectares) of the disturbance footprint once the final design has been approved. Please provide precise location of all works to be undertaken, structures to be built or elements of the action that may have impacts on MNES.	Section 6
The description must include a map (or maps) which clearly identify the final road design and all components of the action and their location within the Project Area.	Figure 1-2
The description of the action must also include details on how the works are to be undertaken (including stages of development and their timing) and design parameters for those aspects of the structures or elements of the action that may have relevant impacts.	Section 4
The description of the action must provide the details of the relevant condition of state approvals and other relevant approvals, if applicable.	Section 5
A copy of ecology report and hydrological assessments prepared to inform the state approval and other permits processes must be attached.	Appendix B
The Department notes that the final design for the Rockhampton Ring Road has not yet been finalised, therefore Preliminary Documentation must describe and assess each potential design option for the proposed action.	Section 4
The Department considers the proposed action may have or is likely to have a significant impact on the listed threatened species and communities (Sections 18 and 18A) and listed migratory species (Section 20 and 20A) known to or likely to occur within the Project Area, including but not limited to: *Listed threatened species and ecological communities:* • The Fitzroy River turtle (*Rheodytes leukops*) – Vulnerable; • White-throated snapping turtle (*Elseya albagula*) – Critically endangered; • Australian painted snipe (*Rostratula australis*) – Endangered; • Curlew sandpiper (*Calidris ferruginea*) – Critically endangered; • Koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT) – Vulnerable;	Noted

Comment	Corresponding section of PD Response
• White-throated needletail (*Hirundapus caudacutus*) – Vulnerable; • Squatter pigeon (*Geophaps scripta scripta*) – Vulnerable; • Grey-headed flying-fox (*Pteropus poliocephalus*) – Vulnerable; • Cycas ophiolitica – Critically endangered; • Black ironbox (*Eucalyptus raveretiana*) – Endangered; • Brigalow (*Acacia harpophylla* dominant and co-dominant) –Endangered; • Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions – Endangered; • Weeping Myall Woodland – Endangered. *Listed Migratory Species* • Latham's snipe (*Gallinago hardwickii*) – Migratory; • Caspian tern (*Hydroprogne caspia*) – Migratory; • Eastern osprey (*Pandion haliaetus*) – Migratory; • Glossy ibis (*Plegadis falcinellus*) – Migratory; • Marsh sandpiper (*Tringa stagnatilis*) – Migratory.	
Preliminary documentation must provide a robust assessment of the potential habitat available within, adjacent to and/or downstream of the Project Area for MNES. The habitat assessment for MNES must consider and align with the information in the SPRAT Database and relevant DAWE documents and, at a minimum, include: • a quantification of the total individuals/populations and justifications of the survey methods; • provide a discussion of the vegetation composition and structure on suitable soils (such as specific tree species, riparian areas and microhabitat features, etc.) and association with habitat types of a species; • identify the MNES and their habitat within the Project Area including: − known records of individuals (or evidence of individuals) derived from desktop analysis and/or field surveys; − area (in hectares) and habitat condition; − any breeding, foraging, dispersal, refuge/shelter, suitable habitats, roosting, known important habitat; − for migratory species known Important Bird Area and Directory of Important Wetlands (DIWA) of the Fitzroy floodplain and delta, etc.). • provide mapping of MNES and their habitat type/s that are found to be, or may potentially be, present within, adjacent to and/or downstream of the Project Area including an overlay of the project disturbance footprint; and • full justification of all discussions and conclusions based on the best available information, including relevant conservation advices, recovery plan, threat abatement plans and guidance documents, should be included if applicable.	Section 5
The Preliminary Documentation must include an assessment of potential impacts (including direct, indirect, facilitated, and cumulative impact, including longer impacts of the ring road operation) that may occur as a result of all elements and project phases of the proposed action (e.g. construction and post-construction) on the MNES, including but not limited to: • the total size (in hectares) of the disturbance footprint for MNES and their habitat type; • a discussion on the impacts associated with changes to surface hydrology to habitat in the proposed action area and surrounding areas including but not limited to: − flooding; − sedimentation and erosion; − increased water table; − increased in dissolved salt content and the potential of reduction of the extent of foraging habitat for migratory bird species. • impacts associated with fragmentation and edge effects;	Section 7

Comment	Corresponding section of PD Response
• the impacts of dust, noise, light and vehicle strike resulting from the construction and operation of the project; • an assessment of the likely duration of impacts on MNES as a result of the proposed action • discussion of the risk of introduction and proliferation weeds and spread of pathogens during construction; • details on whether any impacts are likely to be unknown, unpredictable, irreversible or sub-lethal (reversible over time) and what confidence level is placed on the predictions; • in discussing potential impacts, consider how the interactions of extreme environmental events (for example: flood events) and any related cumulative impacts may have on the proposal and the environment; • full justification of all discussions and conclusions based on the best available information, including relevant conservation advices, recovery plan, threat abatement plans and guidance documents, should be included if applicable.	
For listed threatened species and ecological communities, the Preliminary Documentation must demonstrate, with supporting evidence, that the action will not be inconsistent with Australia's obligations under: (i) the Biodiversity Convention; (ii) the Convention on Conservation of Nature in the South Pacific (Apia Convention); (iii) the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); and (iv) a recovery plan or threat abatement plan.	Section 5
For migratory species, the Preliminary Documentation must demonstrate, with supporting evidence, that the action will not be inconsistent with Australia's obligations under: (i) the Bonn Convention, (ii) CAMBA; (iii) JAMBA; (iv) ROKAMBA; and (v) any international agreement approved under subsection 209(4) of the EPBC Act.	Section 5
The Preliminary Documentation must provide information on proposed avoidance, safeguards and mitigation measures to deal with all stages of the action on MNES. The Preliminary Documentation must include relevant impacts of the proposed action on MNES, including those required by other Commonwealth, State and local government approvals. Committed language (e.g. 'will') rather than non-committal language (e.g. 'may', 'where possible', 'if required', etc.) must be used.	Section 7
The proposed measures must consider the 'S.M.A.R.T' principle: • S – Specific (what and how); • M – Measurable (baseline information, number/value, auditable); • A – Achievable (timeframe, money, personnel); • R – Relevant (conservation advices, recovery plans, threat abatement plans); and • T – Time-bound (specific timeframe to complete).	Section 7
Specific and detailed descriptions of proposed measures must be provided and substantiated, based on best available practices, and must include the following elements: • an assessment of the predicted effectiveness and environmental outcomes of the proposed measures, including details of any baseline data or proposed monitoring required to demonstrate progress towards achieving these outcomes; • any statutory or policy basis for the proposed measures, including reference to the SPRAT Database and relevant approved conservation advices, and a discussion on whether the proposed measures are consistent with relevant recovery plans and threat abatement plans; • details of ongoing management, including monitoring programs to support an adaptive management approach and determine the effectiveness of the proposed measures; • information on the timing, frequency and duration of the measures to be implemented; • the name of the agency responsible for endorsing or approving each measure or monitoring program; and	Section 7 and Appendix B

Comment	Corresponding section of PD Response
• details of the management actions such as Environmental Management Plan and Erosion Sediment Control Plan, and timeframes for implementation, to be carried out to meet the offset completion criteria. An outline of any management plans must: − set out the framework for management, mitigation and monitoring of relevant impacts of the proposed action, including any provisions for independent environmental auditing; − address the project phases (construction, operation, road maintenance, rehabilitation) separately; − state the environmental objectives, performance criteria, monitoring, reporting, corrective action, responsibility and timing for each relevant MNES environmental issue; − describe contingencies for events such as heavy or prolonged rainfall, increased sedimentation, and/or weed invasion into the wetlands and floodplains.	
Describe the residual impacts on MNES that are likely to occur as a result of the proposed action, after proposed avoidance and/or mitigation measures are taken into account. If it is determined that residual impacts are likely to be significant, please provide an environmental offsets package. If applicable, please include the reasons why avoidance or mitigation of impacts cannot be reasonable achieved.	Section 7
Environmental offsets are measures to compensate for residual significant impacts to MNES. Offsets do not reduce the impacts of an action and are not intended to make proposals with unacceptable impacts acceptable. They simply provide an additional tool that can be used during project design and the Preliminary Documentation process.	Noted
Please note, the Department is likely to require an environmental offset be approved prior to the commencement of the action to align with the EPBC Act Environmental Offsets Policy. Offsets must directly contribute to the ongoing viability of the listed threatened and migratory species.	Noted
Where an offset is proposed, with a completed Offsets Assessment Guide calculation, all inputs must be supported by robust scientific evidence and/or supporting evidence (e.g. historical grazing regimes, satellite imagery, and statements from landholders).	Not applicable
Where the proposed offset area/s supports an environmental offset for multiple MNES, proposed management action/s for one protected matter must not be detrimental (i.e. have an impact) to other protected matters.	Noted
Where offset area/s have been nominated, include a draft Offset Area Management Plan (OAMP) that includes information to demonstrate how the environmental offset/s compensate for residual significant impacts of the proposed action on relevant MNES, and/or their habitat. The draft OAMP must be in accordance with the principles of the EPBC Act Environmental Offsets Policy and all requirements of the Offsets Assessment Guide include, at a minimum: • a description of the offset area/s, including location, size, condition, environmental values present and surrounding land uses; • baseline data and other supporting evidence, including the ecological field data, that documents the presence of the relevant MNES, and the quality of their habitat within the offset area/s; • details of how the environmental offset/s meets the requirements of the Department's EPBC Act Environmental Offsets Policy (2012), including the Offsets Assessment Guide (2012), available at: www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy; • an assessment of the site habitat quality for the offset area/s using an appropriate methodology, with justification and supporting evidence (e.g. using the Queensland Guide to determining terrestrial habitat quality: A toolkit for assessing land-based offsets under the Queensland Environmental Offsets Policy (2020);	Not applicable

Comment	Corresponding section of PD Response
• the methodology, with justification and supporting evidence, used to inform the inputs of the Offsets Assessment Guide in relation to the impact site for each relevant MNES, including: − total area of habitat (in hectares); − habitat quality (e.g. using the Queensland Government Guide to determining terrestrial habitat quality: A toolkit for assessing land-based offsets under the Queensland Environmental Offsets Policy (2020)). This guide can be found at the following website: https://environment.des.qld.gov.au/__data/assets/pdf_file/0017/102833/habitat-quality-assessment-guide-v1-3.pdf. • the methodology, with justification and supporting evidence, used to inform the inputs of the Offsets Assessment Guide in relation to each potential offset area for each relevant MNES, including: − time over which loss is averted; − time until ecological benefit; − risk of loss (%) without offset and risk of loss (%) with offset; − confidence in result (%). • details of how the offset area/s will provide connectivity with other habitats and biodiversity corridors and/or will contribute to a larger strategic offset for the relevant listed threatened species and communities and migratory species; • maps and shapefiles to clearly define the location and boundaries of the offset area/s, accompanied by the offset attributes (e.g. physical address of the offset area/s, coordinates of the boundary points in decimal degrees, the listed threatened species and migratory species that the environmental offset/s compensates for, and the size of the environmental offset/s in hectares); • specific offset completion criteria derived to demonstrate the improvement in the quality of habitat in the offset area/s over an agreed completion timeframe and the interim milestones that set targets at certain time intervals; • details of the nature, timing and frequency of monitoring to inform progress against achieving the interim milestones (the frequency of monitoring must be sufficient to track progress towards each set of milestones, and sufficient to determine whether the offset area/s are likely to achieve those milestones in adequate time to implement all necessary corrective actions); • proposed timing for the submission of monitoring reports which provide evidence demonstrating whether the interim milestones have been achieved; • timing for the implementation of corrective actions if monitoring activities indicate the interim milestones have not been achieved; • risk analysis and a risk management and mitigation strategy for all risks to the successful implementation of the OAMP and timely achievement of the offset completion criteria; • if proposed for listed threatened species and communities and migratory species, evidence of how the management actions and corrective actions take into account relevant approved conservation advices and are consistent with relevant recovery plans and threat abatement plans; and • details of the legal mechanism for legally securing the proposed offset area/s, such that legal security remains in force over the offset area/s for the whole period of offsets.	
The draft Offset Management Plan must be prepared by a suitably qualified person and in accordance with the Department's Environmental Management Plan Guidelines (2014), available at: www.environment.gov.au/epbc/publications/environmental-management-plan-guidelines.	Not applicable
The draft OAMP must include robust scientific evidence (e.g. published research, pilot studies, previously successful projects/programs, etc.) to demonstrate the success of proposed measures to create, revegetate, regenerate and/or improve habitat (e.g. water quality monitoring, wetlands rehabilitation) in the proposed offset area/s for listed threatened species and communities and migratory species.	Not applicable

Comment	Corresponding section of PD Response
Please note, it is the Department's expectation that the agreed inputs into the Offsets Assessment Guide are specified in the conditions of approval where the action is approved, subject to conditions, under the EPBC Act.	Noted
The Preliminary Documentation must include a discussion of how the project will conform to the principles of Ecologically Sustainable Development. To assist you, the National Strategy for Ecologically Sustainable Development (1992) is available at: www.environment.gov.au/about-us/esd/publications/national-esd-strategy.	Section 9
The Preliminary Documentation must include details of any proceedings under a Commonwealth, State or Territory law for the protection of the environment or the conservation and sustainable use of natural resources against: • the person proposing to take the action; and • for an action for which a person has applied for a permit, the person making the application. If the person proposing to take the action is a corporation, details of the corporation's environmental policy and planning framework must also be included.	Section 10
The Preliminary Documentation must include a discussion and analysis of the social and economic impacts of the project, both positive and negative. Economic and social impacts should be considered at the local, regional and national levels. Matters of interest may include: • details of any public consultation activities undertaken, including any consultation with Indigenous stakeholders, and their outcomes; • projected economic costs and benefits of the project (in dollars), including the basis for their estimation through cost/benefit analysis or similar studies; and • employment opportunities expected to be generated by the project (including construction and operational phases).	Section 11

1. Introduction

1.1 Project Background

The RRR is the key piece of road infrastructure within the Fitzroy River Floodplain aimed at addressing long-term solutions for flooding impacts on freight, road and rail transport in and around the city of Rockhampton.

The RRR Project will provide a western road link of the Bruce Highway to the west of Rockhampton, with key linkages into the city at the Capricorn Highway, West Rockhampton, Alexandra Street and Yaamba Road (Rockhampton – Yeppoon Road).

The RRR alignment will integrate with major infrastructure already completed, including Yeppen North and Yeppen South, as well as current works in development including the Rockhampton Northern Access Upgrade and Capricorn Highway Duplication (Rockhampton – Gracemere).

The RRR project commences on the Capricorn Highway approximately 2 km west of the intersection of the Bruce and Capricorn Highways (Yeppen Roundabout) and its alignment traverses north through the Western Yeppen Floodplain, sweeping around the Rockhampton Airport at Pink Lily and connecting to West Rockhampton near Rockhampton – Ridgelands Road before crossing the Fitzroy River north of Limestone Creek. After crossing the Fitzroy River, the RRR intersects Alexandra Street in Parkhurst and connects with the Bruce Highway at the Yaamba Road and Rockhampton - Yeppoon Road intersection.

The total combined length of the Project is approximately 17 km (including the West Rockhampton Connector). The length of the Project from the Capricorn Highway intersection to the Yeppoon Road intersection is approximately 14.7 km (excluding the West Rockhampton Connector).

Figure 1-1: Project locality

The project is a joint initiative of the Australian and Queensland governments and intends to:

- Improve road safety and provide strength to the region's economy by improving freight efficiency and flood resilience
- Strengthen connectivity between key employment, leisure, tourism and residential growth areas of Rockhampton and the wider region

- Provide job opportunities for residents of Central Queensland and surrounding regions, along with providing opportunities for local businesses to help deliver the Project.

The Project Area and Project Footprint are shown in Figure 1-2. The Project Area generally aligns with the gazetted road corridor for the Rockhampton Ring Road. It is the area proposed to be disturbed, altered, or used for the construction or operation of the Rockhampton Ring Road. The Project Footprint is the area within the Project Area that will be used for the operation of the Rockhampton Ring Road. Works associated with the construction and operation of the Project will generally be undertaken within the Project Area. Relocation and reconfiguration of affected Public Utility Plant which have the potential to impact MNES are also shown in Figure 1-2. Further details of the Project are provided in Section 4.

1.2 Purpose of the Preliminary Documentation

This Preliminary Documentation Report has been prepared in direct response to additional information requested by the Department of Agriculture Water and the Environment (DAWE) as part of the "Controlled Action: Preliminary Documentation" determination for the Rockhampton Ring Road made on 16 June 2020 (EPBC Reference: 2020/8628). The Controlled action decision is based on DAWE's assessment of the project as potentially resulting in a Significant Impact on the following Matters of National Environmental Significance:

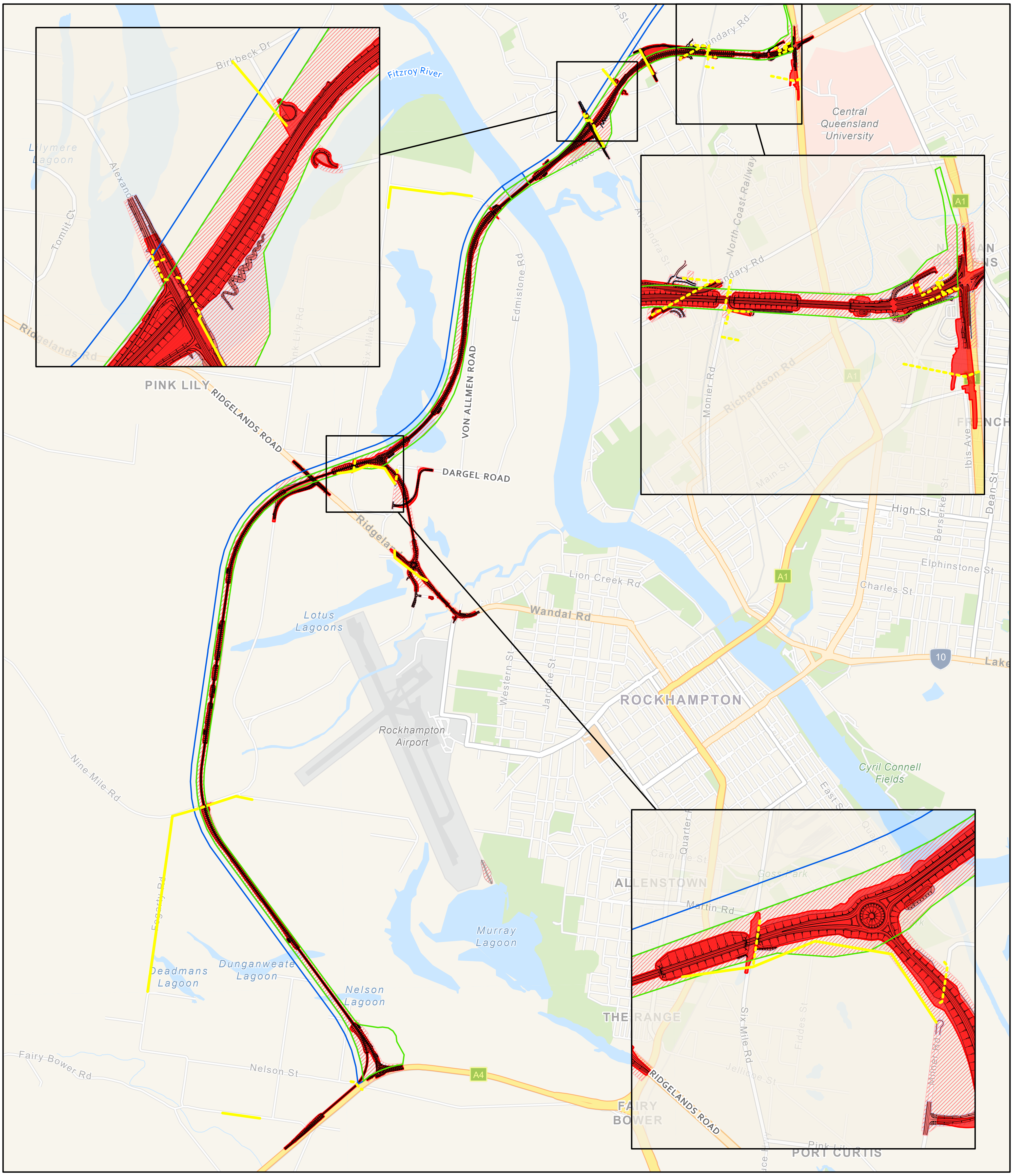
- Listed threatened species and communities (Sections 18 and 18A)
- Migratory species (Sections 20 and 20A).

Information provided within this report is in response to an information request from DAWE received on 23 July 2020. In summary, this response has been developed to provide additional information on the following:

- Existing environment
- Description of the action
- Legislative approvals
- Matters of National Environmental Significance
- Habitat assessment
- Impact assessment
- Proposed avoidance, mitigation and management measures
- Residual impacts and proposed environmental offsets
- Ecologically sustainable development
- The environmental record of the persons proposing to take the action
- Social and economic matters.

This Preliminary Documentation Report has been developed in accordance with Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Significant Impact Guidelines 1.1 and 1.2.

Figure 1-2: Locality



Legend

- Gazetted Corridor
- Future North Coast Rail Line
- Preliminary Design

Public Utility Plant Works

- Aboveground - potential vegetation clearing/trimming
- Underground - potential trench/underboring

- Project Area
- Project Footprint

JSDJV does not warrant that this document is definitive nor free of errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

GDA 1994 MGA Zone 56

A3 1:40,000

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0 0.5 1
Kilometers

Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: SMEC: Design (2021); ESRI: Basemap (2021); Ergon: PUP (2021)

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1.3 Preliminary Documentation Report Preparation

The following persons were involved in preparing the Preliminary Documentation Report:

- Mellissa Zulpo – Manager Environment (Jacobs SMEC Design Joint Venture)
- Kylie McPherson - Associate Environmental Scientist (Jacobs SMEC Design Joint Venture)
- Dan Weller – Senior Ecologist, migratory bird specialist (Jacobs SMEC Design Joint Venture)
- Ashely Marsden – Associate Environmental Scientist (Jacobs SMEC Design Joint Venture)
- Colin Vaughan – Associate Environmental Scientist (Jacobs SMEC Design Joint Venture)
- Dr David Shape – Senior Environmental Scientist (Jacobs SMEC Design Joint Venture)
- Jon Alexander – Principal Environmental Scientist (Jacobs SMEC Design Joint Venture)
- Eric Van Dyk - Technical Principal Roads & Highways and Design Manager (Jacobs SMEC Design Joint Venture)
- Amy Kirkpatrick – Senior Environmental Planner (Arcadis)
- Alexis Wileman - Principal Engineer (TMR)
- Gavin Hill - Project Manager (Major Planning Projects) (TMR).

All persons and agencies consulted during the development of this Preliminary Documentation Report have been cited throughout the report.

2. Assessment Methods

The environmental attributes present within and adjacent to the Project Area have been identified via desktop assessments and field surveys, which are summarised in the following sections.

2.1 Desktop Assessment

The following reports have been previously prepared as part of the Detailed Business Case phase of the Project, and were reviewed as part of the desktop assessment:

- *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) Referral (AECOM, 2020a)
- Flora and Wetlands Technical Report Rockhampton Ring Road – Business Case (AECOM, 2020f)
- Migratory Shorebird Survey Report (AECOM, 2020b)
- Review of Environmental Factors – Rockhampton Ring Road – Detailed Business Case (AECOM, 2020c)
- Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road – Business Case (AECOM, 2020d)
- Threatened Turtle and Fish Habitat Assessment (AECOM, 2020e)
- Wetland Impact Assessment Rockhampton Ring Road Project (C&R Consulting, 2020).

The following databases and mapping were accessed to update the information presented in the previous reporting:

- The Commonwealth EPBC Act Protected Matters Search Tool, which provides modelled likelihood of species and communities
- The Queensland Department of Environment and Science WildNet database, which holds observations of species from a variety of sources including government agencies, researchers, business, natural resource management bodies and citizen science programs
- The Queensland Department of Resources Regulated Vegetation Management Map and the Vegetation Management Supporting map, which includes essential habitat, wetlands, watercourses as mapped under the Queensland *Vegetation Management Act 1999*
- The Queensland Department of Environment and Science Protected Plants Flora Survey Trigger map, to identify areas where threatened or near threatened flora species are likely to occur
- The Queensland Department of Environment and Science Wetland Protection Area mapping, to identify the presence and extent of wetlands
- The Queensland Department of Environment and Science Biomaps, for spatially validated records of threatened species
- Birdlife Australia Birdata database, which provides reliable and vetted observations of birds by experienced bird observers and birding groups, long-standing monitoring programs with time-series data
- Cornell Lab of Ornithology eBird database, which provides rich data sources for basic information on bird abundance and distribution at a variety of spatial and temporal scales.
- Atlas of Living Australia, which is a collaborative, digital, open infrastructure that pulls together Australian biodiversity data from multiple sources.

Birdata and eBird provide the most up-to-date and comprehensive records of bird observations. WildNet and the Atlas of Living Australia both acquire the majority of their bird observation data from these sources through established data sharing agreements. Birddata and eBird have therefore been used as the primary source for all bird observations, and cross-checked against WildNet and Atlas of Living Australia to ensure records are not overlooked. It is also important to note that WildNet includes observations of species from a variety of sources including citizen science programs, whereas Birddata and eBird provide reliable and vetted observations of birds by experienced bird observers and birding groups.

The following additional data and reports have been developed as part of the Preliminary and Detailed Design phase of the Project, and were reviewed as part of the desktop assessment:

- Contaminated Land Gap Analysis (Jacobs SMEC Design Joint Venture, 2021c)
- Geotechnical investigation data.

2.2 Field Surveys

Field surveys to support the Detailed Business Case were undertaken in 2019 and 2020, with additional surveys undertaken in 2020 and 2021 during the Preliminary and Detailed Design phases of the Project. The scope of field surveys is discussed in the following sections.

It is noted that all field surveys represent a ‘snapshot’ of the species using the Project Area and Survey Area at single points in time, and do not account for seasonal or long-term variations in fauna movements. As such, it was assumed that no detection did not equate to absence, especially where potential habitat was identified and/or species records occurred nearby.

2.2.1 Regional Ecosystems Surveys

The assessment of the regional ecosystems (RE) and flora within the Project Area was undertaken in February and October 2019. The surveys were undertaken in accordance with the methodology developed by the Queensland Herbarium, Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland (Neldner, Dillewaard, Butler, 'Ryan, & Wilson, 2017). Vegetation was sampled at nine secondary and 90 quaternary level sites across the Project Area. Survey sites were selected to sample the variation in vegetation mapped, including both remnant and non-remnant areas, and targeting each RE identified across the Project Area.

At each secondary site, full floristics, structural and abundance information was collected within a 50 m by 10 m transect. This included a full species list and vegetation structural descriptions including strata, height, abundance and cover values for each species. At each quaternary site, the dominant species were recorded including a vegetation structural description of the dominant overstorey species.

As per the Queensland Department of Environment and Science Queensland Herbarium methodology, each survey site was attributed to a RE based on the land zone and dominant species observed. RE mapping boundaries were adjusted based on field verification. During field survey, opportunistic observations of flora species outside of secondary and quaternary sites were also recorded. Survey methods are further detailed in the Flora and Wetlands Technical Report Rockhampton Ring Road – Business Case (AECOM, 2020f) (Appendix B).

2.2.2 Threatened Ecological Community Surveys

In addition to the data collected as part of the RE verification, areas identified as potential Threatened Ecological Communities (TEC) were assessed in the field against the relevant conservation advice for that TEC. Specifically, potential TECs must meet key diagnostic criteria and condition thresholds outlined in the conservation advice to be considered as a TEC. The brigalow (*Acacia harpophylla* dominant and co-dominant) TEC was the only TEC confirmed as present in the Project Area during field surveys. In February and October 2019 (AECOM, 2020f), the brigalow TEC was mapped as a patch of non-remnant RE 11.3.1, which included regrowth vegetation that met the key diagnostic criteria and condition thresholds detailed in the conservation advice for the TEC (Threatened Species Scientific Committee, 2013). Survey methods are further detailed in the Flora and Wetlands Technical Report Rockhampton Ring Road – Business Case (AECOM, 2020f).

The TEC was re-surveyed in July 2021 to confirm the extent of the habitat in the Project Area. Survey methods are further detailed in the Ecosure data of *Eucalyptus raveretiana* and Brigalow TEC (Ecosure, 2021b).

2.2.3 Conservation Significant Flora Species Surveys

In February and October 2019, the Project Area was surveyed utilising the random meander survey technique to identify potential conservation significant flora species under the EPBC Act. A flora survey, in accordance with the Flora Survey Guideline – Protected Plants (Queensland Government Department of Environment and Heritage Protection, 2014) was undertaken in areas of the alignment identified as high risk on the flora survey trigger map (Queensland Department of Environment and Science, 2019b).

Survey methods are further detailed in the Flora and Wetlands Technical Report Rockhampton Ring Road – Business Case (AECOM, 2020f) (Appendix B).

The only threatened species listed under the *Queensland Nature Conservation Act 1992* (NC Act) or EPBC Act that was identified during the field surveys was *Eucalyptus raveretiana* (black ironbox), which is listed as vulnerable under the EPBC Act. As part of the Preliminary and Detailed Design phase, a *Eucalyptus raveretiana* population survey was undertaken to confirm the extent of the population previously identified at Limestone Creek. The survey comprised a desktop review and targeted field survey including the following:

- A desktop review of RE mapping, Biomaps and previous reporting
- A targeted survey of *Eucalyptus raveretiana* individuals in the previously identified suitable habitat.

The population survey was undertaken in December 2020 in general accordance with the random meander survey technique as detailed in the *Flora Survey Guideline – Protected Plants* (Queensland Government Department of Environment and Science, 2020a). Survey methods are further detailed in the Technical Note – *Eucalyptus raveretiana* Population Survey (Jacobs SMEC Design Joint Venture, 2021f) (Appendix B).

All *Eucalyptus raveretiana* were identified in the field and their location recorded using a handheld GPS. The extent of suitable habitat within the Project Area was assessed in the field and mapped using Quantum Geographic Information Systems (QGIS) software in the office. The population survey was undertaken at the following locations:

- 200 m upstream from where the project traverses Limestone Creek
- 200 m downstream from where the project traverses Limestone Creek
- A 100 m stretch of Limestone Creek west (downstream) from the Bruce Highway.

A detail survey was conducted in July 2021 to confirm the exact location of individuals of *Eucalyptus raveretiana* in the Project Area previously recorded using a handheld GPS. Survey methods are detailed in the report titled Ecosure data of *Eucalyptus raveretiana* and Brigalow TEC (Ecosure, 2021b) (Appendix B).

2.2.4 Weed Species Surveys

Local, State and Commonwealth listed weed species were recorded as incidental sightings where located within or immediately adjacent to the Project Area. Weed species were also recorded as part of the RE surveys. The results are presented in the Flora and Wetlands Technical Report (AECOM, 2020f) (Appendix B).

2.2.5 Wetland Delineation and Connectivity Surveys

Wetland delineation was undertaken generally in accordance with the Queensland Wetland Definition and Delineation Guideline Part A and Part B (Queensland Government Department of Environment and Resource Management, 2011). Mapping of fauna habitat types relied upon the outcomes of the wetland delineation surveys. The results are presented in the Flora and Wetlands Technical Report (AECOM, 2020f) (Appendix B).

A wetlands assessment was undertaken to assess the characteristics of each wetland and their function within the overall Fitzroy River catchment through surface water and ground water monitoring and visual observations. Conceptual models of wetland connectivity and recharge were developed based on the modelled surface hydrology and analysed chemistry of the surface and groundwaters associated with each wetland potentially impacted by the Project. Survey methods are further detailed in the Wetland Impact Assessment Rockhampton Ring Road Project report (C&R Consulting, 2020) (Appendix B).

C&R Consulting (2020) presents an assessment of the environmental values, the function of the high ecological significance wetlands intersected by Project Footprint, and the potential impacts from the proposed development by:

- Undertaking a desktop review of all publicly available information on the wetlands associated with the site
- Detailing the background setting of the area including climate, soils, aquatic fauna and flora as well as outlining the environmental values associated with the wetlands
- Assessing the characteristics of each wetland and their function within the overall Fitzroy River catchment

- Developing conceptual models based on the modelled surface hydrology and analysed chemistry of the surface and groundwaters associated with each of the potentially impacted wetland
- Undertaking an impact assessment of the likely impacts associated with the proposed development.

2.2.6 Fauna Species Field Surveys

Three fauna field surveys have been completed as part of the Detailed Business Case assessment, including:

- Initial terrestrial ecological survey
- Targeted turtle survey and fish habitat assessment
- Additional terrestrial ecological survey (migratory birds).

Initial surveying was completed by two ecologists over two 5-day periods in February 2019. The first February survey (4 - 8 February) comprised the general fauna assessments and ornamental snake targeted surveying. This was followed by an additional 5-day survey (11 - 15 February) primarily focused on migratory birds.

The Project Area was subsequently revised following the Detailed Business Case phase, and additional areas not surveyed in February were surveyed over a single day in October 2019 by two ecologists. Survey methods are summarised below and further detailed in the Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d).

A subsequent targeted turtle habitat survey was completed in 2021 and included a comprehensive assessment of the Fitzroy River and Limestone Creek. The survey methods are summarised below and further detailed in the Technical Note – Turtle Habitat Survey (Ecosure, 2021a).

An additional two migratory bird surveys were undertaken during 2021 to supplement the two surveys completed during the Detailed Business Case phase, thereby achieving the requirement of a total of four surveys as specified in the Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of the Environment and Energy, 2017a). Survey methods are summarised below and further detailed in the Migratory Bird Survey Report (Jacobs SMEC Design Joint Venture, 2021a).

The location of the fauna surveys is shown in Figure 2-1.

2.2.7 Fauna Habitat Assessment Surveys

Habitat assessments were undertaken to characterise the fauna habitat values within the Project Area. These assessments provided an indication of likely fauna utilisation and suitability for fauna species, including conservation significant fauna. Habitat attributes recorded during the assessment include:

- Vegetation structure and dominant species, including a description of canopy, shrub and ground layer structure and composition
- Presence and abundance of tree hollows and stags
- Presence and abundance of woody debris such as habitat logs and ground timber
- Presence and abundance of koala food trees
- Presence and abundance of soil cracks and gilgai (i.e. a small lake formed from a depression in the soil surface in expanding clay soils that seasonally contains water. The term is also used to refer to the overall difference in elevation of the surface area, consisting of mounds and depressions, not just the lakes themselves)
- Rocky habitat such as surface rocks, boulders, crevices, overhangs and caves
- Proximity to water (both permanent and ephemeral (only flows for a brief period as a direct result of precipitation))
- Presence of habitat features necessary for shorebirds e.g. muddy margins, fringing vegetation, riparian vegetation
- Disturbance from invasive weeds/pests

- Other disturbances such as grazing pressure, clearing, thinning or fire
- Any other significant habitat features, or values present e.g. large nesting trees.

Included in the habitat assessments were searches for signs of animal activity, including tracks, scats, scratches, bones, fur, feathers, nests, foraging holes and diggings.

At all fauna habitat assessment locations, active searches, incidental observations and visual and auditory survey of birds (including for migratory birds where suitable conditions existed) were conducted.

The location of the habitat surveys is shown in Figure 2-1.

2.2.8 Active Searches and Incidental Observations

Active searches were undertaken for reptiles, amphibians, small mammals and cryptic or ground-dwelling bird species. Active searching was also undertaken for conservation significant fauna species identified as potentially occurring during the desktop assessment, including migratory shorebirds, koala, grey-headed flying-fox, ornamental snake and squatter pigeon.

This included scanning the trees and ground, searching beneath microhabitat (i.e. a habitat which is of small or limited extent and which differs in character from some surrounding more extensive habitat) such as rocks, fallen timber and peeling bark, digging through leaf litter and soil at tree bases and flushing birds from areas with a dense or grassy ground cover. Active searches were undertaken within suitable microhabitat at each habitat assessment site (i.e. across the broad range of habitat types throughout the Project Area).

All fauna observed incidentally within or in proximity to the Project Area were also recorded, including those seen while travelling along roads and tracks.

2.2.9 Microchiropteran Bat Call Detection Surveys

Microchiropteran bat echolocation calls were recorded using Anabat SD2 and Song Meter SM2 ultrasonic bat call detectors, configured to record microchiropteran species potentially occurring in the area including the threatened large-eared pied bat (*Chalinolobus dwyeri*), Corben’s long-eared bat (*Nyctophilus corbeni*) and ghost bat (*Macroderma gigas*). Call recording was conducted across the Project Area between dusk and dawn across the broad range of habitat types. Where possible, detection units were positioned in natural flyways, favourable for microchiropteran bat detection. Three units were deployed in six separate locations for a combined 23 recording nights.

2.2.10 Camera Traps

Camera traps were deployed in strategic positions to record visitation by nocturnal and diurnal animals. A variety of species were targeted, including feral ground-dwelling fauna such as foxes (*Vulpes vulpes*) and dogs (*Canis lupus*). Strategic locations included fauna corridors and watering points such as wetlands and creek lines. A honey-oat mix or chicken necks were used as an attractant, placed on the ground in front of camera traps. Four cameras were set at a total of six locations for a combined 24 camera trap nights.

2.2.11 Visual and Auditory Identification Surveys of Birds

Roaming/meandering bird surveys were undertaken using both visual and auditory identification. Surveys were conducted for the duration of each survey period at each habitat assessment site and during transit between sites. Hilltop vantage points were used to observe aerial hunters, feeders and scavengers. Overall, a total of 39.5 person hours of bird surveys were completed within the Project Area.

2.2.12 Spotlighting

In order to locate other nocturnal fauna such as the threatened koala (*Phascolarctos cinereus*), greater glider (*Petauroides volans*) and ornamental snake (*Denisonia maculata*), spotlighting on foot using head torches and hand-held spotlights was undertaken in areas of representative habitat for the species from habitat assessments.

Spotlighting for the koala and greater glider was predominately undertaken in riparian woodland habitat. For ornamental snake, spotlighting was undertaken in areas that contained an abundance of soil cracks, riparian zones, wetlands and in areas mapped as 'essential habitat' on the Queensland government's RE mapping (which does not necessarily indicate species presence, only suitable habitat).

A total of 36 person hours of spotlighting surveys were completed across five sites within the Project Area.

2.2.13 Targeted Turtle Survey

Field assessments were undertaken in June 2019 to determine presence of, and potential habitat for, the Fitzroy River turtle (*Rheodytes leukops*) within the Project Area (AECOM, 2020e). Methods employed during the assessment included:

- Detailed physical habitat assessments to determine potential nesting and foraging habitat
- Live capture and release trapping with a survey effort of 20 trap units (16 cathedral trap units and four crab pot units) within Pink Lily Lagoon, five cathedral traps units within Dunganweate Lagoons, and five cathedral trap units within Fitzroy River
- Active searches for turtle signs (active nests, tracks, broken eggshells)
- Opportunistic observations of turtles and predators.

The surveys could not be entirely undertaken in accordance with the Survey Guidelines for Australia's Threatened Reptiles: Survey Guidelines for Australia's Threatened Reptiles (Australian Government Department of sustainability, Enviornment, Water, Population and Communities, 2011) due to the potential presence of estuarine crocodile (*Crocodylus porosus*) presenting a safety hazard to survey work. The following capture methods were not utilised due to the risk of estuarine crocodile:

- Diving
- Hand capture in shallow waters or upon rocks
- Dip netting from the banks in water deeper than 1 m.

As the turtle surveys undertaken during the Detailed Business Case phase of the Project did not comprehensively survey the banks of the Fitzroy River and Limestone Creek, in December 2020 (Ecosure, 2021), a turtle habitat assessment was completed of both banks of the Fitzroy River and Limestone Creek (to the extent they are within the Project Area) for the following threatened turtle species:

- Fitzroy River turtle listed as vulnerable under both EPBC Act and NC Act
- White-throated snapping turtle (*Elseya albagula*) listed as critically endangered under the EPBC Act and the NC Act.

2.2.14 Targeted Migratory Shorebird Surveys

Habitat assessments completed in February 2019 during the general fauna survey allowed for required survey effort per wetland to be estimated beforehand; large wetlands or wetlands with greater ecological value had greater survey effort during the migratory shorebird surveys. All wetlands were identified to be non-tidal.

As prescribed in the EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of the Environment and Energy, 2017a) wetlands and watercourses mapped within and adjacent to the Project Area were targeted for migratory shorebird surveys to identify areas of potential important habitat. The survey coverage, survey timing and minimum data requirements relating to non-tidal areas, as defined in the Referral guideline for 14 birds listed as migratory species under the EPBC Act (Australian Government Department of Environment, 2015a), were considered when developing the survey methodology.

Additional wetland areas outside of the Project Area were also included in the surveys to ensure all of the habitat thought to be used by the same local population of migratory shorebirds and the entire area of contiguous habitat where shorebirds may occur was being adequately covered.

Consideration of habitat usage at both the local Project Area scale and broader regional scale is important for migratory bird species that frequent dynamic inland wetland areas as they are particularly responsive to changes in habitat conditions. A key defining feature of the National Migratory Shorebird Program (formerly Shorebirds 2020) run by BirdLife Australia is the notion of a 'Shorebird Area'. Following Clemens et al. (2010), a shorebird area is defined as: the geographic area that has been used by the same group of shorebirds over the main non-breeding period, which is effectively the home range of the local shorebird population when present. Shorebird areas may include multiple roosting and feeding habitats and while most migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of the same area where there is evidence of regular bird movement between them (Australian Government Department of the Environment, 2015a). Migratory shorebird areas therefore often extend beyond the boundaries of a property or project area and may also extend beyond Ramsar boundaries for internationally important areas (Australian Government Department of the Environment, 2015a).

Multiple survey techniques were employed to maximise detection of migratory shorebirds utilising habitat within the Project Area, and to assess the relative importance of habitat for these species within the Project Area.

The survey techniques included:

- **Point count surveys** – This technique involved recording the presence and abundance of each species detected at a series of specified locations. Sampling points were systematically pre-determined within the Survey Area and were scheduled for visits at different times throughout daylight hours. Spotting scopes were used to visually identify species from a distance, and record abundance, behaviours and species' richness. Time allocated at each point was a minimum of 20 minutes, however this was regularly significantly extended where it was considered to be necessary (i.e. when bird abundance and diversity was high). A total of 70 point count surveys were conducted as part of the March 2021 surveys.
- **Flushing transects** – This involved a group of observers walking parallel at 3-5 m spacing, across an area of suitable habitat. This technique was employed to target Latham's snipe as the species typically utilises fringing vegetation for cover and can be difficult to detect by point count surveys. A total of four flushing transects were completed at wetlands which supported fringing vegetation in which snipe were found to be seeking refuge. The majority of wetlands had notably low water levels which resulted in this methodology not being required.
- **Habitat assessment** – A total of 21 habitat assessments were undertaken to characterise the habitat values for migratory shorebirds within the Survey Area. Habitat attributes recorded during the habitat assessments include:
  - A description of the soil and the wetland features (i.e. wetted width, shape, depth)
  - Presence of habitat features necessary for shorebirds e.g. muddy margins, fringing vegetation, riparian vegetation
  - Presence and abundance waterbirds and shorebirds
  - Habitat suitability for wading shorebirds
  - Habitat suitability for Latham's snipe
  - Disturbance
  - Survey conditions
  - Any other significant habitat features or values present.

Four targeted migratory bird surveys were completed during the Austral (i.e. southern hemisphere) spring and summer season across three years as follows:

- Survey 1; 11 February 2019 to 15 February 2019 – Detailed Business Case Phase (Table 2-1)
- Survey 2; 16 March 2020 to 20 March 2020 – Detailed Business Case Phase (Table 2-2)
- Survey 3; 8 March 2021 to 11 March 2021 – Preliminary Design Phase (Table 2-3)
- Survey 4; 24 March 2021 to 26 March 2021 – Preliminary Design Phase (Table 2-3).

2.2.14.1 Survey Locations and Effort – 2019

The 2019 surveys were undertaken at various times during the day, including dawn and dusk. The survey timing followed the EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of the Environment and Energy, 2017a), occurring when the majority of migratory shorebirds are present in the area (Rockhampton's wet season). A spotting scope and binoculars were used to visually identify species from a distance, and observe abundance of individuals, behavior and species' richness. Table 2-1 details the 2019 migratory bird survey effort.

Table 2-1 Targeted 2019 migratory shorebird surveys

Site Name	Coordinates	Date and Time	Total Survey Effort (person hours)
Pink Lily Lagoon, including smaller lagoons east of Von Allmen Road	-23.344985, 150.476504 -23.340021, 150.484086 -23.343134, 150.485835	07/02/2019, 3pm to 4pm 07/02/2019, 6pm to 10pm 11/02/2019, 9am to 10am 11/02/2019, 4pm to 5pm 12/02/19, 1pm to 4pm 14/02/2019, 10am to 11:30am	23
Lotus Lagoon	-23.369691, 150.463480	04/02/2019,6pm to 10pm 05/02/2019, 8am to 10am 05/02/2019, 12:30pm to 1:30pm 06/02/2019, 4pm to 5pm 07/02/2019, 5pm to 6pm 14/02/2019, 8am to 10am	22
Dunganweate Lagoons, including smaller waterbody directly south and likely connected during flooding	-23.400136, 150.461978 -23.401566, 150.464829	08/02/2019 9am to 12pm 13/02/2019 6:30am to 8am	9
Nelson Lagoon	-23.403563, 150.469213	13/02/2019, 9am to 12pm	6
Murray Lagoon	-23.398403, 150.485484	04/02/2019, 10am to 2pm	8
Yeppen Lagoon	-23.407611, 150.493667	13/02/2019, 8am to 10am	4
Black Duck Lagoon	-23.360347, 150.479072	08/10/2019, 1pm to 3pm	4
Capricorn Highway Wetland	-23.411715, 150.476140	Fauna values at this location could not be assessed due to access limitations.	Effort is considered nil.
		TOTAL	**76**

2.2.14.2 Survey Location and Effort – 2020

Greater survey effort was undertaken at large wetlands or wetlands with greater ecological value as identified during previous surveys. All wetlands were identified to be non-tidal and as such the survey coverage, survey timing and minimum data requirements relating to non-tidal areas as defined in the significant impact guidelines (Australian Government Department of the Environment and Energy, 2017a) were considered when developing the methodology. Table 2-2 details the 2020 migratory bird survey effort.

Table 2-2 Targeted 2020 migratory shorebird surveys

Site Name	Coordinates	Date and Time	Total Survey Effort (person hours)
Pink Lily Lagoon, including smaller lagoons east of Von Allmen Road	-23.344985, 150.476504 -23.340021, 150.484086 -23.343134, 150.485835	16/03/2020: 12.30pm – 4.15pm 18/03/2020: 4.45pm – 5.45pm 19/03/2020: 7.30am – 9.30am	21
Lotus Lagoon	-23.369691, 150.463480	17/03/2020: 7.45am – 9.00am 17/03/2020: 7.45am – 9.30am 17/03/2020: 9.30am – 11.15am 17/03/2020: 1.30pm – 3.45pm 17/03/2020: 4.30pm – 5.00pm	15
Dunganweate Lagoons, including smaller waterbody directly south and likely connected during flooding	-23.400136, 150.461978 -23.401566, 150.464829	18/03/2020: 8:45am – 10:30am 19/03/2020: 3.30pm – 4.30pm	9
Nelson Lagoon	-23.403563, 150.469213	19/03/2020: 4.45pm – 5.15pm 20/03/2020: 7.30am – 9.30am	11
Murray Lagoon	-23.398403, 150.485484	Fauna values at this location could not be assessed.	Effort is considered nil.
Yeppen Lagoon	-23.407611, 150.493667	Fauna values at this location could not be assessed.	Effort is considered nil.
Black Duck Lagoon	-23.360347, 150.479072	Fauna values at this location could not be assessed.	Effort is considered nil.
Capricorn Highway Wetland	-23.411715, 150.476140	19/03/2020: 11.15am – 12.15pm 19/03/2020: 12.15pm – 12.30pm	2.5
		TOTAL	**76**

2.2.14.3 Survey Location and Effort – 2021

During the 2021 targeted migratory bird surveys, there was an increased survey effort undertaken at large wetlands or wetlands with greater ecological value for migratory birds as identified during the previous 2019 and 2020 surveys, as well as at additional wetlands beyond the boundaries of the Project Area. Given the results from previous surveys in 2019 and 2020 yielded a high abundance of Latham's snipe, this species was specifically targeted with additional techniques including the implementation of flushing transects through suitable wetland and wetland margin habitats.

The timing and effort of surveys at each wetland is described in Table 2-3. Each wetland was targeted at different times throughout the day where possible, including dawn and dusk to observe diurnal and crepuscular (twilight) habits, as well as avoiding the hottest part of the day when birds are least active, and visibility is poor.

Table 2-3 Targeted 2021 migratory shorebird surveys

Reference ID	Wetland Name	Coordinates	Survey Date	Survey Effort
1	Murray Lagoon	-23.3971, 150.4812 -23.3992, 150.4884 -23.3997, 150.4881	9/3/2021 11/3/2021 25/3/2021	7 point count surveys (each survey)
2	Crescent Lagoon	-23.3979, 150.4755 -23.3979, 1503.4755	9/3/2021 25/3/2021	5 point count surveys (each survey)
3	Lower Gracemere Lagoon	-23.3843, 150.4051 -23.3846, 150.4055	10/3/2021 25/3/2021	2 point count surveys (each survey)
4	Padygole Lagoon	-23.4326, 150.443	9/3/2021 10/3/2021 26/3/2021	2 point count surveys (each survey)
5	Little Lion Lagoon	-23.3591, 150.4172 -23.3665, 150.4209	10/3/2021 25/3/2021 10/3/2021 25/3/2021	4 flush transects (each survey) 16 point count surveys (each survey)
6	Dunganweate Lagoons	-23.3993, 150.4631	10/3/2021 25/3/2021	2 point count surveys (each survey)
7	Nelson Lagoon	-23.4034, 150.4718 -23.4036, 150.4704	10/3/2021 25/3/2021	2 point count surveys (each survey)
8	Dunganweate South Lagoon	-23.401, 150.4652	10/3/2021 25/3/2021	2 point count surveys (each survey)

Reference ID	Wetland Name	Coordinates	Survey Date	Survey Effort
9	Deadmans Lagoon	-23.3995, 150.4503 -23.4008, 150.451	10/3/2021 25/3/2021	2 point count surveys (each survey)
10	Yeppen Lagoon	-23.4063, 150.4923	9/3/2021 24/3/2021	2 point count surveys (each survey)
11	Capricorn Lagoon	-23.4127, 150.4735 -23.414, 150.478	9/3/2021 25/3/2021	2 point count surveys (each survey)
12	Woolwash Lagoon	-23.4387, 150.5337	9/3/2021 24/3/2021	2 point count surveys (each survey)
13	Fitzroy River South Bank	-23.3282, 150.885	9/3/2021 24/3/2021	6 point count surveys (each survey)
14	Sullivan Road Wetland	-23.4491, 150.4807	9/3/2021 26/3/2021	2 point count surveys
15	Pink Lily Lagoon	-23.3421, 150.4792 -23.3391, 150.4784	9/2/2021 24/3/2021	2 point count surveys (each survey)
16	Lotus Lagoon	-23.3667, 150.4610 -23.3686, 150.4605 -23.3700, 150.4604 -23.3718, 150.4592 -23.3730, 150.4589 -23.3625, 150.4742 -23.3644, 150.4742	10/3/2021 24/3/2021 25/3/2021	12 point count surveys (each survey)
17	Black Duck Lagoon	-23.3608, 150.4794 -23.3607, 150.4790	9/3/2021 24/3/2021	2 point count surveys (each survey)

2.2.15 Regulatory survey guidelines

Table 2-4 details the relevant regulatory survey guidelines, the regulatory survey guidelines requirements, the seasonal survey requirements and survey effort completed to date. A justification of the survey methods is also provided. The associated survey reports outlining further details of survey methods are provided in Appendix B.

Table 2-4 Survey guidelines and survey effort completed to date

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
EPBC Act referral guidelines for the vulnerable koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) (Australian Government Department of the Enviornment, 2014)	The EPBC Act referral guidelines for the koala Australian Capital Territory (Australian Government Department of the Enviornment, 2014) do not prescribe specific survey effort requirements. Survey effort is determined on a case by case basis. Recommended methods include: • Spotlighting with call playback • Remote camera • Spot Assessment Technique (Philips & Callaghan, 2011)- Sampling of a minimum of 30 koala food trees within suitable habitat.	Optimal time period for direct observation surveys is between August and January	February and October 2019: • 36 person hrs of spotlighting across 5 sites over 6 nights. • Targeted habitat assessments were conducted for the species throughout the duration of the field survey.	Surveys undertaken in accordance with Commonwealth survey guidelines. Not all recommended survey methods are required.	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d)
Draft referral guidelines for nationally listed Brigalow Belt reptiles (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011a): Ornamental snake (*Denisonia maculata*)	One off diurnal active searches of microhabitat for 1.5 hours in each hectare of suitable habitat. A minimum of 3 days with 1 repeat (6 days) • Spotlighting: - Targeting water-inundated gilgais, wetlands, riparian habitats and the surrounding environment (e.g. roads) and large logs between dusk and early morning hours	Late September to March	February 2019: • 36 person hrs of spotlighting across 5 sites over 6 nights. • Targeted habitat assessments were conducted for the species throughout the duration of the field survey.	Surveys undertaken in accordance with Commonwealth survey guidelines	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d)

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
(Australian Government Department of sustainability, Enviornment, Water, Population and Communities, 2011) Survey guidelines for Australia's threatened reptiles (Australian Government Department of Sustainability , Environment, Water, Population and Communities, 2011b): Ornamental snake (*Denisonia maculata*)	- 1.5 hours in each hectare of suitable habitat. - A minimum of 3 nights with 1 repeat. • Opportunistic surveys of roads.				

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
Survey guidelines for Australia's threatened reptiles: Fitzroy River turtle and white-throated snapping turtle (Australian Government Department of Sustainability , Environment, Water, Population and Communities, 2011b)	No prescribed effort, however recommended survey techniques for Fitzroy River turtle are: • Snorkelling is most effective, however not recommended where a risk of estuarine crocodile encounter is possible (which is possible in the Fitzroy River and Limestone Creek). • Meat-baited traps should be trialled Although white-throated snapping turtle is not explicitly included in the guideline, recommended techniques typically applied to the detection of freshwater turtles are: • Snorkelling, or • Baited trapping	N/A	June 2019: Survey effort at three sites: • 26 cathedral trap units and 4 crab pot units. • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. December 2020 Habitat assessment of the banks of the Fitzroy River and Limestone Creek to confirm suitability of the banks and waterways for threatened turtle species.	Surveys undertaken in accordance with Commonwealth survey guidelines; however, snorkelling was not progressed due to risks associated with estuarine crocodiles. Survey is considered appropriate given the limitations.	Threatened Turtle and Fish Habitat Assessment Rockhampton Ring Road - Business Case (AECOM, 2020e) Technical Note – Turtle Habitat Survey (Ecosure, 2021a)

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
Survey guidelines for Australia's threatened birds: Squatter pigeon (*Geophaps scripta scripta*) (Australian Government Department of the Enviornment, Water, Heritage and the Arts, 2010)	Road driving during day (driving transects). • Active searches: - 15 hours over 3 days in areas <50 ha. • Flushing surveys: - 10 hours over 3 days in areas <50 ha. • Waterhole searches - Survey effort not specified.	N/A	February and October 2019: • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. <50Ha of suitable habitat within Project Area • 39.5 person hours of bird survey. March 2021: Opportunistic observations during migratory bird surveys	Surveys undertaken in accordance with Commonwealth survey guidelines	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d)
Survey guidelines for Australia's threatened bats (Australian Government Department of the Enviornment, Water, Heritage and the Arts, 2010a): Grey headed flying-fox	Suggested approach is to search appropriate databases and other sources for the locations of camps, and to conduct vegetation surveys to identify feeding habitat.	NA	February 2019: • Microchiropteran bat call detection – three units deployed in six locations for a combined 23 recording nights • Desktop review of databases to identify camps October 2019 • Vegetation survey	Surveys undertaken in accordance with Commonwealth survey guidelines	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d)

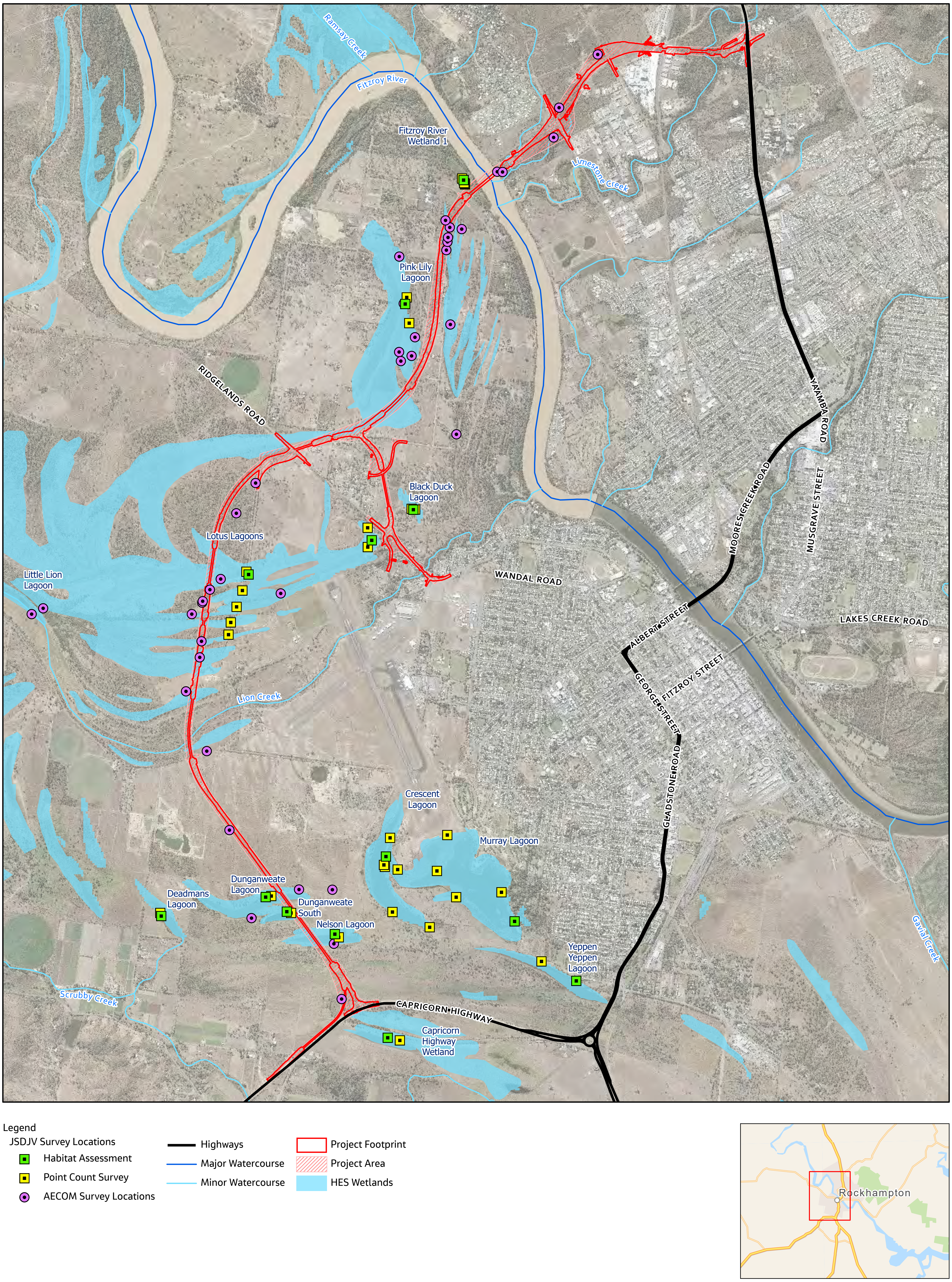
Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
Survey guidelines for Australia's threatened birds (Australian Government Department of the Enviornment, Water, Heritage and the Arts, 2010): Australian painted snipe (*Rostratula australis*)	At suitable wetlands: • Targeted stationary observations: - 10 hours over 5 days • Land-based area searches or line transects - 10 hours over 3 days	NA	February 2019: • Targeted stationary observations: 38 person hours over 10 days • Land-based area searches: 16 person hours • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. March 2021: Opportunistic observations during migratory bird surveys	Surveys undertaken in accordance with Commonwealth survey guidelines	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d) Migratory Bird Survey Report (Jacobs SMEC Design Joint Venture, 2021a)
There are no Commonwealth species-specific guidelines available for: Glossy ibis (*Plegadis falcinellus*) Australasian bittern (*Botaurus poiciloptilus*)	Six, 5 – 10 minute area searches within a 100m x 100m survey site	Spring and summer	February 2019: • Opportunistic surveys. • Targeted stationary observations: 76 person hours over 10 days • Targeted habitat assessments were conducted for the species throughout the duration of the field survey.	Surveys are considered adequate to detect the species.	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d) Migratory Bird Survey Report (Jacobs SMEC Design Joint Venture, 2021a)

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
In the absence of specific guidelines, the Terrestrial Vertebrate Fauna Survey Guidelines for Queensland (Eyre, T J; Ferguson, D J; Smith, G C; Mathieson, M T; Kelly, A L; Venz, M F; Hogan, D L; Rowland, J;, 2018) was adopted for diurnal bird species.			March 2020: • Targeted stationary observations: 58.5 person hours over 5 days • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. March 2021 (two surveys): Opportunistic observations during migratory bird surveys		
Draft referral guideline for 14 migratory birds listed under the EPBC Act (Australian Government Department of Environment, 2015a): • White-throated needletail • Eastern osprey	White-throated needletail does not have any survey guideline requirement due to their transitory and predominantly aerial nature. Ospreys should be surveyed using one or more of the following techniques: • Observations from vantage points to detect birds in flight over suitable habitat • Area searches on foot to detect birds or signs of occupancy in suitable habitat • Transect surveys from vehicles to detect birds or nests in large survey areas	N/A	February 2019: • Opportunistic surveys and targeted wetland migratory bird survey. • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. March 2020:	Surveys for eastern osprey undertaken in accordance with Commonwealth survey guidelines Surveys for white-throated needletail are considered adequate to detect the species.	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d) Migratory Bird Survey Report (Jacobs SMEC Design Joint Venture, 2021a)

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
	• Transect surveys from boats along suitable coastal or riparian habitat • Aerial surveys to detect birds or nests in large survey areas.		Opportunistic observations during migratory bird surveys March 2021 (two surveys): Opportunistic observations during migratory bird surveys		
Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of the Environment and Energy, 2017a): • Latham's snipe • Black-tailed godwit • Bar-tailed godwit (considered to include sub-species) • Marsh sandpiper • Common greenshank • Wood sandpiper	Bird survey by 2 people taking counts: - 1 x survey in December - 2 x survey in January - 1 x survey in February	Summer, and when water is present	February 2019: • Targeted stationary observations: 76 person hours over 10 days • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. March 2020: • Targeted stationary observations: 58.5 person hours over 5 days • Targeted habitat assessments were conducted for the species throughout the duration of the field survey. March 2021:	Surveys were undertaken in accordance with Commonwealth survey guidelines; however did not meet the monthly distribution of effort stipulated in the Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species as there was a late wet season in 2018/2019, so the Detailed Business Case surveys were postponed until February 2019.	Terrestrial Fauna and Migratory Birds Technical Report Rockhampton Ring Road report (AECOM, 2020d) Migratory Bird Survey Report (Jacobs SMEC Design Joint Venture, 2021a)

Relevant regulatory survey guideline	Regulatory survey guideline requirement	Seasonal survey requirement	Survey effort completed to date	Justification of Survey Methods	Survey Report
• Common sandpiper • Pectoral sandpiper • Sharp-tailed sandpiper • Curlew sandpiper • Red-necked Stint			• Targeted stationary point count observations: 224 person hours over 8 days • Targeted flush transects for Latham's snipe • Targeted habitat assessments were conducted for the species throughout the duration of the field survey.	In 2020/2021, there was a late wet season, so the March 2021 surveys were deemed consistent with the guideline requirements.	
There are no Commonwealth species-specific flora survey guidelines, including for *Eucalyptus raveretiana* or other Commonwealth listed flora species or Threatened Ecological Communities.	As there are no Commonwealth survey guidelines, the population survey was undertaken in general accordance with the Queensland Flora Survey Guidelines (2020).	Nil – *Eucalyptus raveretiana* can be identified any time of year.	December 2020. 6 hours x two suitably qualified professionals within the previously identified suitable habitat.	Surveys were undertaken in general accordance with the Queensland government's Flora Survey Guidelines (2020).	Flora and Wetlands Technical Report Rockhampton Ring Road – Business Case (AECOM, 2020f) Technical Note – *Eucalyptus raveretiana* Population Survey (Jacobs SMEC Design Joint Venture, 2021f)

Figure 2-1: Fauna Habitat Assessment Locations



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: Wetlands (2020); SMEC/AECOM: Survey Locations (2021); Metromap: Imagery (2020)

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2.3 Habitat for MNES

2.3.1 Habitat Type Mapping

Mapping of habitat types for MNES within the Project Area was based on field surveys of REs, TECs, flora, wetlands, fauna and fauna habitat, as outlined in Section 2.2. This mapping is referred to as 'field-verified habitat' for the particular MNES. In some instances, REs or wetlands have been mapped in the Project Area by the Queensland Department of Environment and Science but were not field-verified as habitat for particular MNES during the field surveys (e.g. lacustrine or palustrine wetlands as habitat for migratory shorebirds), or have been field-verified as a different habitat (e.g. vegetation mapped as non-remnant by the RE mapping but field-verified as black ironbox high value regrowth).

Potential habitat for MNES, adjacent to and upstream and downstream of the Project Area, has also been mapped based on Queensland Department of Environment and Science RE and wetland mapping. This broader habitat mapping is intended to represent potential habitat for MNES but has not been field-verified as part of the Project.

The REs included in each habitat type are provided in Section 3.5.1 (Table 3.9). Habitat for each MNES is mapped in the Project Area (i.e. field-verified habitat) together with potential habitat for each of the MNES in the broader area (i.e. RE and wetland mapping by the Department of Environment and Science) in Section 6.

The area of habitat to be impacted in the Project Area has been compared to the area of potential habitat in the broader area.

Nesting habitat has also been mapped for those species that have defined nesting habitat in the Project Area or broader area (e.g. estuarine crocodile and squatter pigeon).

2.3.2 Condition of Habitat

Where the habitat is recorded in the Project Area, condition has been described including information on weed cover.

Condition of terrestrial habitat has been based on the *Guide to determining terrestrial habitat quality Methods for assessing habitat quality under the Queensland Environmental Offsets Policy* (Queensland Government Department of Environment and Science, 2020b) and where possible described using the following 'site-based' scale attributes:

- Number of large native trees
- Tree canopy height
- Recruitment of woody perennial species (in the ecologically dominant layer)
- Tree canopy cover
- Native shrub layer cover
- Coarse woody debris
- Native plant species richness for trees, shrubs, grasses, and forbs/others
- Non-native plant cover
- Native perennial grass cover
- Organic litter cover (Queensland Government Department of Environment and Science, 2020b).

In the absence of condition assessment guidelines for aquatic habitats, where possible condition descriptions for aquatic habitats have been based on:

- Substrate type
- Water quantity (presence) and quality

- Physical habitat such as woody debris, undercut banks, overhanging vegetation, exposed roots, and rocky substrates
- Aquatic macrophytes (i.e. an aquatic plant large enough to be seen by the naked eye)
- Fringing or riparian vegetation including tree canopy cover, native shrub layer cover
- Native plant species richness
- Non-native plant cover.

The overall condition of each habitat for MNES has been described as poor, moderate or good based on the description using the above attributes (Table 6-2).

2.4 Impact Assessment

An impact assessment has been undertaken in accordance with the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (Australian Government Department of the Environment, 2013), including:

- Direct impacts
- Indirect (facilitated and downstream) impacts
- Risk assessment
- Cumulative impacts
- Significant impact assessment.

2.4.1 Indirect Impacts

Indirect impacts include facilitated and downstream impacts and are relevant where they are sufficiently close to the Project to be considered a consequence of the Project. The following questions have been used to guide the assessment of indirect impacts (Australian Government Department of the Environment, 2013):

- Would the (indirect) impact have occurred if it was not for the Project?
- Is the Project a 'material and substantial' cause of the indirect impacts?
- Are the potential impacts of any subsequent or third party actions known, or would they be expected to be known, by the person proposing to take the action?

Facilitated impacts are those which result from further actions which are made possible or facilitated by the action. For example, the construction of basic infrastructure in a previously undeveloped area may, in certain circumstances, facilitate the urban or commercial development of that area, or damage to vegetation during the construction phase by workers and vehicles (Australian Government Department of the Environment, 2013).

Downstream impacts take place downstream of the Project and include impacts such as those to wetlands or marine waters from sediment, fertilisers or chemicals which are washed or discharged into river systems (Australian Government Department of the Environment, 2013).

2.4.2 Risk Assessment

A risk assessment has been undertaken to identify the potential impacts to MNES as a result of the Project. The assessment is provided to assess the effectiveness of the proposed mitigation and management measures.

The method has adopted the general principles outlined in Australian Standard ISO 31000:2018 Risk Management Guidelines (Standards Australia, 2018), AS/NZS IEC 31010:2020 Risk management - Risk assessment techniques (Standards Australia, 2020) and the risk assessment framework outlined in the EPBC Act Environmental Management Plan Guidelines (Australian Government Department of Environment, 2014c).

The risk assessment involves the following key steps:

- Establish the context for the risk assessment

- Identify environmental risks to MNES
- Analyse risks without mitigation and management measures in place
- Analyse risks with mitigation and management measures in place
- Evaluate risks to determine if the level of residual risk is acceptable.

Individual ratings are assigned to the likelihood and consequence of each impact. The ratings of these two factors together determines the final risk rating as low, medium, high or severe (Table 2-5).

Criteria for the likelihood of impact occurrence:

- Highly likely (5) – Is expected to occur in most circumstances
- Likely (4) – Will probably occur during the life of the Project
- Possible (3) – Might occur during the life of the Project
- Unlikely (2) – Could occur but considered unlikely or doubtful
- Rare (1) – May occur in exceptional circumstances.

Criteria for the consequence of the impact:

- Minor (1) – Minor incident of environmental damage that can be reversed
- Moderate (2) – Isolated but substantial instances of environmental damage that could be reversed with intensive efforts
- High (3) – Substantial instances of environmental damage that could be reversed with intensive efforts
- Major (4) – Major loss of environmental amenity and real danger of continuing
- Critical (5) – Severe widespread loss of environmental amenity and irrecoverable environmental damage.

2.4.3 Cumulative Impacts

The cumulative impact assessment considered cumulative impacts to MNES associated with:

- The potential for impacts of other projects to compound with the Rockhampton Ring Road Project
- The potential for multiple impacts associated with the Rockhampton Ring Road Project to compound with respect to a single MNES.

For other projects, residual impacts to MNES have been assessed in conjunction with potential impacts to the same MNES for the Rockhampton Ring Road project. For the Rockhampton Ring Road project, the assessment has been informed by the risk assessment, i.e. impacts deemed to have a moderate or high residual risk have been assessed to determine if other potential impacts could be accumulating.

Other projects were identified based on review of the Queensland Government Coordinator-General coordinated project list, the EPBC Act major projects and data from the Queensland Department of Transport and Main Roads planners. Projects were assessed for the potential for cumulative impacts where any one part of the project was located within approximately 50 km of the Rockhampton Ring Road Project and/or the timing of works would overlap.

2.4.4 Significant Impact Assessment

The EPBC Act ensures that nationally significant flora, fauna and habitats are identified, and any potential negative impacts on them are carefully considered before changes in land use or new developments are approved by assessing:

- The environmental context, for example, the sensitivity, value, quality and size of the environment, the site's connectivity to other habitats in the broader landscape and its importance in the conservation of the environment
- The nature of the potential impacts that are likely to result from the Project

- Mitigation measures to avoid or reduce potential impacts.

A significant impact assessment has been undertaken in accordance with the Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (Australian Government Department of the Environment, 2013). Potential impacts associated with construction and operation have been considered together in the assessment.

Table 2-5 Risk Matrix

	Consequence				
Likelihood	**Minor (1)**	**Moderate (2)**	**High (3)**	**Major (4)**	**Critical (5)**
Highly Likely (5)	Medium (5)	High (10)	High (15)	**Severe** (20)	**Severe** (25)
Likely (4)	**Low** **(4)**	Medium (8)	High (12)	High (16)	**Severe** (20)
Possible (3)	**Low** **(3)**	Medium (6)	Medium (9)	High (12)	**Severe** (15)
Unlikely (2)	**Low** **(2)**	**Low** **(4)**	Medium (6)	High (8)	High (10)
Rare (1)	**Low** **(1)**	**Low** **(2)**	**Low** **(3)**	Medium (4)	High (5)

3. Existing Environment

3.1 Climate

The climate of the Rockhampton region is subtropical with the seasons classified as warm and wet summers and or dry winters. The annual mean maximum and minimum temperatures are 28.5°C and 16.8°C, respectively (Australian Government Bureau of Meteorology, 2021). Mean monthly maximum temperature ranges from 23.2°C in July to 32.2°C in December, while the mean monthly minimum temperatures range from 22.2°C in January and February to 9.7°C in July (Australian Government Bureau of Meteorology, 2021).

Rainfall patterns are dominated by intense rainfall events throughout the summer months of each year. Rockhampton lies within the cyclone risk zone and the area is subject to summer thunderstorms. Rainfall events are often highly variable in their spatial and temporal distribution, with much of the rain falling in distinct, spatially separated cells across the landscape. Mean annual rainfall for the region is 815.1 mm, based on nearly 80 years of data (Bureau of Meteorology weather station #039083) (Australian Government Bureau of Meteorology, 2021).

Generally, the majority of the rainfall is experienced in the summer months (wet season), with relatively little rainfall experienced throughout the winter months (dry season); with the exception of an occasional storm (Figure 3-1). Approximately 26% of the yearly total falls between May and October (inclusive) (Australian Government Bureau of Meteorology, 2021). Evaporation tends to exceed rainfall for most days of the year, except for intense rainfall events. The extended dry season causes baking and crusting of surface soils, greatly reducing infiltration unless suitable pre-wetting has been provided by gentle rain prior to the wet season. If gentle pre-wetting rains have not occurred prior to the onset of the wet season, >90% of the initial rainfall event can eventuate as runoff throughout catchments, draining to waterways. This increased runoff has the potential to increase the volume of sediments delivered to waterways and subsequently results in high sediment movement along watercourses.

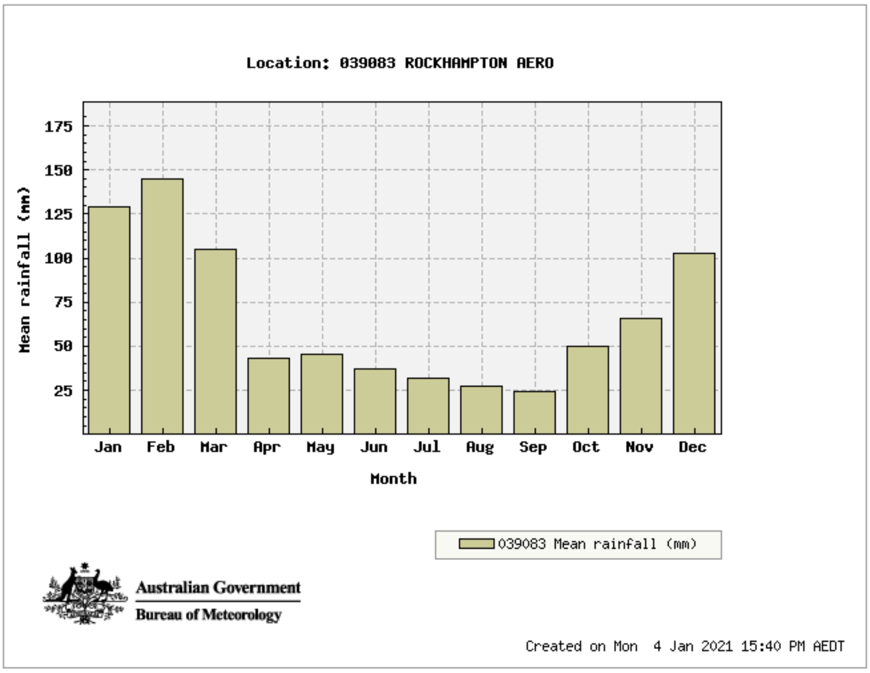


Figure 3-1 Mean rainfall (mm) for years 1939 to 2020 recorded at Rockhampton Aero weather station (039083) (Australian Government Bureau of Meteorology, 2021)

3.2 Water and Flooding

3.2.1 Waterways

The Project is located within the Lower Fitzroy catchment, in central Queensland and is part of the larger Fitzroy Basin. The Fitzroy River is fed by the Dawson, Comet, Nogoa, Isaac and Mackenzie rivers. The Mackenzie and Dawson rivers from the north and south respectively, join to form the Fitzroy River near Duaringa. The Fitzroy River then flows east through Rockhampton into the Great Barrier Reef Marine Park near Curtis Island (Queensland Government Department of Environment and Science, 2021f)

The Fitzroy River, which flows through the city of Rockhampton, drains a catchment of approximately 14.2 million ha and is one of the largest catchments on the east coast of Australia. The catchment extends from the Carnarvon Gorge National Park in the west to Rockhampton. Due to its immense size and fan-like shape, the Fitzroy River catchment can produce severe flooding following heavy rainfall events. Its major tributaries, the Dawson, Mackenzie and Connors Rivers rise in the eastern coastal ranges and in the Great Dividing Range and join together about 100 km west of Rockhampton. Major floods can result from either the Dawson or the Connors-Mackenzie Rivers. Significant flooding in the Rockhampton area can also occur from heavy rain in the local area below Riverslea.

The Project Area is located within the Fitzroy Basin Water Plan Area and the Fitzroy River Sub-basin. The Environmental Protection (Water and Wetland Biodiversity) Policy 2019 identifies the water quality objectives for the area as the Environmental Protection (Water) Policy 2009 Fitzroy River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Fitzroy River Sub-basin (Queensland Government Department of Environment and Heritage Protection, 2011)

The Project falls within the Fitzroy South / Central Tributaries sub-catchment as mapped in WQ1035 -Fitzroy River Sub-basin Environmental Values and Water quality objectives (Queensland Government Department of Environment and Heritage Protection, 2011). The alignment crosses areas mapped as moderately disturbed Fitzroy River Sub-basin fresh waters as well as high ecological value (HEV) palustrine wetlands (mapping unit HEVa2085).

Palustrine wetlands are defined as heavily vegetated, non-riverine or non-channel systems that are generally less than 8 ha in overall size. They can include billabongs, swamps, bogs, springs, soaks and marshes and typically have more than 30% emergent vegetation (Queensland Government Department of Environment and Science, Queensland, 2021b).

The Project Area intersects the following surface features (from north to south) under the *Water Act 2000* (Figure 3-2):

- Limestone Creek (watercourse)
- Unnamed watercourse (drainage feature)
- Unnamed watercourse (drainage feature)
- The Fitzroy River (watercourse)
- Lion Creek (watercourse).

3.2.2 Wetlands

The Project intersects the Fitzroy River Floodplain for most of its length, from approximately the Capricorn Highway to the eastern banks of the Fitzroy River. The Fitzroy River Floodplain comprises the Fitzroy River and associated floodplain wetlands to the north, west and immediate south of Rockhampton. The Fitzroy River Floodplain includes 81 identified water bodies. There are permanent, seasonal and intermittent oxbows, waterholes and swamps, as well as the Fitzroy River channel and its backwaters.

The Queensland Department of Environment and Science has identified Wetland Protection Areas containing wetlands of high ecological significance (HES). A large portion of the Project from approximately the Capricorn Highway to the western banks of the Fitzroy River occurs within the boundaries of the Wetland Protection Areas and identified trigger areas (Figure 3-2). Wetland Protection Areas are identified to manage and improve the quality of water entering the Great Barrier Reef.

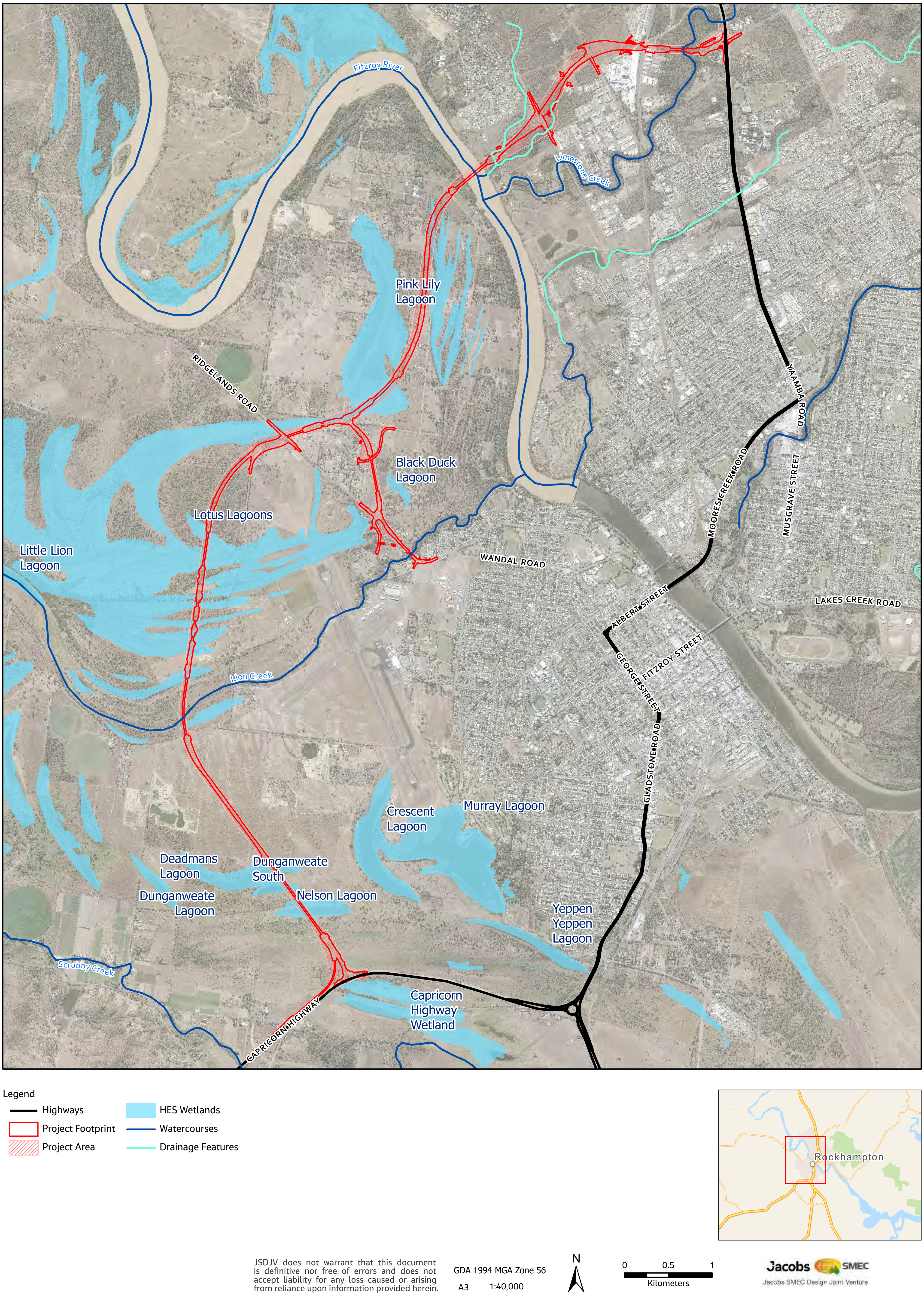
The Project Footprint intersects the following wetlands of high ecological significance:

- Dunganweate Lagoon
- Nelson Lagoon
- Lotus Lagoon
- Pink Lily Lagoon

The Project Area is adjacent to the following wetlands of high ecological significance:

- Capricorn Highway Lagoon.
- Crescent Lagoon
- Murray Lagoon
- Black Duck Lagoon.

Figure 3-2: Waterways and wetlands within and adjacent to the Project Area



Rockhampton Ring Road

Source: Queensland Department of Resources: Wetlands (2020); Metromap: Imagery (2020)

\\AUSYD0VS01\GISWork\QLD_IW243700_Rockhampton_Ring_Road\Spatial\ArcGIS\Figures\RRR_Preliminary_Documentation_Response\RRR_Preliminary_Documentation_Response.aprx Produced: 11/11/2021 Author: MITCHEDR

3.2.3 Surface Water Quality

There is no publicly available surface water monitoring data for the Project Area.

An AECOM field survey (for the purpose of the Threatened Turtle and Fish Habitat Assessment) in June 2019 recorded a range of physio-chemical parameters within the Project Area's waterways, wetlands and lagoons. These included temperature (in degree Celsius), electrical conductivity (in micro Siemens per centimetre (µS/cm)), dissolved oxygen (in mg/L and % saturation), pH and turbidity (in nephelometric turbidity units (NTU)).

During the C&R field assessment in September 2019, an additional round of sampling within the waterways was opportunistically undertaken. Where possible, the second round of sampling was undertaken at the same locations as the initial sampling round, however due to the lack of water / access, some sample locations differed. The physio-chemical parameters recorded included the following parameters:

- pH Value
- Sodium Adsorption Ratio
- Electrical Conductivity (µS/cm)
- Total Dissolved Solids (mg/L)
- Suspended Solids (mg/L)
- Turbidity (NTU)
- Total Hardness (mg/L)
- Total Alkalinity (mg/L)
- Sulphate (mg/L)
- Chloride (mg/L)
- Calcium (mg/L)
- Magnesium (mg/L)
- Sodium (mg/L)
- Potassium (mg/L)
- Fluoride (mg/L)
- Reactive Silica (mg/L)
- Nutrients (mg/L)
- Carbon (mg/L); and
- 17 Metals/Metalloids (mg/L).

A summary of the surface water quality results is provided below.

Results summary in June 2019 (AECOM, 2020e)

- All lagoons showed elevated electrical conductivity values with respect to the water quality objective (445 µS/cm during baseflow or 250 µS/cm during high flow).
- The tributary of the Fitzroy River recorded 3122 µS/cm and Limestone Creek recorded 2855 µS/cm. The Fitzroy River is generally relatively saline, influenced by catchment geology, low flow periods (where conductivity would be higher) and if the system receives saline groundwater inputs.
- The tributary of the Fitzroy River (55.5% saturation) and Limestone Creek (37.6% saturation) also both recorded the lowest dissolved oxygen % saturation readings which significantly exceeded the trigger range of 85 – 110% saturation.

- Other recorded exceedances were only slightly outside of trigger values with the exception of the turbidity (173.3 NTU) in the Fitzroy River being significantly beyond the water quality objective (50 NTU) for moderately disturbed Fitzroy River Sub-basin fresh waters. Rivers of this magnitude experience highly variable turbidity values dependent on degree of catchment modification and seasonal rainfall runoff. Approximately 160 mm had fallen within the six-week period prior to the survey.
- This would have increased flow in the local watercourses, elevating turbidity values from resuspension of sediment. Most rivers within central and northern Queensland experience exceedances of similar turbidity. These recordings are not of concern for the Fitzroy River.
- Turbidity values for Pink Lily Lagoon (19-100 NTU) are elevated with respect to the water quality objective (50 NTU).

Results summary in September 2019 (C&R Consulting, 2020)

- The September results were relatively consistent with the June results.
- All samples (except for the Fitzroy River) were taken from ponded areas, with no continuous flow.
- Limestone Creek (2283 µS/cm) and Neerkol Creek (2641 µS/cm) both recorded elevated electrical conductivity readings with respect to the water quality objective.
- Lion Creek (58.3 % saturation), Limestone Creek (50.4 % saturation) and Neerkol Creek (75.9 % saturation) all recorded low dissolved oxygen readings, whilst Scrubby Creek recorded a high dissolved oxygen reading (139.9 % saturation), all exceeding the water quality objective trigger range of 85 – 110 % saturation.
- Scrubby Creek also recorded a slightly elevated pH reading (8.54 pH). The Fitzroy River recorded elevated turbidity (75.86 NTU-field, 80.4 NTU-lab).
- Pink Lily, Nelson and Dunganweate Lagoons exceeded the guideline value for electrical conductivity in Fitzroy River Sub-basin fresh waters (445 µS/cm). Given the time of year samples were collected (late dry season), elevated electrical conductivity can be expected in these wetland systems where salts are concentrated over the extended dry season.
- Guideline values for pH were exceeded at Pink Lily and Dunganweate Lagoons.
- Suspended solids and turbidity guidelines were exceeded at both Pink Lily and Lotus Lagoons.
- Sulphate levels, elevated above guidelines, were also observed in Nelson and Dunganweate Lagoons.
- Dissolved aluminium exceeded the guidelines for 99% species protection in Black Duck Lagoon and Lotus Lagoon.
- Dissolved arsenic and boron exceeded the guidelines for 99% species protection in Pink Lily Lagoon, Black Duck Lagoon, Lotus Lagoon and Nelson Lagoon.
- Dissolved copper exceeded the guidelines for 99% species protection in Pink Lily Lagoon, Lotus Lagoon and Nelson Lagoon.
- Dissolved nickel exceeded the guidelines for 99% species protection in Pink Lily Lagoon and Lotus Lagoon.
- Nutrients of nitrogen and phosphorus were found to be elevated above guidelines, with ammonia, total organic nitrogen, total nitrogen, and total phosphorus exceeded at all Lagoons.

Further analysis of water quality is provided in the Threatened turtle and fish habitat assessment (AECOM 2019) and Wetland Impact Assessment Rockhampton Ring Road Project (C&R Consulting 2019) (Appendix B).

3.2.4 Groundwater Quality

There are numerous existing groundwater bores located within the vicinity of the Project, 16 of which intercept the Project Area. The Environment Protection Policy Fitzroy River Sub-basin Environmental Values and Water Quality Objectives (Queensland Government Department of Environment and Heritage Protection, 2011) outline 44 Groundwater Zones within the Fitzroy River basin, with defined water quality objectives for shallow (<30 m) and deep (>30 m) aquifers.

In September 2019, C&R Consulting (2020) undertook groundwater quality sampling within the vicinity of the Project Area to inform the Wetland Impact Assessment. The 12 bores monitored for the investigation are divided between two Groundwater Zones (Zone 14 and Zone 22).

The parameters tested during the groundwater quality sampling included:

- pH Value
- Sodium Adsorption Ratio
- Electrical Conductivity (µS/cm)
- Total Dissolved Solids (mg/L)
- Total Hardness (mg/L)
- Total Alkalinity (mg/L)
- Sulphate (mg/L)
- Chloride (mg/L)
- Calcium (mg/L)
- Magnesium (mg/L)
- Sodium (mg/L)
- Potassium (mg/L)
- Fluoride (mg/L)
- Reactive Silica (mg/L)
- Nutrients (mg/L)
- Carbon (mg/L); and
- 17 Metals/Metalloids (mg/L).

The results were compared against the water quality objectives for the 80th percentile of their respective Groundwater Zones. The results show the salt content for most of the bores exceeded the guideline values, particularly calcium, magnesium, sodium, sulphate and chloride ions. Given the time of year samples were collected (late dry season), increased salt levels can be expected as concentrations increase with decreasing water levels.

Manganese and iron also exceeded guideline values in most of the bores. One bore reported copper levels (0.063 mg/L) in exceedance of guideline values (0.05 mg/L). Further monitoring is required to determine natural seasonal variability in groundwater quality.

3.2.5 Wetland Hydrology

Lion, Scrubby and Neerkol Creek catchments are characterised by steep, rapid response upper catchments and broad, gently graded lower catchments with numerous wetlands where the lower catchment has limited channel definition and serves as a sediment deposition zone. These creeks also share the lower catchment with Fitzroy River break out flows.

The majority of the wetlands are mapped as palustrine, although Pink Lily Lagoon and Murray Lagoon also incorporate some lacustrine areas. Lacustrine wetlands or lakes may have fringing vegetation, although the majority of the wetland area is open water. Natural lacustrine systems are generally over 8 ha in size and have deep, standing or slow-moving water (Queensland Government Department of Environment and Heritage Protection, 2011).

Wetlands comprise both permanent, semi-permanent and ephemeral systems, all with signs of disturbance. The wetlands in the Project Area are part of the Fitzroy River floodplain, and during major flood events they have the potential to be connected to the Fitzroy River and tributaries (e.g. Neerkol, Scrubby and Lion creeks), and estuarine waters. The Fitzroy River breaks out at Pink Lily meander between the 20% annual exceedance probability (AEP) and 10% AEP flood events. For smaller flood events, it is the local catchments of Neerkol, Scrubby and Lion Creeks that activate the wetlands.

All six wetlands have associated alluvial aquifers (i.e. an aquifer formed by material laid down by physical processes in a river channel or on a floodplain). Based on water quality results, the wetlands are sustained by surface flows and surface related flows infiltrating into the shallow subsurface zones of the alluvial sediments (i.e. sediments composed of gravel, sand, silt or clay deposited in recent geological time by flowing water in river channels, floodplains, deltas, etc.) (C&R Consulting, 2020). After periods of surface flow, zones of shallow floodplain aquifers (<5 m below the ground level) become saturated with the open waterbodies becoming the surface expression of this shallow alluvial groundwater. The wetlands are sustained by base shallow groundwater (<5 m) which combines with the more direct overland sources to form the wetlands; including:

- Direct rainwater
- Surface flows/runoff where rainwater has reacted with surficial soil/sediment crust which forms after periods of desiccation (i.e. dry periods)
- Water resulting from infiltration of surface waters and rainfall into the predominantly clay rich sediments, with isolated sand bodies of the floodplain. These waters react with the sediments mainly involving a sodium/potassium exchange able to move in either direction dependent on local lithologies (i.e. physical characteristics of a rock/rocks in an area). The reaction of these waters with the constituent sediments also results in the incorporation of some metals and nutrients into the waters.

Water chemistry results were interpreted to help develop draft conceptual models of wetland function, including an understanding of the nature of the flows required across the floodplain to allow the wetlands to continue to function (C&R Consulting, 2020). The chemical composition of the wetlands largely differed to that of the sampled groundwater systems. However, the sampling was undertaken during the dry season when the standing water levels of alluvial groundwaters had greatly reduced (to >5m below ground level). A second sampling event will be undertaken following rainfall in late 2021 to refine the draft conceptual model.

Further analysis of the water chemistry grouped the wetlands into northern (Pink Lily Lagoon), southern (Dunganweate, Nelson and Capricorn Highway Lagoons) and central (Lotus and Black Duck Lagoons). Metal and nutrient loads in the north and south were likely attributed to the flows through the shallow subsurface (alluvial) sediments (<5 m below ground level), combined with runoff from surficial soils in the immediate catchment area surrounding each wetland. Central wetlands appear to receive input from a separate deeper groundwater system that possibly has origins in the upper catchment area of Lion Creek (C&R Consulting, 2020).

Wetland conceptual modelling by C&R Consulting (2020) identified that in order to maintain the sustainability of the wetlands/creeks/lagoons, it is essential that the high frequency (sub-annual to annual; lower volume flood events) flows are maintained. For low frequency (high volume flood) events it is essential that the surface water flows are sufficient to ensure excessive sedimentation does not occur.

More detailed analysis of the hydrology at each wetland is summarised below and further detailed in the Technical Note - Hydraulics of Wetland Connectivity (Jacobs SMEC Design Joint Venture, 2021b) (Appendix B).

It should be noted that water quality modelling is not provided for Capricorn Highway wetland as most of the stormwater flow from the proposed road flows to the north away from the wetland. Only 0.19 ha of road catchment will flow towards the wetland, which is the same as under the existing road design.

The Project Area is located within the Fitzroy Basin Water Resource Plan Area, which came into effect in 2011. The Fitzroy Basin accesses groundwater from three distinct sources which are alluvial soils, sedimentary rock and fractured aquifers. The Fitzroy Basin has a total groundwater resource level of approximately 943,200 ML per annum.

The agricultural industry within the Basin relies on the direct access to river water supplies, however, when this is not possible, irrigated agriculture is supported by groundwater supply. This form of water supply is mainly used for small crops and pastures (Great Barrier Reef Marine Park Authority , 2013)

3.2.5.1 Pink Lily Lagoon

A large wetland complex located south of the Fitzroy River and intersected by the Project Footprint. The complex includes a semi-permanent lacustrine wetland or lake (i.e. holds water for more than one wet season) with fringing sedgeland (Figure 3-3). Associated wetlands include an episodic (i.e. holding water following particular rainfall episode or events) palustrine wetland or vegetated swamp directly south of the main lacustrine wetland (Figure 3-4), and a semi-permanent palustrine wetland east of Von Allmen Road (Figure 3-5). The proposed alignment bridges the episodic palustrine wetland.

During flooding of the Fitzroy River, in any event larger than a 20% AEP flood, overbank flow (breakout) at the Pink Lily Meander near Rockhampton – Ridgelands Road recharges these wetlands from the north-west. In the largest of Fitzroy River floods the lacustrine is completely connected to the semi-permanent wetland across a drowned Von Allmen Road, which in turn discharges back to the river to the east and Lion Creek to the south.

When sufficient volume of water enters Lotus Lagoons from local creek flooding a portion heads east to recharge the Pink Lily Lagoon, whilst at the same time flowing north to spill into the river at Pink Lily meander. There is no spill from the river at Pink Lily meander towards Pink Lily Lagoon in any sized local creek flood. And there is no discharge towards Pink Lily Lagoon except via the remnant finger of Lotus Lagoons running parallel to and north of the proposed alignment. This finger is crossed by Rockhampton – Ridgelands Road embankment with minor culvert structure waterway barrier. In the largest of local catchment events Pink Lily Lagoon connects to Black Duck Lagoon southward over Dargel Road, there is one localised spill channel from the episodic palustrine wetland to the semi-permanent palustrine wetland partway along Von Allmen Road and this in turn discharges south through an ill-defined narrow channel into Lion Creek, not far upstream of its junction with the river.

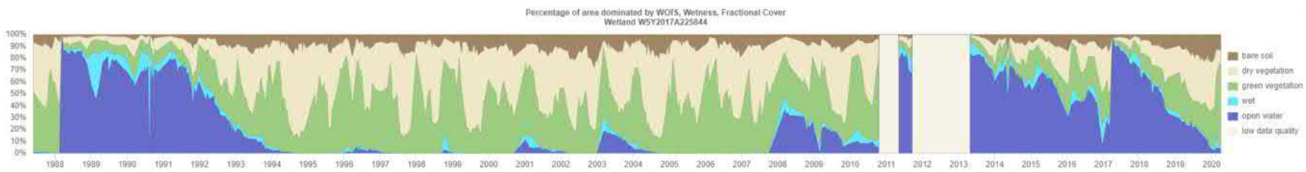


Figure 3-3 Wetland hydrology dynamics for Pink Lily Lagoon lacustrine wetland (representative, largest waterbody polygon) (source: Department of Environment and Science WetlandInfo insight tool)

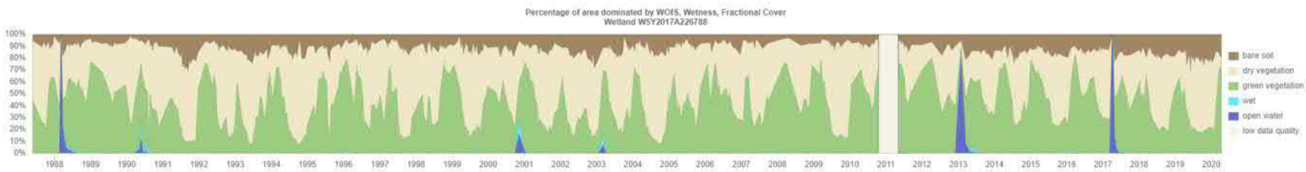


Figure 3-4 Wetland hydrology dynamics for Pink Lily Lagoon palustrine wetland directly south of main lacustrine wetland (source: Department of Environment and Science Wetland*Info* insight tool)

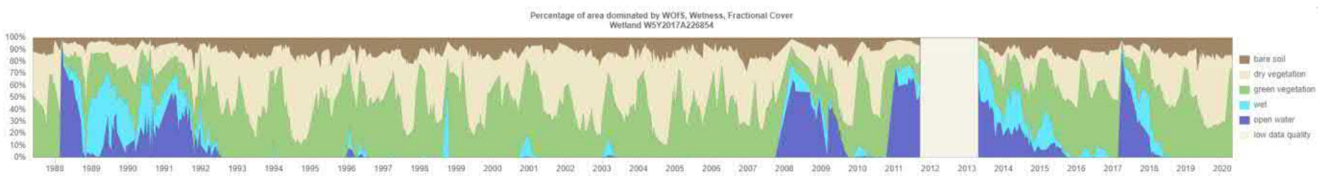


Figure 3-5 Wetland hydrology dynamics for Pink Lily Lagoon palustrine wetland (representative, largest waterbody polygon) to the east of Von Allmen Road (source: Department of Environment and Science Wetland*Info* insight tool)

3.2.5.2 Black Duck Lagoon

A small palustrine wetland with an ephemeral waterbody (Figure 3-6) that typically holds water after wet season rainfall events and dries over the course of the year. The Project Footprint does not intersect the mapped extent of the wetland however the Project Area is within the surrounding trigger area.

During flooding of the Fitzroy River, overbank flow at the Pink Lily Meander recharges these wetlands from the north-west via Lotus Lagoons and from the north via Pink Lily Lagoon. Black Duck Lagoon discharges south to Lion Creek.

During local creek flooding, when sufficient volume of water enters Lotus Lagoons, a portion heads east to recharge the much smaller Black Duck Lagoon. There is no discharge towards Black Duck Lagoon from Lion Creek except via the remnant finger of Lotus Lagoons running parallel to and north of Lion Creek. This finger is crossed by Rockhampton – Ridgelands Road embankment with minor culvert structure waterway barrier. In all but the largest of local creek floods, Pink Lily Lagoon flows are prevented from discharging south into Black Duck Lagoon by high ground along Dargel Road. Black Duck Lagoon has no connectivity east to the semi-permanent wetland of Pink Lily nor south to Lion Creek.

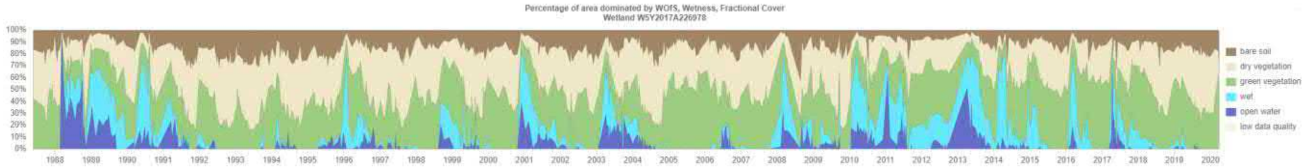


Figure 3-6 Wetland hydrology dynamics for Black Duck Lagoon (representative, largest waterbody polygon) (source: Department of Environment and Science Wetland***Info* insight tool)**

3.2.5.3 Lotus Lagoon

A large floodplain wetland complex that includes several semi-permanent palustrine wetlands (Figure 3-7). It is located east and west of Nine Mile Road, north of the Rockhampton Airport and the Project Area directly intersects this wetland.

During flooding of the Fitzroy River, overbank flow at the Pink Lily Meander recharges these wetlands from the north. Further upstream than the meander, when flood flows exceed the capacity at the meander, riverine flows break into Lilymere Lagoon adjacent Sandy Island and these overtop Rockhampton – Ridgelands Road either side of Pukatika township via ancient riverbed and recharge the northern end of Lotus Lagoons.

When Lion Creek is in flood, flows overtop the natural banks of Lion Creek and cross the low-lying Malchi Nine Mile Road east which then recharge the downstream wetlands, including Lower Gracemere Lagoon (i.e. Paradise Lagoons). Further downstream, Lion Creek feeds Lion Lagoons which discharge directly into Lotus Lagoons. The neighbouring and larger Neerkol Creek system when in high flow breaks into Lower Gracemere Lagoon when its channel capacity is full, before the creek becomes Scrubby Creek. One of the downstream wetland systems that Lower Gracemere Lagoon discharges to is Lotus Lagoons, north west over Nine Mile Road and Lion Creek.

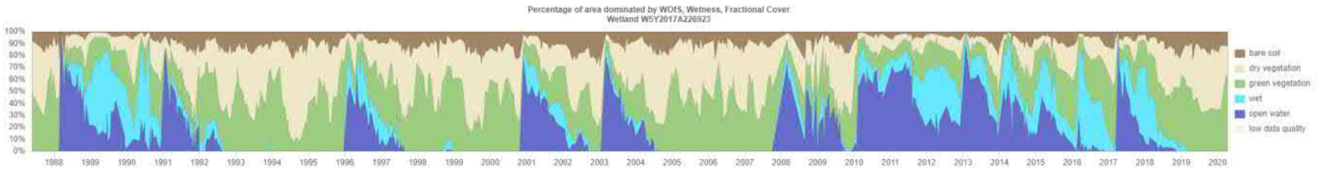


Figure 3-7 Wetland hydrology dynamics for Lotus Lagoon (representative, western waterbody polygon) (source: Department of Environment and Science Wetland***Info* insight tool)**

3.2.5.4 Dunganweate Lagoons

A moderate sized wetland with two elongated and interconnected waterbodies. The northern waterbody is near-permanent, noting that it has only dried once since 1988 in 2007 (Figure 3-8) and the southern waterbody is semi-permanent (Figure 3-9). The Project Footprint directly intersects this wetland.

During flooding of the Fitzroy River, these wetlands can be recharged from the south-east by Gavial Creek backwater and later from the north-west by overbank flow at the Pink Lily Meander.

In creek flooding, one of the downstream wetland systems that Lower Gracemere Lagoon discharges to is Deadmans Lagoon. The upper waterbody of Dunganweate Lagoon receives overflows from Deadmans Lagoon.

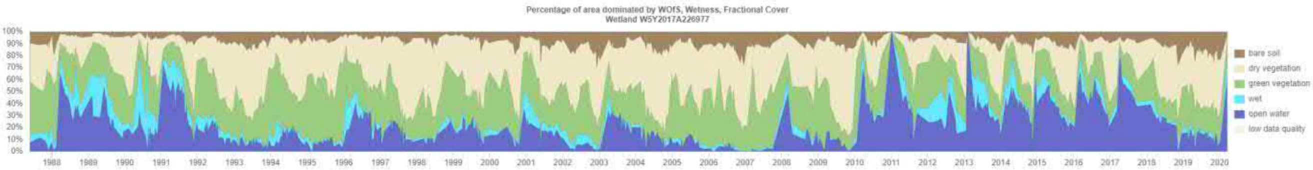


Figure 3-8 Wetland hydrology dynamics for northern Dunganweate Lagoon (representative, main waterbody polygon) (source: Department of Environment and Science Wetland***Info* insight tool)**

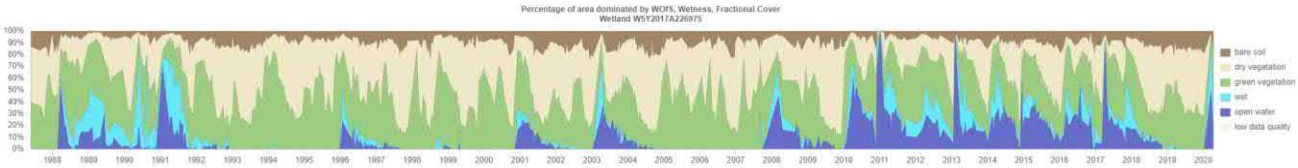


Figure 3-9 Wetland hydrology dynamics for southern Dunganweate Lagoon (representative, main waterbody polygon) (source: Department of Environment and Science Wetland*Info* insight tool)

3.2.5.5 Nelson Lagoon

A small wetland with a semi-permanent waterbody (Figure 3-10), located directly south of Dunganweate Lagoons and directly intersected by the Project Footprint. During flooding of the Fitzroy River, this wetland is recharged from the south-east by Gavial Creek and tributaries' backwater, and later from the north by breakout flow at the Pink Lily Meander.

This lagoon is likely connected to Dunganweate Lagoons during minor flood events, and Crescent and Murray lagoons in larger events. In creek flooding, one of the downstream wetland systems that Lower Gracemere Lagoon discharges to is Deadmans Lagoon. Nelson Lagoon receives overflows from Deadmans Lagoon.

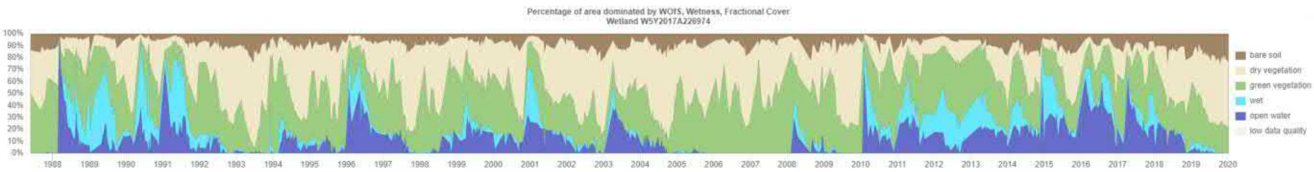


Figure 3-10 Wetland hydrology dynamics for Nelson Lagoon (representative, main waterbody polygon) (source: Department of Environment and Science Wetland***Info* insight tool)**

3.2.5.6 Capricorn Highway Lagoon

Two small elongated and interconnected palustrine wetlands located south of the Capricorn Highway and connected to Neerkol Creek. The northern waterbody is episodic (Figure 3-11) and the southern waterbody is near-permanent, having only dried at a few times since 1988 (Figure 3-12). This lagoon is located outside of the Project Area.

During flooding of the Fitzroy River, this wetland is recharged from the south-east by backwater from Scrubby Creek and two associated lagoons north which are openings under North Coast Rail and the Bruce Highway upstream of Gavial Creek. Fitzroy River breakouts also enter from the north across Capricorn Highway from the Yeppen floodplain at higher flood stages.

Rainfall events centred on the smaller Scrubby Creek, Washpool Creek and Sheepwash Creek catchments feed the Capricorn Highway Lagoons from the south. The lagoons are additionally fed via underdrainage between Fairy Bower Road and Nelson Road at the Capricorn Highway from breakout flood flows traversing east from Deadmans Lagoon and further east along the Capricorn Highway via additional underdrainage. For larger sized events in Neerkol Creek, the entire Capricorn Highway is overtopped from Fairy Bower Road to the roundabout with the Bruce Highway. These floodwaters break into this lagoon system across Capricorn Highway via low lying floodplain channel on the northern side of the highway.

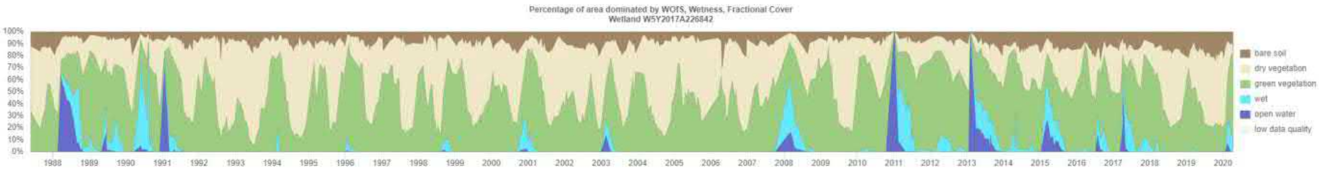


Figure 3-11 Wetland hydrology dynamics for Capricorn Highway Lagoon (north) (representative, main waterbody polygon) (source: Department of Environment and Science Wetland***Info*** **insight tool)**

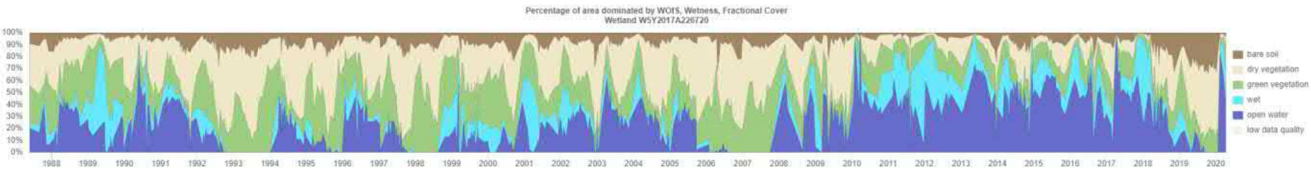


Figure 3-12 Wetland hydrology dynamics for Capricorn Highway Lagoon (south) (representative, main waterbody polygon) (source: Department of Environment and Science Wetland*Info* insight tool)

3.2.5.7 Crescent Lagoon

A large, lacustrine wetland with a near-permanent waterbody, that is only recorded to have dried once since 1988 in 2007 (Figure 3-13). It is located outside of the Project Area, west of the Rockhampton Airport. This lagoon is located outside of the Project Area.

During flooding of the Fitzroy River, this wetland is recharged from the south-east by Gavial Creek backwater, via Yeppen Lagoon, and later from the north by breakout flow at the Pink Lily Meander.

In local catchment events, Crescent Lagoon receives overflows from Nelsons Lagoon initially, with larger Neerkol Creek floods breaking from Dunganweate Lagoon into Crescent Lagoon as well. Discharges at the southern tip join back into the Yeppen floodplain channel contiguous with Yeppen Lagoon. In higher flow events Crescent Lagoon is connected to Murray Lagoon all along its eastern bank. In larger local floods again, Lion Creek in the north overtops airport reclaimed land and discharges into the northern tip of this lagoon.

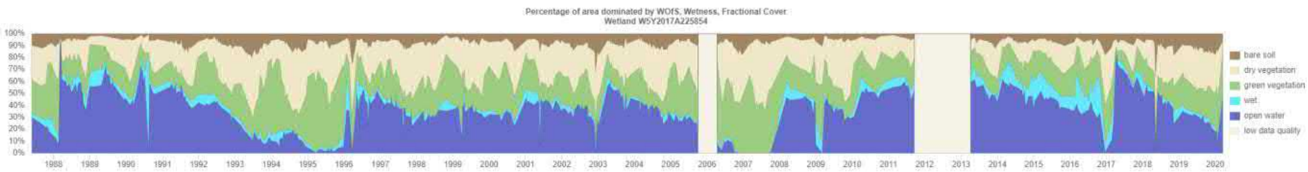


Figure 3-13 Wetland hydrology dynamics for Crescent Lagoon (representative, main waterbody polygon) (source: Department of Environment and Science Wetland***Info*** **insight tool)**

3.2.5.8 Murray Lagoon

A large, lacustrine wetland with a permanent waterbody (Figure 3-14). This lagoon is located outside of the Project Area, west of the Botanic Gardens and south of the Rockhampton Airport.

During flooding of the Fitzroy River, this wetland is recharged from the south-east by Gavial Creek backwater, via Yeppen Lagoon, and later from the north by breakout flow at the Pink Lily Meander.

Manmade drainage discharges to drainage channel from the airport precinct and from flood fringe residential blocks in West Wandal. This "airport" channel discharges into Murray Lagoon via a low flow stormwater harvesting pond. In higher flow events Crescent Lagoon is connected to and flows into Murray Lagoon all along the adjoining bank.

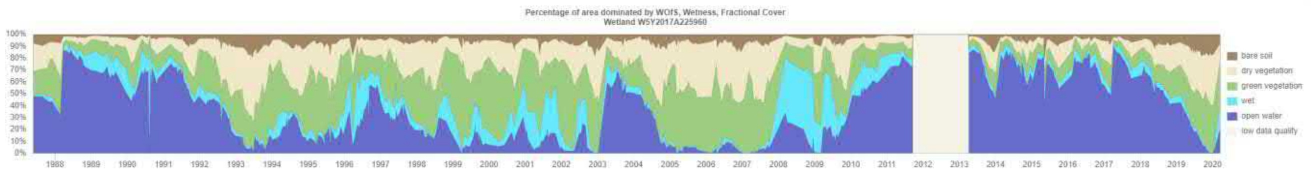


Figure 3-14 Wetland hydrology dynamics for Murray Lagoon (representative, main waterbody polygon) (source: Department of Environment and Science Wetland***Info*** **insight tool)**

3.2.5.9 Yeppen Lagoon

An elongated, palustrine wetland with a permanent waterbody (Figure 3-15) upstream of the Bruce Highway. This lagoon is located south-east of Murray Lagoon, outside of the Project Area.

During flooding of the Fitzroy River, this wetland is recharged from the south-east by Gavial Creek backwater. At higher flood stages, flows overtop Capricorn Highway from south to north to equalize backwater between Capricorn Highway Lagoons and Yeppen Lagoon.

In creek flooding events, one of the downstream wetland systems that Lower Gracemere Lagoon discharges to is Deadmans Lagoon. The waterbody of Yeppen Lagoon receives overflows from Deadmans Lagoon flowing directly east via low lying floodplain adjacent and north of the Capricorn Highway. In addition, discharges flowing east from Dunganweate and Nelson Lagoons arrive indirectly via Crescent Lagoon. When Murray Lagoon discharges, it flows south into Yeppen Lagoon. The final source of floodwaters into this lagoon is across Capricorn Highway flowing north from the Capricorn Highway Lagoon system via low lying floodplain on the northern side of the highway, this occurring for rainfall events centred on the smaller Scrubby Creek, Washpool Creek and Sheepwash Creek catchments which feed the Capricorn Highway Lagoons from the south. Yeppen Lagoon outflows discharge through triple bridges on the Bruce Highway and North Coast Rail north of the Capricorn Highway roundabout before reentering the Gavial Creek main channel, Woolwash Reserve Lagoons and Duckpond Lagoon before outletting to Fitzroy River.

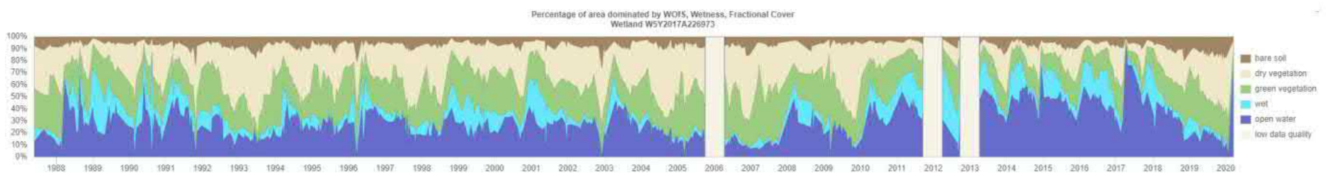


Figure 3-15 Wetland hydrology dynamics for Yeppen Lagoon (representative, main waterbody polygon) (source: Department of Environment and Science Wetland***Info*** **insight tool)**

3.2.6 Groundwater Dependent Ecosystems

No groundwater dependent ecosystems are mapped within the Project Area with the nearest being approximately 14 km north (Queensland Government, 2019).

3.3 Soils and Geology

3.3.1 Major Surface Geology

The Queensland Geology Map from the Geological Survey of Queensland shows that surface geology in the vicinity of the alignment corridor comprises Quaternary age alluvial estuarine sediments (Qa and Qa/2) and the Rockhampton Group/Mount Alma formations (Cr, Dca). The major surface geology units mapped within the Project Area are described in Table 3-1 and shown in Figure 3-16.

The quaternary alluvial soils are primarily encountered around creek beds and low-lying areas and consist of clay, silt, sand and gravel. The quaternary age alluvial estuarine sediments (Qa) are dissected by three major channels of younger Holocene alluviums (located south, through the middle and north of the alignment, within Fitzroy River channel).

At the northern end of the alignment, The Rockhampton Group/Mount Alma formations (Cr, Dca) are present while the eastern and south western side of the alignment are flanked by the Rockhampton Group and Casuarina Beds (to the east).

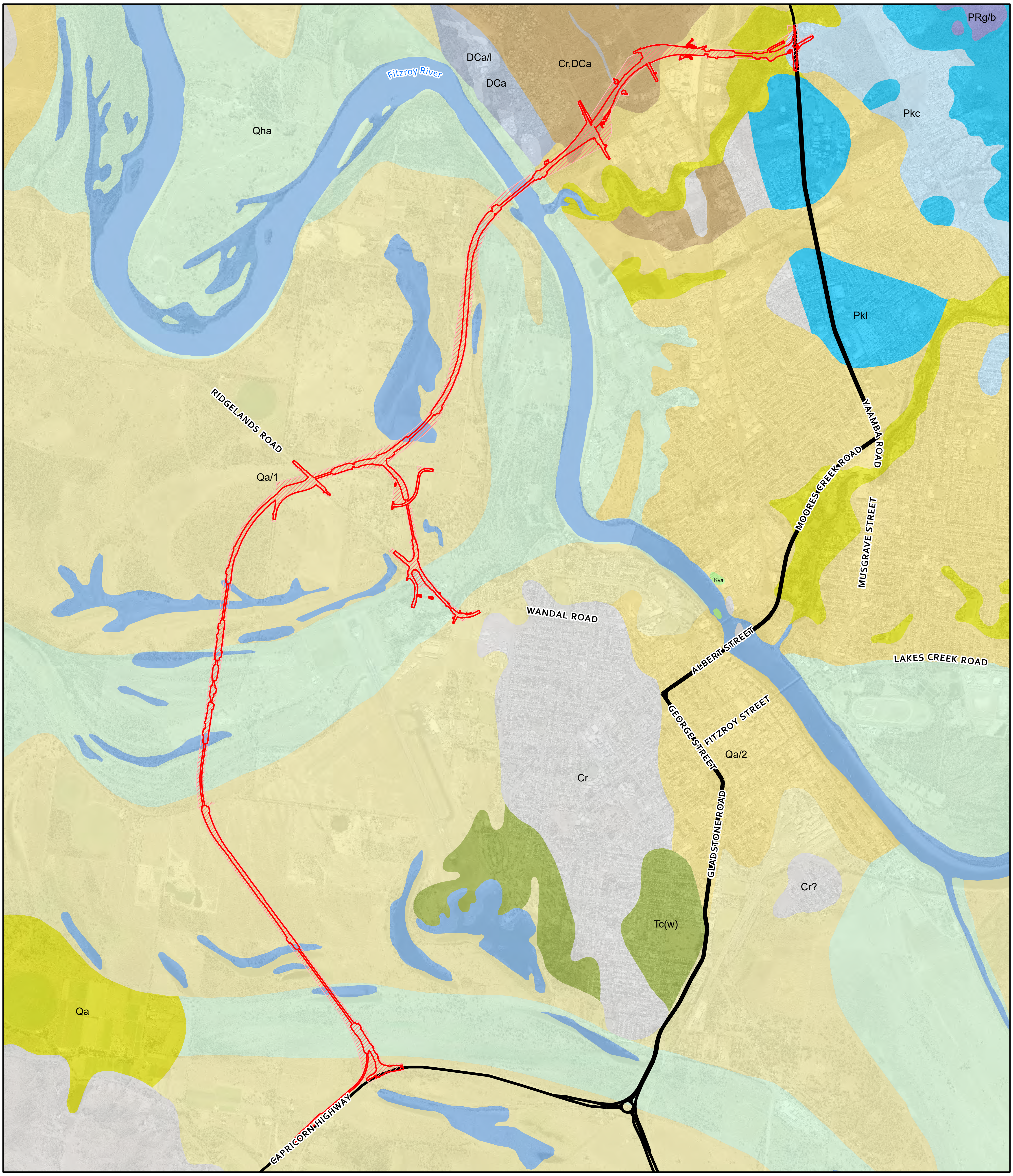
The quaternary alluvium is most likely overlying sedimentary and volcaniclastics rocks belonging to the Rockhampton Group and Mount Alma formation. The Rockhampton Group contains dark grey mudstone, siltstone, felsic volcaniclastic sandstone, conglomerate, ooid-bearing sandstone and conglomerate with mudstone and limestone. The Mount Alma formation contains thinly interbedded fine-grained sandstone and siltstone, thick beds of conglomerate with andesitic to dacitic clasts and siltstone rip-up clasts.

Overall, the available findings from the geotechnical site investigations undertaken are generally consistent with the published geological mapping.

Table 3-1 Major surface geology units and lithology mapped within the Project Area

Unit Name	Map Symbology	Age	Lithology Summary
Qa/1-Yarrol/Scag	Qa/1	Quaternary	Clay, silt, sand, gravel; intermediate
Qa/2-Yarrol/Scag	Qa/2	Quaternary	Clay, silt, sand, gravel; highest terraces of Boyne and Fitzroy River floodplain alluvium
Qha-QLD	Qha	Holocene	Sand, gravel, silt and clay; active stream channels and low terraces
Qa-QLD	Qa	Quaternary	Clay, silt, sand, gravel; flood-plain alluvium
Chalmers Formation	Pkc	Early Permian	Siltstone, lithic sandstone, rhyolitic to andesitic volcaniclastic breccia, rhyolitic and dacitic tuff, minor andesitic tuff
Lakes Creek Formation	Pkl	Early Permian	Siltstone and lithic sandstone
Rockhampton Group, Mount Alma Formation	Cr, DCa	Late Devonian – Early Carboniferous	Complex zone containing fold and fault repetitions of Rockhampton Group and Mount Alma Formation
Rockhampton Group	Cr/l	Early Carboniferous	Oolitic limestone, calcareous sandstone

Figure 3-16: Major surface geology units and lithology within Project Area as shown on the Queensland Geology Map

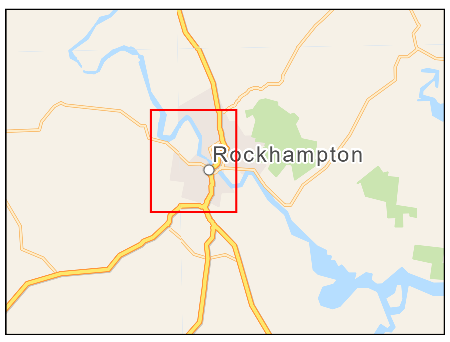


Legend

- Highways
- Project Footprint
- Project Area

Surface Geology

- Alton Downs Basalt
- Casuarina beds(w)
- Chalmers Formation
- Lakes Creek Formation
- Mount Alma Formation
- Mount Alma Formation/l
- PRg/b-YARROL/SCAG
- Qa/1-YARROL/SCAG
- Qa/2-YARROL/SCAG
- Qa-QLD
- Qha-QLD
- Rockhampton Group
- Rockhampton Group,Mount Alma Formation
- Rockhampton Group/l
- Rockhampton Group?
- Water body (unspecified)



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Source: Queensland Department of Resources: Roads, Surface Geology; Metromap: Imagery (2020)

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3.3.2 Australian Soil Resource Information System Soil Classification

Two soil types are mapped within the Project Area on the Australian Soil Resource Information System (CSIRO Land and Water, 2021) mapping. These are described in Table 3-2 and shown in Figure 3-17.

Table 3-2 Australian Soil Resource Information System Soil Classification (CSIRO Land and Water, 2021)

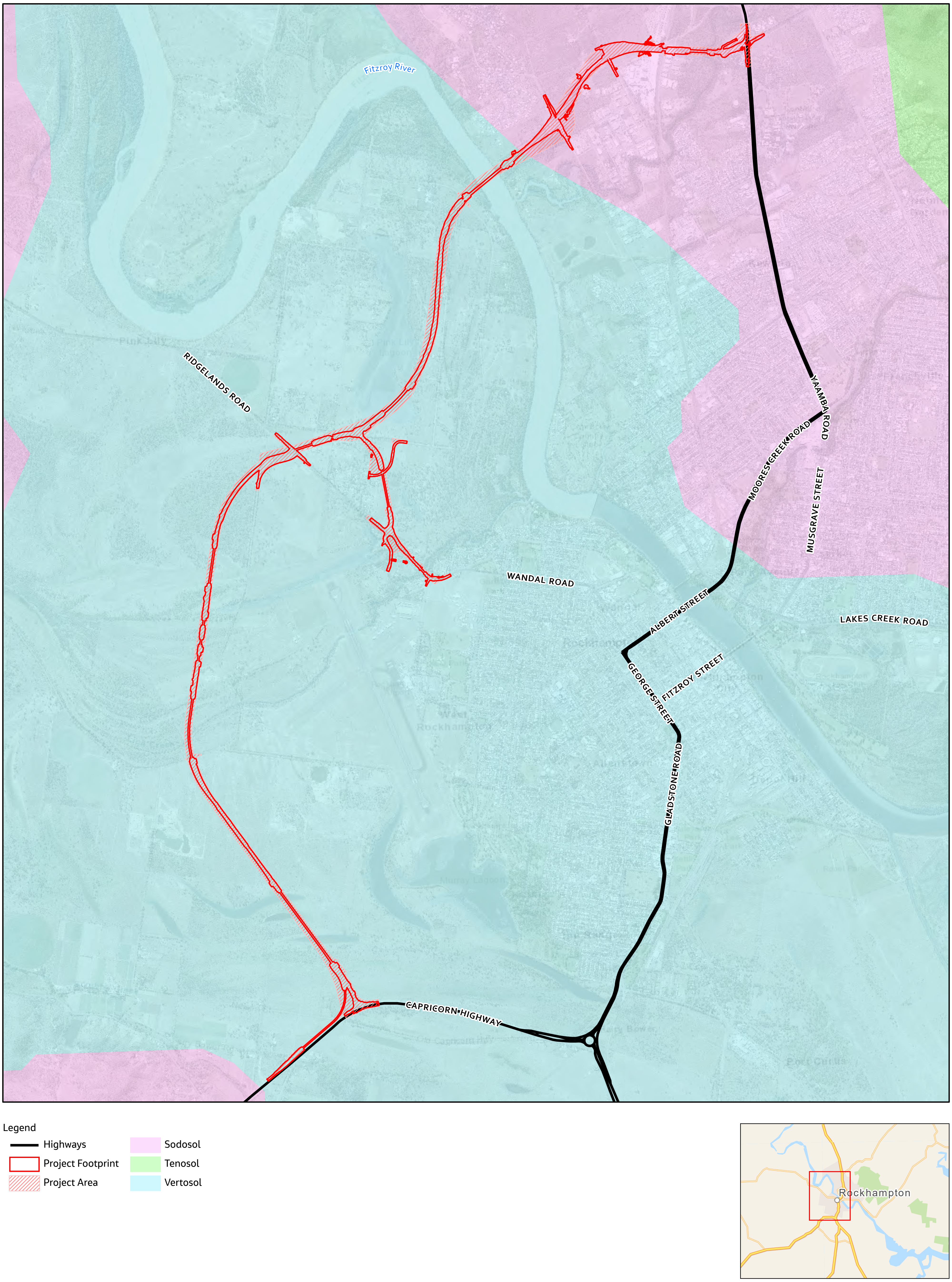
Australian Soil Classification	General Description
Sodosols	Sodosols are only found in poorly drained sites with rainfall between 50mm and 1,100 mm. Generally, sodosols have very low agricultural potential with high sodicity leading to high erodibility, poor structure and low permeability. These soils have low to moderate chemical fertility and can be associated with soil salinity.
Vertosols	These soils have high agricultural potential with high chemical fertility and water-holding capacity, but they require significant amounts of rain before water is available to plants. Gypsum and/or lime may be required to improve their structure. Heavy plastic clays can be difficult to cultivate especially when they are wet. Shrink-swell phenomena also creates problems for foundations of buildings built on Vertosols.

3.3.3 Acid Sulfate Soils

Acid sulfate soil is the common name for naturally occurring sediments and soils containing iron sulfides. The exposure of these soils to oxygen by drainage or excavation, oxidises the iron sulfides and generates sulfuric acid. The sulfuric acid can be readily released into the environment, with potential adverse effects on the natural and built environments. The majority of acid sulfate soils are formed when available sulfate (which occurs widely in seawater, marine sediment, or saturated decaying organic material) reacts with dissolved iron and iron minerals forming iron sulfide minerals, the most common being pyrite.

Review of Australian Soil Resource Information System mapping (CSIRO Land and Water, 2021) indicates there are areas of extremely low, low and high probability of acid sulfate within the Project Area. Preliminary acid sulfate soil investigations undertaken at bridge and culvert locations have identified some areas that require further investigation to confirm the presence of acid sulfate soils. Further investigation will be undertaken prior to construction to determine the specific location and intensity of future investigations and sample collection for laboratory analysis in the associated areas. Further details are provided in Section 7.1.2.4 and the Environmental Management Plan (Appendix A) and Construction Acid Sulfate Soil Sub Plan.

Figure 3-17: Soil types mapped within the Project Area as per Australian Soil Resource Information System



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Source: Queensland Department of Resources: Roads; CSIRO: Soils (2019); Metromap: Imagery (2020)

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3.3.4 Contaminated Land

Areas of potential contamination have been identified through review of:

- listings on the Queensland Government Environmental Management Register/Contaminated Land Register
- historical aerial imagery
- Queensland Government records of Environmental Relevant Activities (as defined in Schedule 2 of the *Queensland Environment Protection Regulation 2019*)

Potential point sources of contamination within and adjacent to the Project Area include:

- Environmental Relevant Activities within the Project Area
- down gradient areas of per- and polyfluoroalkyl substances sources
- sewage treatment
- storage of petroleum, oil and lubricants and chemicals
- laydown yards and trucking yards
- uncharacterised stockpiles and fill activities
- buildings to be demolished and areas where buildings have been previously demolished
- informal waste disposal/unsealed storage of building materials and scrap metal.

Potential diffuse sources of potential contamination have also been identified and include petroleum, oil and lubricants from spills along the existing road alignment and as well as persistent chemicals such as organochloride and organophosphate pesticides from agricultural activities.

Further investigation will be undertaken prior to construction to determine the locations within the Project Area that require site investigation to assess the presence of contaminants and required management measures. Further details are provided in the Environmental Management Plan (Appendix A) and Erosion and Sediment Control Sub Plan and Groundwater and Surface Water Sub Plan.

Further details are provided in the Environmental Management Plan (Appendix A) and Construction Erosion and Sediment Control Sub Plan and Construction Groundwater and Surface Water Sub Plan.

3.4 Flora and Vegetation Communities

3.4.1 Mapped Regulated Vegetation

The Flora and Wetlands Technical Report (AECOM, 2020f) (Appendix B) identifies that there are four vegetation management categories mapped as present within the Project Area (Table 3-3). In Queensland, mapped remnant and high value regrowth vegetation are described as regional ecosystems (REs). REs are vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

Table 3-3 Regulated vegetation categories mapped within the Project Area

Category	Description
B	Remnant vegetation. Remnant vegetation is vegetation, part of which forms the predominant canopy of the vegetation: (a) covering more than 50% of the undisturbed predominant canopy (b) averaging more than 70% of the vegetation's undisturbed height (c) composed of species characteristic of the vegetation's undisturbed predominant canopy.
C	High value regrowth. High value regrowth vegetation means vegetation located: (a) on freehold land, indigenous land, or land subject of a lease issued under the Queensland *Land Act 1994* for agriculture or grazing purposes or an occupation licence under that Act; and (b) in an area that has not been cleared (other than for relevant clearing activities) for at least 15 years
R	Regrowth within 50 m of a watercourse or drainage feature in the Great Barrier Reef catchment areas. Regrowth vegetation is non-remnant vegetation that has a significant woody component but fails to meet the structural and/or floristic characteristics of remnant vegetation. Includes vegetation that has regrown after clearing or been heavily thinned or logged and may retain significant biodiversity values.
X	Non-remnant vegetation, i.e. all other vegetation, including cleared areas.

3.4.2 Mapped Regional Ecosystems

The Flora and Wetlands Technical Report (AECOM, 2020) identifies that the majority of the vegetation intersected by the Project Footprint is non-remnant vegetation (Category X, Category R and Category C) with discrete areas of remnant vegetation present throughout the alignment (Category B). Table 3-4 lists and describes the ten REs mapped as present within the Project Area.

The biodiversity status is based on an assessment of the condition of remnant vegetation in addition to the criteria used to determine the class under the *Queensland Vegetation Management Act 1999*. The Vegetation Management Class is listed in the *Queensland Vegetation Management Regulation 2012*.

Under the *Queensland Vegetation Management Act 1999*, the criteria used to assess the Vegetation Management Class and Biodiversity Status of REs are given below:

Endangered

A RE has a Vegetation Management Class of 'endangered' if:

- remnant vegetation is less than 10% of its pre-clearing extent across the bioregion; or
- 10–30% of its pre-clearing extent remains and the remnant vegetation is less than 10,000 ha.

In addition to the above criteria, for biodiversity planning purposes a RE is listed with a biodiversity status of ‘endangered’ if:

- less than 10% of its pre-clearing extent remains unaffected by severe degradation and/or biodiversity loss; or
- 10–30% 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 RE subject to a threatening process.

Of concern

A RE has a Vegetation Management Class ‘of concern’ if:

- remnant vegetation is 10–30% of its pre-clearing extent across the bioregion; or
- more than 30% of its pre-clearing extent remains and the remnant extent is less than 10,000 ha.

In addition to the above criteria, for biodiversity planning purposes a RE is listed with a biodiversity status 'of concern' if:

- 10–30% of its pre-clearing extent remains unaffected by moderate degradation and/or biodiversity loss.

No concern at present/Least concern

A RE has a Vegetation Management Class of ‘least concern’ 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 above criteria, for biodiversity planning purposes a RE is listed with a biodiversity status ‘no concern at present’ if:

- the degradation criteria listed above for ‘endangered’ or ‘of concern’ REs are not met.

Table 3-4 Mapped regional ecosystems within the Project Area

RE	Short Description	Vegetation Management Class	Biodiversity Status
11.3.1	Open forest dominated by *Acacia harpophylla*. A low tree layer dominated by *Casuarina cristata*, *Lysiphyllum carronii* and *Alectryon diversifolius*.	Endangered	Endangered
11.3.2	*Eucalyptus populnea* woodland on alluvial plains.	Of concern	Of concern
11.3.3	*Eucalyptus coolabah* woodland on alluvial plains.	Of concern	Of concern
11.3.4	*Eucalyptus tereticornis* and/or *Eucalyptus spp*. woodland on alluvial plains.	Of concern	Of concern
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines.	Least concern	Of concern
11.3.25f	Main river channels. Open water or exposed stream beds and bars.	Least concern	Of concern

RE	Short Description	Vegetation Management Class	Biodiversity Status
11.3.27	Freshwater wetlands	Least concern	Of concern
11.3.27a	Vegetation ranges from open water +/- aquatics and emergent.	Least concern	Of concern
11.3.27c	Mixed grassland or sedgeland with areas of open water +/- aquatic species.	Least concern	Of concern
11.11.15	*Eucalyptus crebra* woodland on deformed and metamorphosed sediments and interbedded volcanics.	Least concern	No concern at present
11.12.1	*Eucalyptus crebra* woodland on igneous rocks.	Least concern	No concern at present

3.4.3 Conservation Significant Flora

The desktop assessment undertaken as part of the Flora and Wetlands Technical Report (AECOM, 2020) identified 12 conservation significant flora species with the potential to occur within the Project Area. These species and their respective conservation status under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act) are detailed in Table 3-5.

Table 3-5 Conservation significant flora with potential to occur within the Project Area

Scientific Name	Common Name	EPBC Act Status	NC Act Status
Backhousia oligantha	-	Not listed	Endangered
Callicarpa thozetii	-	Not listed	Endangered
Cycas megacarpa	Marlborough blue	Endangered	Endangered
Cycas ophiolitica	Cycad	Endangered	Endangered
Dichanthium setosum	Bluegrass	Vulnerable	Not listed
Eucalyptus raveretiana	Black ironbox	Vulnerable	Not listed
Graptophyllum excelsum	Scarlet fuchsia	Not listed	Near Threatened
Livistona drudei	Fan palm	Not listed	Vulnerable
Marsdenia brevifolia	-	Vulnerable	Vulnerable
Phaius australis	Lesser swamp orchid	Endangered	Endangered

Scientific Name	Common Name	EPBC Act Status	NC Act Status
Samadera bidwillii	Quassia	Vulnerable	Vulnerable
Stackhousia tryonii	-	Not listed	Near Threatened

3.4.4 Significant Biodiversity Values

The Queensland Department of Environment and Science attributes biodiversity significance on a bioregional scale through a Biodiversity Planning Assessment. A Biodiversity Planning Assessment involves the integration of ecological criteria using the Biodiversity Assessment and Mapping Methodology and is developed in two stages: 1) diagnostic criteria, and 2) expert panel criteria. The diagnostic criteria are based on existing data, which is reliable and uniformly available across a bioregion, while the expert panel criteria allow for the refinement of the mapped information from the diagnostic output by incorporating local knowledge and expert opinion.

The Biodiversity Assessment and Mapping Methodology has application for identifying areas with various levels of significance solely for biodiversity reasons. These include threatened ecosystems or taxa, large tracts of habitat in good condition, ecosystem diversity, landscape context and connection, and buffers to wetlands or other types of habitat important for the maintenance of biodiversity or ecological processes.

Biodiversity Planning Assessments assign three levels of overall biodiversity significance, which are all present within the Project Area (Figure 3-18):

- **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. This includes areas flagged as being of State significance due to the presence of endangered, vulnerable and/or near threatened 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.

3.4.5 Field Survey Results

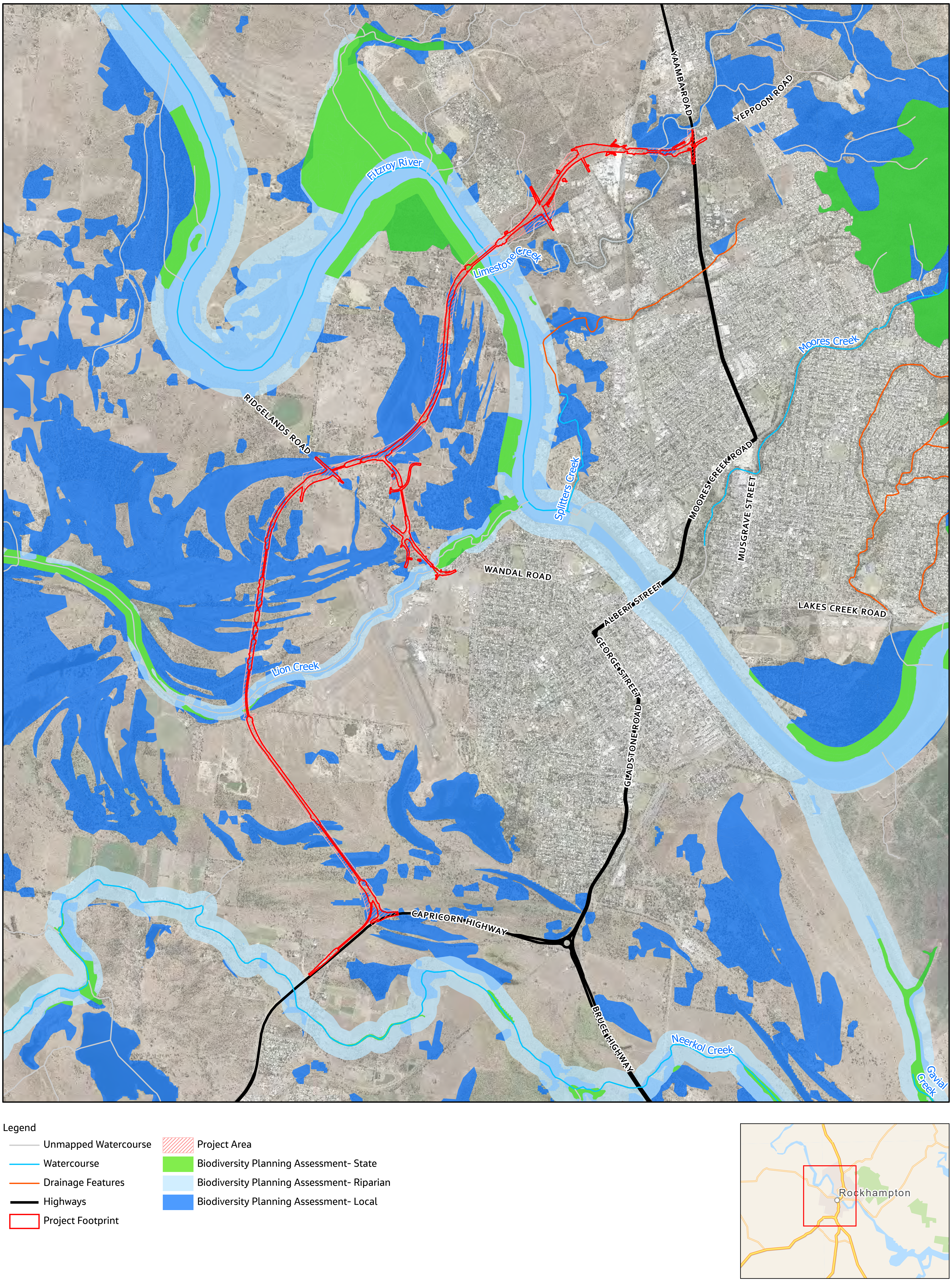
3.4.5.1 Flora Species

The field surveys identified the presence of 259 taxa representing 72 families. The dominant families present were:

- Myrtaceae – 17 species
- Fabaceae – 22 species
- Poaceae – 43 species.

The only threatened species listed under the NC Act or EPBC Act that was identified during the field surveys was *Eucalyptus raveretiana* (black ironbox), which is listed as vulnerable under the EPBC Act. Black ironbox was identified within the Project Area along Limestone Creek in association with the field verified RE 11.3.25a. Within this vegetation community, black ironbox forms the dominant canopy species. A black ironbox population survey was undertaken in December 2020 with the results documented in the Technical Note – *Eucalyptus raveretiana* Population Survey (JSDJV, 2020) (Appendix B). The population survey identified 63 individual black ironbox growing within 200 m upstream and downstream of the Project Area with additional individuals anticipated to be present outside of the surveyed area (Figure 6-4).

Figure 3-18: Location of Biodiversity Significant areas within and adjacent to the Project Area



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Source: Queensland Department of Resources: Roads (2020); BPA, Watercourses (2019); Metromap: Imagery (2020)

3.4.5.2 Weeds

A total of 100 introduced species were recorded within the Project Area, including the following:

- 11 weeds of national significance
- 19 restricted invasive species listed under the *Queensland Biosecurity Act 2014*
- 23 declared species under the Rockhampton Regional Council Biosecurity Plan.

The weeds of national significance, restricted invasive species listed under the Queensland *Biosecurity Act 2014* and the weeds listed under the under the Rockhampton Regional Council Biosecurity Plan are shown in Table 3-6.

Table 3-6 Weed species identified within the Project Area

Scientific name	Common name	WONS status[1]	B Act status[2]	RRC BP[3]
Bryophyllum delagoense	mother of millions	-	Restricted	Declared
Cardiospermum grandiflorum	balloon vine	-	Restricted	Declared
Cascabela thevetia	yellow oleander	-	Restricted	Declared
Cryptostegia grandiflora	rubber vine	WONS	Restricted	Declared
Eichhornia crassipes	water hyacinth	WONS	Restricted	Declared
Harrisia martinii	harrisia cactus	-	Restricted	Declared
Hymenachne amplexicaulis	hymenachne	WONS	Restricted	Declared
Lantana camara	lantana	WONS	Restricted	Declared
Lantana montevidensis	creeping lantana	-	Restricted	Declared
Leonotis nepetifolia	lion tail	-	-	Declared
Leucaena leucocephala	leucaena	-	-	Declared
Opuntia streptacantha	westwood pear	WONS	Restricted	Declared
Opuntia stricta	prickly pear	WONS	Restricted	Declared
Opuntia tomentosa	velvety tree pear	WONS	Restricted	Declared
Parkinsonia aculeata	parkinsonia	WONS	Restricted	Declared
Parthenium hysterophorus	parthenium	WONS	Restricted	Declared
Ricinus communis	castor oil plant	-	-	Declared
Salvinia molesta	salvinia	WONS	Restricted	Declared
Schinus terebinthifolius	broad-leaved pepper			
Sporobolus pyramidalis / natalensis	giant rat's tail grass	-	Restricted	Declared

Scientific name	Common name	WONS status[1]	B Act status[2]	RRC BP[3]
Stachytarpheta jamaicensis	snake weed	-	-	Declared
Vachellia nilotica	prickly acacia	WONS	Restricted	Declared
Ziziphus mauritiana	chinee apple	-	Restricted	Declared

1 WONS – Weeds of National Environmental Significance. Problematic plant species in Australia as defined by the Centre for Invasive Species Solutions

2 B Act – Queensland *Biosecurity Act 2014* restricted matter includes a range of invasive plants that are present in Queensland. These invasive plants have significant adverse impacts in Queensland, and it is desirable to manage them and prevent their spread, thereby protecting un-infested parts of the State.

3 RRC BP – Rockhampton Regional Council Biosecurity Plan for Pest Management: 2017 – 2021 (Rockhampton Regional Council, 2017) – Invasive species identified as having a significant local impact within the Rockhampton region. The plan was developed to address the requirement of the Queensland *Biosecurity Act 2014*.

3.4.5.3 Regional Ecosystems

The field survey identified that only eight REs are present within the Project Area, with some present as high value regrowth. Table 3-7 details the field verified REs within the Project Area, while the following REs were not identified as present within the Project Area:

- RE 11.3.2, described as the 'of concern' *Eucalyptus populnea* woodland on alluvial plains.
- RE 11.3.27, described as the 'least concern' freshwater wetlands. Whilst this RE is present, the field surveys were able to refine the RE mapping and attribute a sub-RE
- RE 11.12.1, described as the 'least concern' *Eucalyptus crebra* woodland on igneous rocks.

Figure 3-19 shows the distribution of the field verified Regulated Vegetation Categories (as defined in Table 3-3) and associated Vegetation Management Status within the Project Area.

Table 3-7 Field verified regional ecosystems within the Project Area

RE	Description	Vegetation Management status	Biodiversity status
11.3.1	Open forest dominated by *Acacia harpophylla*. A low tree layer dominated by *Casuarina cristata*, *Lysiphyllum carronii* and *Alectryon diversifolius*. This vegetation community is present as high value regrowth.	Endangered	Endangered
11.3.3	*Eucalyptus coolabah* open woodland to woodland with a grassy understorey. This vegetation community is present as high value regrowth.	Of concern	Of concern
11.3.4	*Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains. This vegetation community is present as remnant RE and high value regrowth	Of concern	Of concern

RE	Description	Vegetation Management status	Biodiversity status
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines	Least concern	Of concern
11.3.25a	*Eucalyptus raveretiana* (sometimes emergent), *Melaleuca fluviatilis* woodland.	Least concern	Of concern
11.3.25f	Main river channels. Open water or exposed stream beds and bars.	Least concern	Of concern
11.3.27a	Vegetation ranges from open water +/- aquatics and emergents such as *Chara* spp., *Nitella* spp., *Myriophyllum verrucosum, Nymphaea violacea, Pyrgillus javanicus, Potamogeton crispus, Potamogeton tricarinatus, Ottelia ovalifolia, Vallisneria caulescens* and *Nymphoides indica*. A narrow fringing woodland commonly dominated by *E. camaldulensis* or *E. coolabah* but also a range of other tree species may be present	Least concern	Of concern
11.3.27c	Mixed grassland or sedgeland with areas of open water +/- aquatic species. Dominated by a range of species including *Eleocharis* spp., *Nymphoides* spp. and sometimes *Phragmites australis*.	Least concern	Of concern
11.11.15	*Eucalyptus crebra* woodland on deformed and metamorphosed sediments and interbedded volcanics	Least concern	No concern at present

3.4.5.4 Threatened Ecological Communities

The brigalow (*Acacia harpophylla* dominant and co-dominant) TEC has been identified as present north of the Fitzroy River, as a patch of non-remnant (high value regrowth) RE 11.3.1. The TEC was originally located within the Detailed Business Case Project Footprint; however, design alterations during the Preliminary and Detailed Design phase have mostly avoided this TEC, with most of the TEC in the Project Area now located outside of the Project Footprint (Figure 3-19).

High value regrowth containing RE 11.3.3 was identified as present within the Project Area (Table 3-7). This RE corresponds with the species composition of the coolibah – black box woodlands of the Darling Riverine Plains and Brigalow Belt south bioregions TEC. However, the patch of high value regrowth containing RE 11.3.3 is present approximately 3 km north of the northernmost limits of the mapped extent of the Brigalow Belt South Bioregion. Therefore, this patch of RE 11.3.3 does not meet the key diagnostic characteristics of the TEC.

3.5 Fauna

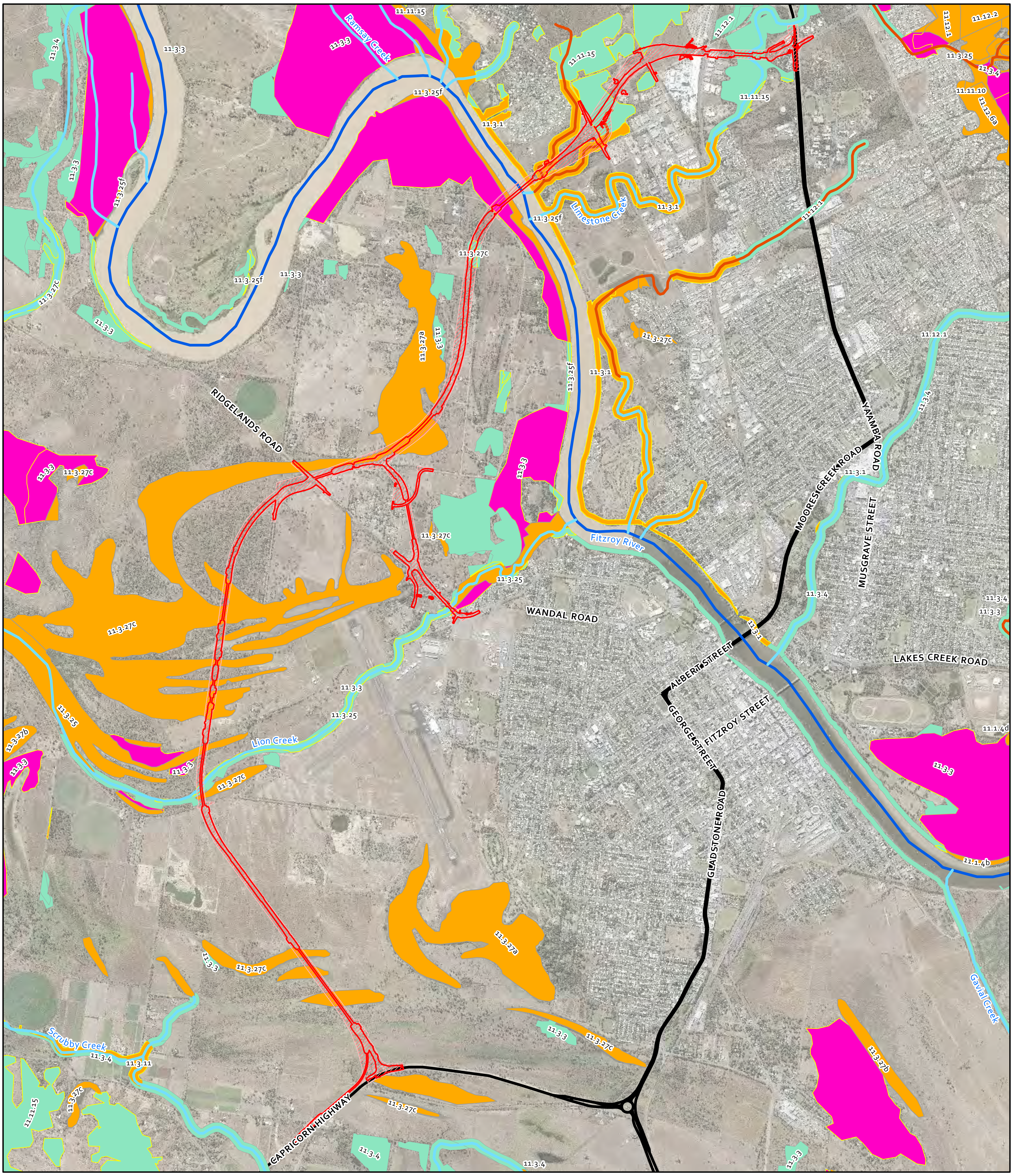
3.5.1 Fauna Habitats

Based on the Queensland Department of Environment and Science RE and wetland mapping and the outcomes of the flora and fauna field surveys (Section 3.4.5), nine habitat types have been identified within the Project Area. These habitat types, the corresponding REs, and the extent to which they are present within the Project Footprint are detailed in Table 3-8 and are shown in Figure 3-20 and Figure 3-21.

There is potential habitat for Marlborough blue and weeping Myall woodland TEC in Project Area based on RE mapping, however these MNES were not identified in the targeted field surveys. These MNES are discussed further in Section 6.

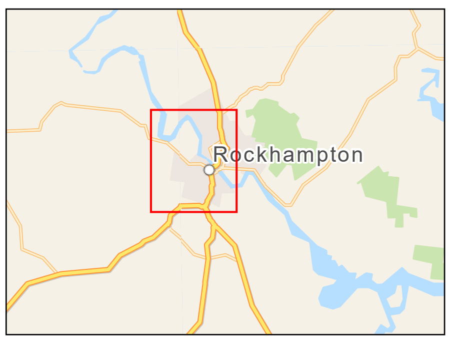
Potential habitat for MNES in the broader area is based on Queensland Department of Environment and Science RE and wetland mapping, with the REs and/or wetland types included in each habitat type provided in Table 3-9 and mapped for each of the MNES in Section 6. These habitats have not been field-verified as habitat for MNES by the Project but provide an indication of potential habitat in the broader area.

Figure 3-19: Regulated Vegetation Categories and Threatened Ecological Communities



Legend

- Major Watercourse
- Minor Watercourse
- Highways
- Drainage Features
- Project Footprint
- Project Area
- Category A or B area containing endangered and is S20AH
- Category A or B area containing of concern
- Category A or B area containing of concern and is S20AH
- Category A or B area that is least concern
- Category A or B area that is least concern and S20AH



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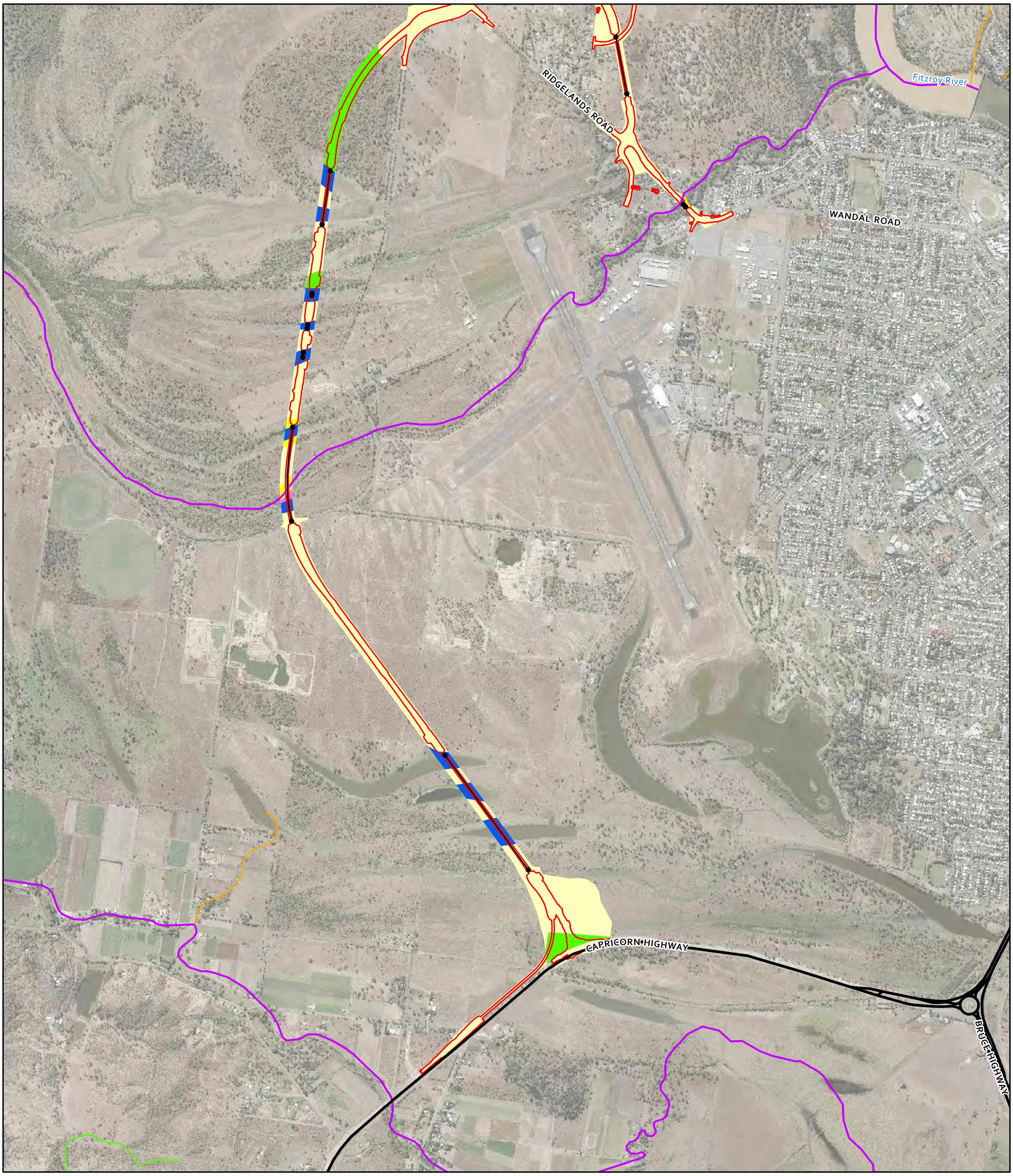
Source: Queensland Department of Resources: Roads, Railways, RE, Watercourses (2020); Metromap: Imagery (2020)

Figure 3-21: Field-verified habitat within the southern Project Area



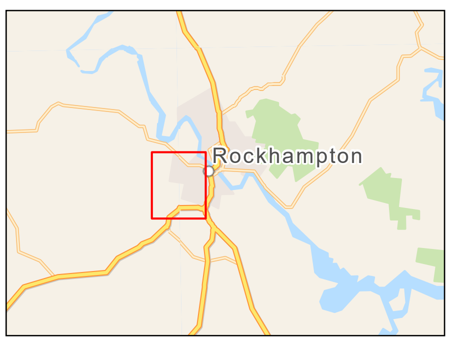
Legend

- Bridges
- Highways

Waterways for Waterway Barrier Works Risk of Impact

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

- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Lacustrine or palustrine wetland
- Modified grasslands
- Fringing riparian woodland



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Jacobs SMEC Design Joint Venture

Source: AECOM/Jacobs: Fauna Habitats (2021); Metromap: Imagery (2020)

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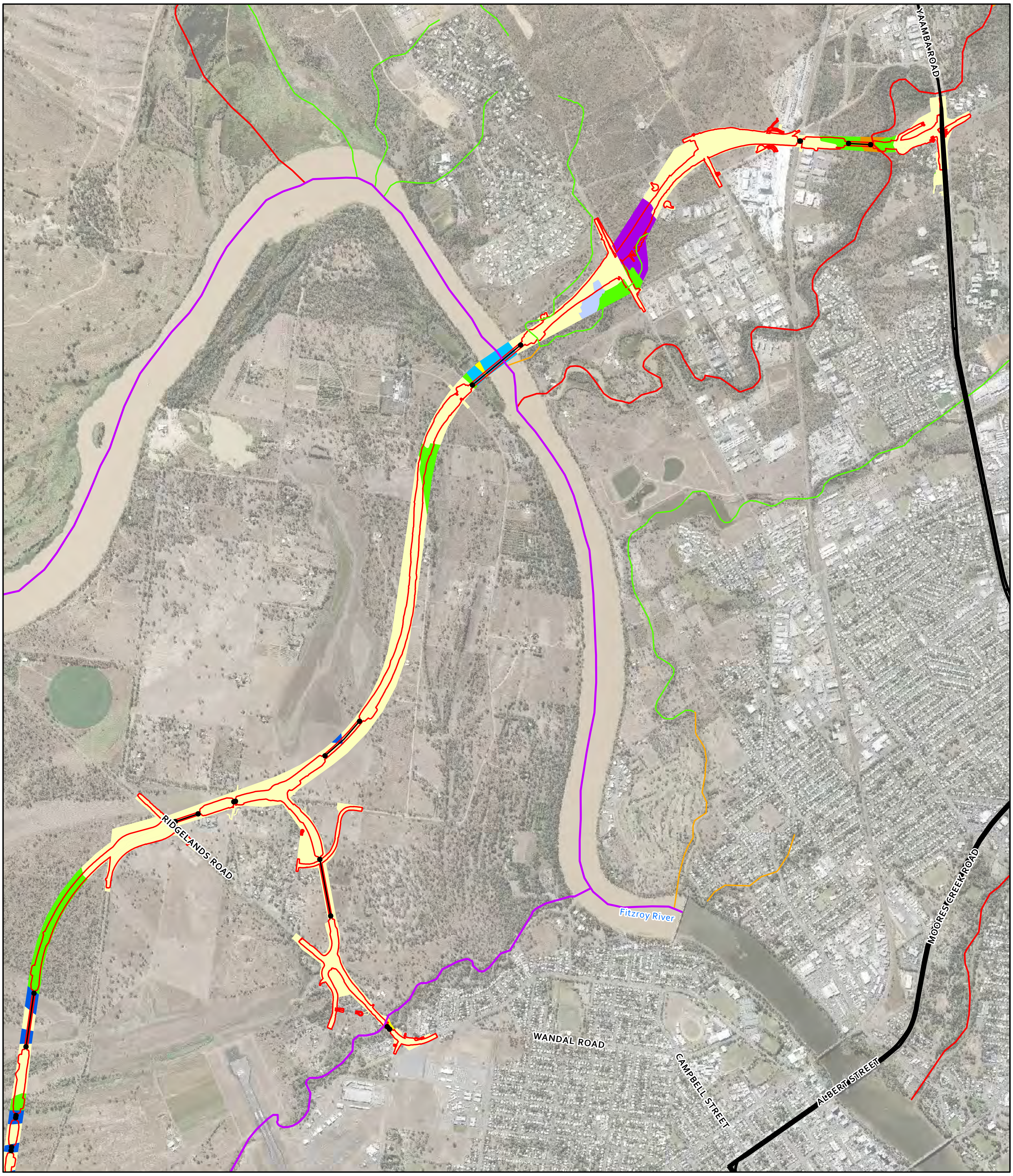
Figure 3-20: Field-verified habitat within the northern Project Area



Legend

- Bridges
- Highways

Waterways for Waterway Barrier Works Risk of Impact

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

- Project Footprint
- Brigalow woodland
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on metamophics
- Fringing riparian woodland with Eucalyptus raveretiana
- Lacustrine or palustrine wetland
- Modified grasslands
- Riverine waterbody
- Fringing riparian woodland

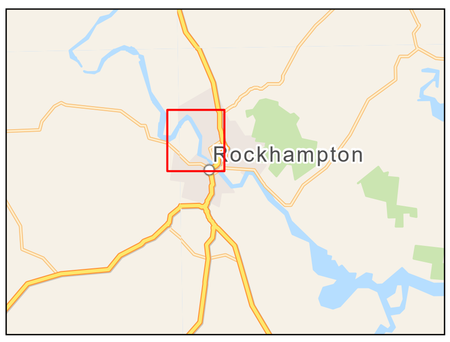


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Table 3-8 Field-verified habitat types and corresponding regional ecosystems within the Project Area

Habitat ID	Habitat Short Description	Corresponding RE/ high value regrowth	Approximate Area (ha)
1	Lacustrine or palustrine wetland	RE 11.3.27a	9.5
		RE 11.3.27c	
2	Riverine waterbody	RE 11.3.25f	3.3
3	Fringing riparian woodland	RE 11.3.25	2.0
4	Fringing riparian woodland with *Eucalyptus raveretiana*	RE 11.3.25a	1.0
5	Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis*	RE 11.3.4	0.3
		High value regrowth 11.3.4	
6	Eucalyptus woodland on alluvial floodplain	High value regrowth 11.3.3	20.7
6	Eucalyptus woodland on metamorphics or granitic	RE 11.11.15	7.9
8	Brigalow woodland	High value regrowth 11.3.1	1.9
9	Modified grasslands	Non-remnant	163.8
Total			**210.5**

Table 3-9 Habitat types, corresponding regional ecosystems and/or wetland types, and approximate extent in the broader area

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
Mangroves and saltmarsh Approximately 132.2 ha	Estuarine crocodile Grey-headed flying fox Common sandpiper White-throated needletail	11.1.2b Samphire forbland on marine clay plains	Samphire forbland on Quaternary estuarine deposits. Mainly saltpans and mudflats with clumps of saltbush including one or several of the following species; *Tecticornia* spp. (e.g. *Tecticornia indica* subsp. *julacea, Tecticornia indica* subsp. *leiostachya*), *Sesuvium portulacastrum, Salicornia quinqueflora* subsp. *Quinqueflora, Suaeda australis, Suaeda arbusculoides, Tecticornia australasica, Scleria ciliaris, Marsilea mutica, Salsola australis,* algal crusts and the grass *Sporobolus virginicus*. Sedges may be common. Estuarine wetlands (e.g. mangroves).
		11.1.4b Mangrove low open forest and/or woodland on marine clay plains	*Avicennia marina* low open shrubland to closed forest on Quaternary estuarine deposits. There may be occasional *Ceriops australis, Rhizophora spp., Bruguiera spp., Excoecaria agallocha or Lumnitzera spp*. An occasional presence of species such as *Aegialitis annulata* and/or *Aegiceras corniculatum* may occur. Open shrublands of *Avicennia marina* may have a sparse presence of samphires such as *Suaeda spp., Tecticornia australasica* and *Salicornia spp*. Occurs in all intertidal environments from the seaward edge (as a pioneer) to accreting banks (as a fringe), to the landward edge adjacent to claypans (Bruinsma 2000; Danaher 1995). Estuarine wetlands (e.g. mangroves).
		11.1.4d Mangrove low open forest and/or woodland on marine clay plains	Dominated by a range of species from genera such as from *Avicennia sp., Ceriops sp., Rhizophora sp.* and *Bruguiera sp*. which form a low closed forest. A low shrub layer composed of species such as *Acanthus ilicifolius, Acrostichum speciosum, Crinum pedunculatum* or juvenile canopy species is often present. Epiphytes on the canopy are common. Occurs on the landward edge of the tidal flats and in the upper tidal reaches of creeks and rivers where there is a high freshwater influence. Estuarine wetlands (e.g. mangroves).

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
Lacustrine or palustrine wetland Approximately 2,942.0 ha	Estuarine crocodile Australian painted snipe Ornamental snake Squatter pigeon Black-tailed godwit Caspian tern Common greenshank Common sandpiper Curlew sandpiper Eastern osprey Glossy ibis Latham's snipe Little curlew Marsh sandpiper Pectoral sandpiper Red-necked stint Sharp-tailed sandpiper White-throated needletail Wood sandpiper	11.1.3 Sedgelands on marine clay plains (palustrine wetland)	Sedgelands to grasslands on Quaternary estuarine deposits. Sedgeland dominated by a range of sedges and grasses which include *Eleocharis philippinensis, Cyperus alopecuroides, Cyperus scariosus and Cyperus iria* and the grasses *Sporobolus virginicus* and *Paspalum vaginatum*. Other typical species in shallower margins include *Fimbristylis ferruginea, Phyla nodiflora* and *Cyperus polystachyos* var. *polystachyos.* Occasional twiners such as *Vincetoxicum carnosum* may be present. Occurs in depressions on Quaternary estuarine deposits which are brackish to saline. These are may be seasonally inundated with fresh water, but dry out completely before the next season's rain.
		11.3.27 Freshwater wetlands (lacustrine or palustrine wetland)	Freshwater wetlands. Vegetation is variable including open water with or without aquatic species and fringing sedgelands and eucalypt woodlands. Occurs in a variety of situations including lakes, billabongs, oxbows and depressions on floodplains.
		11.3.27a Lacustrine wetland	Vegetation ranges from open water +/- aquatics and emergents such as *Chara spp. Nitella spp., Myriophyllum verrucosum, Nymphaea violacea, Pyrgillus javanicus, Potamogeton crispus, Potamogeton tricarinatus, Ottelia ovalifolia, Vallisneria caulescens* and *Nymphoides indica*. A narrow fringing woodland commonly dominated by *Eucalyptus camaldulensis or Eucalyptus coolabah* but also a range of other tree species may be present. In dry seasonal conditions, non-woody vegetation may be completely absent from ephemeral waterbodies, with only bare claypans present. During drying-off periods, herbaceous species such as *Sesbania cannabina, Glinus lotoides* and *Cullen spp.* may be present and dominant on drying lake margins. Larger ephemeral - permanent water bodies (lakes).
		11.3.27b Lacustrine wetland	Vegetation ranges from open water +/- aquatics and emergents such as *Potamogeton crispus, Myriophyllum verrucosum, Chara spp., Nitella spp. Nymphaea violacea, Ottelia ovalifolia, Nymphoides indica, Nymphoides crenata, Potamogeton tricarinatus, Cyperus difformis, Vallisneria caulescens* and *Hydrilla verticillata*. Often with fringing woodland, commonly *Eucalyptus camaldulensis* or *Eucalyptus coolabah* but also a wide range of other species including *Eucalyptus platyphylla, Eucalyptus tereticornis, Melaleuca spp., Acacia holosericea* or other *Acacia spp*. Occurs on billabongs.

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
		11.3.27c Palustrine wetland	Mixed sedges or grasses with areas of open water +/- aquatic species. Dominated by a range of species including *Eleocharis spp., Nymphoides spp*. And sometimes *Phragmites australis*. During drying or drought periods, such ephemeral waterbodies may be dominated by herbaceous species such as Glinus lotoides, or exist as bare claypan. Occurs on closed depressions on alluvial plains that are intermittently flooded in inlands parts of the bioregion.
		11.3.27x1b Palustrine wetland	Sedgelands to grasslands on Quaternary deposits. Often occurs as an Eleocharis dulcis sedgeland but a variety of other species dominate in local areas including Typha orientalis and Phragmites australis. Trees and large shrubs are generally absent. Occurs on broad drainage depressions situated on old alluvial plains.
Riverine waterbody Approximately 682.2 ha	Estuarine crocodile Fitzroy River turtle White-throated snapping turtle Ornamental snake Caspian tern Eastern osprey Glossy ibis White-throated needletail	11.3.25f Riverine wetland or fringing riverine wetland	Main river channels. Open water or exposed stream beds and bars. Usually devoid of emergent vegetation although scattered trees and shrubs such as *Melaleuca viminalis* or *Melaleuca* spp. May be present and aquatic species may be abundant particularly in water holes and lagoons. Occurs in river channels.

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
Fringing riparian woodland Approximately 1137.5 ha	Marlborough blue Estuarine crocodile Fitzroy River turtle White-throated snapping turtle Grey-headed flying-fox Koala Ornamental snake Eastern osprey Glossy ibis White-throated needletail	11.3.25 *Eucalyptus tereticornis* or *Eucalyptus camaldulensis* woodland fringing drainage lines	*Eucalyptus tereticornis* or *Eucalyptus camaldulensis* woodland to open forest. Other tree species, including *Casuarina cunninghamiana, Eucalyptus coolabah, Melaleuca bracteata, Melaleuca viminalis, Livistona spp.* (in north), *Melaleuca spp.* and *Angophora floribunda*, may occur. An tall shrub layer may occur, including *Acacia salicina, Acacia stenophylla* and *Lysiphyllum carronii*. Low shrubs are present, but rarely form a conspicuous layer. The ground layer is open to sparse and dominated by perennial grasses, sedges or forbs. Occurs on fringing levees and banks of major rivers and drainage lines of alluvial plains throughout the region. Soils are very deep, alluvial, grey and brown cracking clays with or without some texture contrast. These are usually moderately deep to deep, soft or firm, acid, neutral or alkaline brown sands, loams or black cracking or non-cracking clays, and may be sodic at depth.
Eucalyptus woodland on alluvial floodplain Approximately 2,323.8 ha	Grey-headed flying-fox Koala Ornamental snake Squatter pigeon White-throated needletail	11.3.29a *Eucalyptus crebra, Eucalyptus exserta, Melaleuca spp.* woodland on alluvial plains	*Eucalyptus crebra +/- Corymbia dallachiana +/- Corymbia erythrophloia, Eucalyptus moluccana* woodland.
		11.3.3 *Eucalyptus coolabah* woodland on alluvial plains	*Eucalyptus coolabah* woodland to open woodland. A secondary tree or shrub layer may occur, including *Eucalyptus populnea, Melaleuca bracteata, Acacia stenophylla, Alectryon oleifolius, Terminalia oblongata* (in the north), *Acacia pendula, Acacia cambagei and Duma florulenta*. The ground layer is dominated by a range of grass and forb species depending on season. Occurs on Cainozoic alluvial plains or levees with clay or sometimes texture contrast soils.

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
		11.3.3c *Eucalyptus coolabah* woodland on alluvial plains	*Eucalyptus coolabah* woodland to open woodland (to scattered trees) with a sedge or grass understorey in back swamps and old channels. The ground layer is dominated by a range of sedge or grass species depending on hydrological regime, soil and management conditions. Characteristic ground layer species include *Eleocharis spp.* or *Marsilea spp*. in more frequently inundated sites tending toward a grassy ground layer in less frequently flooded sites. Occurs in flooded back swamps and old channels on Cainozoic alluvial plains or levees. Generally clay or sometimes texture contrast soils.
		11.3.9 *Eucalyptus platyphylla, Corymbia spp.* woodland on alluvial plains	*Eucalyptus platyphylla* with occasional trees of *Corymbia clarksoniana, Corymbia intermedia, Eucalyptus tereticornis or Lophostemon suaveolens* woodland to open woodland. A lower tree layer of *Melaleuca viridiflora* is occasionally present. This association has a grassy ground layer, with species including *Heteropogon contortus, Sorghum nitidum, Chrysopogon fallax, Alloteropsis semialata and Aristida holathera,* or in some situations with short grasses such as *Chloris spp., Fimbristylis dichotoma, Cyperus spp., Schizachyrium fragile* and *Ectrosia leporina*. Occurs on Cainozoic alluvial plains, on sandy surface with clay subsoil. Usually with "wet" influence, either closely adjacent to major river, or undergoes inundation relatively frequently. May occur in wet depressions.
Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis* Approximately 2,812.4 ha	Marlborough blue Grey-headed flying-fox Koala Ornamental snake Squatter pigeon White-throated needletail	11.3.4 *Eucalyptus tereticornis* and/or *Eucalyptus spp.* woodland on alluvial plains	*Eucalyptus tereticornis* woodland to open forest. Other tree species that may be present include *Eucalyptus camaldulensis, Corymbia tessellaris, Corymbia clarksoniana, Eucalyptus melanophloia, Eucalyptus platyphylla* or *Angophora floribunda. Eucalyptus crebra* and *Lophostemon suaveolens* may be locally common. A shrub layer is usually absent, and a grassy ground layer is prominent, and may include any of *Bothriochloa bladhii* subsp. *bladhii, Aristida spp., Heteropogon contortus, Dichanthium spp.* and *Themeda triandra*. Occurs on Cainozoic alluvial plains and terraces. Occurs on variety of soils, including deep cracking clays, medium to fine textured soils, and deep texture-contrast soils.

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
Eucalyptus woodland on metamorphics or granitic Approximately 5,906.9 ha	Grey-headed flying fox Koala White-throated needletail	11.11.10 *Eucalyptus melanophloia* woodland on deformed and metamorphosed sediments and interbedded volcanics	*Eucalyptus melanophloia +/- Eucalyptus crebra +/- Corymbia dallachiana +/- Corymbia erythrophloia* grassy or occasionally shrubby woodland or low woodland. Occurs on moderately to strongly deformed and metamorphosed sediments and Permian sediments.
	Marlborough blue Grey-headed flying fox Koala White-throated needletail	11.11.15 *Eucalyptus crebra* woodland to open woodland on deformed and metamorphosed sediments and interbedded volcanics	*Eucalyptus crebra +/- Corymbia erythrophloia +/- Eucalyptus populnea +/- Eucalyptus melanophloia +/- Corymbia tessellaris +/- Corymbia clarksoniana* woodland to open woodland often with a shrubby layer. *Eucalyptus exserta* and *Eucalyptus platyphylla* present in central coastal part of bioregion. Occurs on undulating rises and low hills, often with distinct strike pattern formed on moderately to strongly deformed and metamorphosed sediments and interbedded volcanics and Permian sediments.
		11.11.3 *Corymbia citriodora, Eucalyptus crebra, Eucalyptus acmenoides* open forest on old sedimentary rocks with varying degrees of metamorphism and	*Corymbia citriodora, Eucalyptus crebra* and *E. acmenoides* open forest often with a *Allocasuarina torulosa* and whipstick *Lophostemon confertus* and/or *Xanthorrhoea spp.* and *Macrozamia spp*. tall shrub or low tree layer. Generally occurs on sub-coastal hills and ranges formed on moderately to strongly deformed and metamorphosed sediments and interbedded volcanics

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
		folding. Coastal ranges	
		11.12.1 *Eucalyptus crebra* woodland on igneous rocks	*Eucalyptus crebra +/- Corymbia erythrophloia* woodland to open woodland. *Eucalyptus. melanophloia* is rarely present and may be locally dominant. Also includes localised areas may be dominated by *Eucalyptus persistens*. Occurs on ranges on igneous rocks.
		11.12.2 *Eucalyptus melanophloia* woodland on igneous rocks	*Eucalyptus melanophloia and Corymbia erythrophloia +/- Eucalyptus. populnea* grassy woodland. *Eucalyptus moluccana* sometimes present on colluvial lower slopes. Occurs on undulating rises and low hills formed from Mesozoic to Proterozoic igneous rocks.
		11.12.3 *Eucalyptus crebra, Eucalyptus tereticornis, Angophora leiocarpa* woodland on igneous rocks especially granite	*Eucalyptus crebra, Eucalyptus tereticornis +/- Angophora leiocarpa* and *Eucalyptus melanophloia* woodland. Other tree species that may be present include *Corymbia clarksoniana, Corymbia tessellaris, Corymbia erythrophloia, Corymbia citriodora and Eucalyptus exserta.* There is usually a low tree layer with species including *Alphitonia excelsa* and *Petalostigma pubescens*. Occurs on hills and lower slopes derived from granitic rocks.
		11.12.6a *Corymbia citriodora* open forest on igneous rocks (granite)	*Eucalyptus crebra +/- Corymbia citriodora and/or Eucalyptus acmenoides +/- Lophostemon suaveolens* woodland to open forest

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
Brigalow woodland Approximately 284.1 ha	Brigalow TEC Grey-headed flying fox White-throated needletail	11.12.21 *Acacia harpophylla* open forest on igneous rocks. Colluvial lower slopes	*Acacia harpophylla* open forest with or without semi-evergreen vine thicket species. A moderately tall dense shrub layer of *Geijera parviflora* and *Eremophila mitchellii* may occur where semi-evergreen vine thicket species are absent. Lower shrubs of *Carissa ovata, Alectryon sp*. and *Capparis spp*. may also be present. Occurs on Mesozoic to Proterozoic igneous rocks on colluvial lower slopes of volcanic hills and strongly undulating plains. Soils range from moderately deep cracking clays to clay loams and deep texture contrast soils.
		11.3.1 *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains	*Acacia harpophylla* and/or *Casuarina cristata* open forest (particularly in southern parts), with or without scattered emergent *Eucalyptus spp*. such as *E. coolabah, E. largiflorens, E. populnea, E. orgadophila, and E. woollsiana*. A low tree layer dominated by *Geijera parviflora* and *Eremophila mitchellii* is usually present. The vegetation sometimes occurs as low open forest or woodland. The ground stratum is usually sparse. Associated with Cainozoic alluvial plains which may be occasionally flooded. Landforms range from level to very gently sloping plains, alluvial flats, drainage floors, back-swamps and abandoned channels. Associated soils are predominantly deep to very deep cracking clays, sometimes with gilgai or texture contrast soils with sandy surface (particularly where Eucalyptus populnea is present).
Modified grasslands Approximately 24,043.3 ha	Squatter pigeon Glossy ibis White-throated needletail	Non-remnant vegetation	Non-remnant vegetation
Semi-evergreen vine thicket Approximately 2,654.8 ha	White-throated needletail	11.11.18 Semi-evergreen vine thicket on old sedimentary rocks with varying degrees of metamorphism and folding	Semi-evergreen vine thicket. Occurs on undulating plains, rises and gentle slopes of ranges formed on moderately to strongly deformed and metamorphosed sediments and interbedded volcanics

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
	White-throated needletail	11.12.4 Semi-evergreen vine thicket and microphyll vine forest on igneous rocks	*Araucaria cunninghamii* is a common emergent from the general canopy layer. Canopy species include *Falcataria toona, Ficus virens, Canarium australianum, Alstonia scholaris, Planchonella pohlmaniana, Cleistanthus dallachyanus* and *Backhousia citriodora.* Common shrub or understorey species are *Mackinlaya macrosciadea, Baloghia inophylla, Polyalthia nitidissima, Bosistoa medicinalis and Aglaia sapindina*. The sparse ground layer includes species such as *Scleria sphacelata* and *Adiantum hispidulum*. Vines and epiphytes are common and include *Microsorum punctatum, Cissus oblonga, Smilax australis* and *Pisonia aculeata. Eucalyptus moluccana* often associated with lower slopes on sandy sites. Occurs on low hills, ranges and boulder strewn slopes formed from Mesozoic to Proterozoic igneous rocks including granite.
	Black ironbox Ornamental snake White-throated needletail	11.3.11 Semi-evergreen vine thicket on alluvial plains	Semi-evergreen vine thicket or semi-deciduous notophyll vine forest, frequently with emergent *Eucalyptus tereticornis or Eucalyptus raveretiana.* Common species include *Diospyros humilis, Diospyros geminata, Brachychiton australis, Brachychiton rupestris, Geijera salicifolia, Lysiphyllum spp., Mallotus philippensis* and *Streblus brunonianus*. Occasional shrubs such as *Carissa ovata* may occur. Forbs such as *Nyssanthes spp*. may also be present. Occurs on Cainozoic alluvial plains.
Eucalyptus populnea woodland on alluvial floodplains Approximately 1,460 ha	Weeping Myall woodland Grey-headed flying-fox Koala Ornamental snake Squatter pigeon White-throated needletail	11.3.2 *Eucalyptus populnea* woodland on alluvial plains	*Eucalyptus populnea* woodland to open woodland. Occasionally, *Eucalyptus melanophloia* or *Eucalyptus crebra* may be present. A secondary tree layer may occur and include species such as *Geijera parviflora, Eremophila mitchellii, Acacia salicina, Cassia brewsteri,* and *Acacia excelsa.* The ground layer is dominated by a range of tussock grasses, including *Chloris spp., Enteropogon spp.* and *Aristida spp*. Occurs on Cainozoic alluvial plains with variable soil types including texture contrast, deep uniform clays, massive earths and sometimes cracking clays.

Habitat Short Description and Approximate Extent	MNES	Corresponding RE and/or Wetland Type	RE or Wetland Description
Estuarine waterbody Approximately 357.3 ha	Estuarine crocodile Black-tailed godwit Caspian tern Common greenshank Common sandpiper Curlew sandpiper Eastern osprey Latham's snipe Marsh sandpiper Pectoral sandpiper Red-necked stint Sharp-tailed sandpiper White-throated needletail	Estuarine waterbody	Estuarine wetlands are located in areas where a river, or other freshwater source, meets the sea.

3.5.2 Waterways and Fish Passage

The Project Area intersects five waterways that are shown on the spatial data layer Queensland Waterways for waterway barrier works (Figure 3-2):

- Unnamed creek, which is mapped as a Low Risk (green) waterway
- Unnamed creek, which is mapped as a Low Risk (green) waterway
- Limestone Creek, which is mapped as a High Risk (red) waterway
- Fitzroy River, which is mapped as a Major Risk (purple) waterway
- Lion Creek, which is mapped as a Major Risk (purple) waterway.

The Project Area is not mapped within a Declared Fish Habitat Area or within tidal waterways.

3.5.3 Connectivity

The Project Area is situated close to the city of Rockhampton, and mainly intersects pastoral land which supports non-remnant vegetation. Native vegetation communities within the Project Area occur mostly as isolated patches, generally surrounding wetlands and other water bodies. The fauna habitat within the Project Area is not physically connected to any significant regional fauna corridors.

Although modified, palustrine and lacustrine wetlands, especially during non-drought conditions, are likely to provide large scale movement opportunities for amphibians and reptiles.

3.5.4 Wetlands

The western side of Rockhampton is surrounded by an ‘Important Bird Area or Key Biodiversity Area (as identified by BirdLife Australia and BirdLife International). The Fitzroy River Floodplain and Delta Important Bird Area extends from Yaamba to the coast at Port Alma and is approximately 98,743 ha in size and is also listed in the Australian Government Department of Agriculture, Water and the Environment’s Directory of Important Wetlands of Australia (DIWA). The Fitzroy River floodplain extends north-west from Rockhampton and largely consists of cleared and grazed land that generally extends to the banks of dissecting streams. In some places it is bordered by remnant woodland along drainage channels or punctuated by heavily disturbed sedgeland and marsh with aquatic macrophytes associated with ephemeral lagoons (BirdLife International, 2021).

Within the Fitzroy River Floodplain and Delta Important Bird Area, and to the south of the Project Area, exists a mosaic of wetlands of varying sizes, depths and hydroperiods. The wetlands include Pink Lily Lagoon, Lotus Lagoon, Lower Gracemere Lagoon, Crescent Lagoon and Murray Lagoon (which can be described as floodwater lagoons/wetlands) as well as the semi-permanent pools within the defined natural course of Lion Creek.

For the purpose of this report, wetlands have been described by their associated lagoon/s. The Project Area directly intersects the following wetlands:

- Pink Lily Lagoon, including the small lagoon west of Von Allmen Road
- Lotus Lagoon, including waterbodies east and west of Nine Mile Creek Road
- Dunganweate Lagoon, including the small lagoon directly south
- Nelson Lagoon

In addition, the Project Area is adjacent to the following wetlands:

- Black Duck Lagoon
- Crescent Lagoon
- Murray Lagoon
- Capricorn Highway wetland.

These wetlands are contiguous, forming part of the wider Fitzroy River floodplain and are recharged from the local Neerkol and Lion Creek catchments. The Pink Lily Lagoon is also recharged during major Fitzroy River flood events, during which significant overbank flow occurs at the Pink Lily Meander. This results in flood flows spreading over the broad floodplain to the west and south of Rockhampton. This floodwater re-joins the Fitzroy River south of the city at Gavial Creek. Major floods can last for several weeks.

Lion and Neerkol Creek catchments are characterised by steep, rapid response upper catchments and broad, gently graded lower catchments with numerous wetlands where the lower catchment has limited channel definition and serves as a sediment deposition zone. These creeks also share the lower catchment with Fitzroy River break out flows. Lion Creek and Neerkol Creek are responsible for recharging lagoons and pastures across the local catchment and have significant flood extents in large events, with the Neerkol Creek the dominant system.

Wetlands are significant landscape features, and provide important bird habitat (Queensland Wetlands Program, 2013) consisting of:

- Diverse mosaics of wetlands ranging from permanent deep-water habitats through to ephemeral swamps that support migratory shorebirds
- Regionally significant breeding populations of waterfowl, including cotton pygmy geese, black swans, black-necked storks, magpie geese and brolgas
- A seasonally dry environment but with a number of permanent freshwater lagoons and at least one perennial stream fed by groundwater.

The wetlands within and adjacent to the Project Area are shown on Figure 3-2 and are described in Section 3.2.2.

The majority of the wetlands within and adjacent to the Project Area are highly variable in terms of their size, depth, bank profile, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the Austral summer when most migratory shorebird populations are in Australia. Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to migratory shorebirds, is also highly variable between years and within seasons. As a result, an identified important habitat area at any given wetland, defined by the presence of 18 birds or more for Latham's snipe, or 0.1% of a flyway population of any other migratory shorebird species, may only constitute important habitat once in a series of consecutive years, and may not be considered important habitat on a consistent or predictable annual basis (e.g. when dry).

In a broader local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain and Delta collectively comprise important habitat for Latham's snipe, and possibly for other migratory shorebird species.

3.5.5 Desktop Records of Threatened Fauna Species

The desktop assessment identified 31 threatened fauna species with the potential to occur within the Project Area (AECOM, 2020d). These species and their conservation status under the EPBC Act and NC Act are detailed in Table 3-10.

Table 3-10 Threatened fauna species with the potential to occur within the Project Area

Scientific Name	Common Name	EPBC Act Status	NC Act Status
Birds			
Botaurus poiciloptilus	Australasian bittern	Endangered	-
Calidris ferruginea	curlew sandpiper	Critically Endangered / Migratory	Endangered
Erythrotriorchis radiatus	red goshawk	Vulnerable	Endangered
Geophaps scripta	squatter pigeon (southern)	Vulnerable	Vulnerable
Hirundapus caudacutus	white-throated needletail	Vulnerable / Migratory	-
Limosa lapponica menzbieri	northern Siberian bar-tailed godwit	Critically Endangered	Endangered
Neochmia ruficauda	star finch	Endangered	Endangered
Poephila cincta	black-throated finch (southern)	Endangered	Endangered
Rostratula australis	Australian painted snipe	Endangered	Vulnerable
Turnix melanogaster	black-breasted button quail	Vulnerable	Vulnerable
Mammals			
Chalinolobus dwyeri	large-eared pied bat	Vulnerable	Vulnerable
Dasyurus hallucatus	northern quoll	Endangered	-
Macroderma gigas	ghost bat	Vulnerable	Endangered
Nyctophilus corbeni	Corben’s long-eared bat	Vulnerable	Vulnerable
Petauroides volans	greater glider	Vulnerable	Vulnerable
Phascolarctos cinereus	koala	Vulnerable	Vulnerable
Pteropus poliocephalus	grey-headed flying-fox	Vulnerable	-
Reptiles			
Crocodylus porosus	estuarine crocodile	-	Vulnerable
Delma torquata	collared delma	Vulnerable	Vulnerable

Scientific Name	Common Name	EPBC Act Status	NC Act Status
Denisonia maculata	ornamental snake	Vulnerable	Vulnerable
Egernia rugosa	Yakka skink	Vulnerable	Vulnerable
Elseya albagula	white-throated snapping turtle	Critically Endangered	Endangered
Furina dunmalli	Dunmall's snake	Vulnerable	Vulnerable
Hemiaspis damelii	grey snake	-	Endangered
Rheodytes leukops	Fitzroy River turtle	Vulnerable	Vulnerable
Fish			
Maccullochella peelii	Murray cod	Vulnerable	-

3.5.6 Desktop Records of Migratory Fauna

The desktop assessment identified an additional 23 migratory species (excluding those listed in Table 3-10) with the potential to occur within and adjacent to the Project Area (AECOM, 2020d). These species and their respective conservation status under the EPBC Act and NC Act are detailed in Table 3-11.

Table 3-11 Migratory fauna species with the potential to occur within the Project Area

Scientific Name	Common Name	EPBC Act Status	NC Act Status
Migratory Marine Birds			
Apus pacificus	fork-tailed swift	Migratory Special	Least Concern
Calonectris leucomelas	streaked shearwater	Migratory Special	Least Concern
Hydroprogne caspia	Caspian tern	Migratory Special	Least Concern
Macronectes giganteus	southern giant petrel	Migratory Special	Least Concern
Plegadis falcinellus	glossy ibis	Migratory Special	Least Concern
Sterna albifrons	little tern	Migratory Special	Least Concern
Thalassarche impavida	Campbell albatross	Migratory Special	Least Concern
Migratory Terrestrial Species			
Cuculus optatus	oriental cuckoo	Migratory Special	Least Concern
Monarcha melanopsis	black-faced monarch	Migratory Special	Least Concern

Scientific Name	Common Name	EPBC Act Status	NC Act Status
Monarcha trivirgatus	spectacled monarch	Migratory Special	Least Concern
Myiagra cyanoleuca	satin flycatcher	Migratory Special	Least Concern
Rhipidura rufifrons	rufous fantail	Migratory Special	Least Concern
Migratory Wetland Species			
Actitis hypoleucos	common sandpiper	Migratory Special	Least Concern
Calidris acuminata	sharp-tailed sandpiper	Migratory Special	Least Concern
Calidris ruficollis	red-necked stint	Migratory Special	Least Concern
Calidris melanotos	pectoral sandpiper	Migratory Special	Least Concern
Gallinago hardwickii	Latham's snipe	Migratory Special	Least Concern
Limosa	black-tailed godwit	Migratory Special	Least Concern
Limosa lapponica	bar-tailed godwit	Migratory Special	Least Concern
Pandion haliaetus	eastern osprey	Migratory Special	Least Concern
Tringa glareola	wood sandpiper	Migratory Special	Least Concern
Tringa nebularia	common greenshank	Migratory Special	Least Concern
Tringa stagnatilis	marsh sandpiper	Migratory Special	Least Concern

3.5.7 Desktop of Migratory Bird Records

The eBird Australia and BirdLife Australia Birdata databases hold records of the following previously identified migratory birds:

- Black-tailed godwit (*Limosa limosa*), 2018 – multiple records within 5 km of the Project Area
- Caspian tern (*Hydroprogne caspia*), 2018 – greater than 10 records within the Project Area
- Common greenshank (*Tringa nebularia*), 2016 – one record approximately 1.5 km from the Project Area
- Eastern osprey (*Pandion haliaetus*), 2017 – one record approximately 1.5 km from the Project Area
- Latham's snipe (*Gallinago hardwickii*), 2018 – greater than 10 records within 5 km of the Project Area
- Little curlew (*Numenius minutus*) (undated) – one record approximately 3 km from the Project Area
- Little tern (*Sterna albifrons*), 2017 – one record approximately 1.5 km from the Project Area
- Marsh sandpiper (*Tringa stagnatilis*), 2018 – greater than 5 records within 5 km of the Project Area

- Red-necked stint (*Calidris ruficollis*), 2018 – one record approximately 1.5 km from the Project Area
- Sharp-tailed sandpiper (*Calidris acuminata*), 2018 – multiple records within 5 km of the Project Area
- Western Alaskan bar-tailed godwit (*Limosa lapponica baueri*), 2016.

3.5.8 Field Survey Results

3.5.8.1 Fauna Species Richness

A total of 153 fauna species were recorded during the survey program, comprised of the following:

- Four amphibians
- Nine reptiles
- 18 mammals
- 122 bird species.

All species observed were typical for the region and habitat types recorded within the Project Area. The full species list is provided in the Terrestrial Fauna and Migratory Birds Technical Report (AECOM, 2020d) and the Migratory Bird Survey Report (Jacobs SMEC Design Joint Venture, 2021a)

3.5.8.2 Birds

A total of 122 bird species was detected during the survey program or as incidental sightings. Of these species, 45 were waterbirds or shorebirds, including the following eight listed migratory bird species:

- Latham's snipe (*Gallinago hardwickii*)
- Marsh sandpiper (*Tringa stagnatilis*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- Black-tailed godwit (*Limosa limosa*)
- Caspian tern (*Hydroprogne caspia*)
- White-winged black tern (*Chlidonias leucopterus*).
- Eastern osprey (*Pandion cristatus*)
- Glossy ibis (*Plegadis falcinellus*).

The remaining bird species were all woodland bird species commonly associated with eucalypts and known to occur in modified areas.

3.5.8.3 Mammals

Eighteen mammal species have been recorded during the field surveys, comprised of the following:

- Two arboreal mammals
- Two macropod (i.e. plant eating marsupial mammals including kangaroos and wallabies) species
- Five exotic pest species
- Nine bat species.

A single black flying-fox was detected during spotlighting. No threatened mammal species were recorded during the field surveys.

Eight microbat species were confirmed using the microchiropteran ultrasonic call detectors. A total of 4,395 distinct bat calls were recorded across 23 detector nights at six sites from 6 February to 14 February 2019. Bat calls were positively identified to one of eight distinct species, plus two species groups (*Chalinolobus morio*/*Vespadelus troughtoni* and *Nyctophilus* spp.) within which the species cannot be reliably differentiated.

The *Nyctophilus* species group comprised *N. geoffroyi*; *N. gouldi*; and *N. bifax*. The threatened *N. corbeni* was not listed as a potential species responsible for the *Nyctophilus* calls. Approximately 50% (2,108) of the identified calls captured by the detectors belonged to just one species: *Miniopterus australis*. Over 57% of all distinct bat calls occurred in the fringing riparian habitat, including almost 75% of the total *M. australis* calls.

No calls from the threatened large-eared pied bat (*Chalinolobus dwyeri*) or ghost bat (*Macroderma gigas*) were detected on the ultrasonic recorders during the survey period. The complete Microbat Call Identification Report is included in Appendix B of the Terrestrial Fauna and Migratory Birds Technical Report (AECOM, 2020d).

Koalas (*Phascolarctos cinereus*) may occur in the Project Area. During the field survey, no koalas were observed in the Project Area; however one recent record (2011) is available within 10 km. Koalas were actively searched for in the Project Area, including spotlighting on foot using head torches and hand-held spotlights was also undertaken in areas of representative habitat such as riparian woodlands. A total of 36 person hours of spotlighting surveys were completed across 5 sites within the Project Area.

3.5.8.4 Reptiles and Amphibians

A relatively low diversity of reptiles (nine species) and amphibians (four species) were recorded during the AECOM 2019 field surveys. All reptiles recorded were all common and known to occur in woodland habitats or urban environments, including the following:

- Common tree snake (*Dendrelaphis punctulatus*)
- Eastern bearded dragon (*Pogona barbata*)
- Keelback snake (*Tropidonophis mairii*)
- Wall skink (*Cryptoblepharus virgatus*).

The results from the desktop review concluded that Project Area may provide suitable habitat for the ornamental snake (*Denisonia maculata*). Field survey timing was appropriate given the species' peak activity period; however climatic conditions were not ideal for the detection of ornamental snake with unseasonably dry conditions. During dry times, this species can remain 'inactive in suitable shelter sites for months' (Australian Government Department of Agriculture, Water and the Environment, 2021e). Although targeted during spotlighting, the ornamental snake was not recorded nor any other threatened reptile species.

The ornamental snake principally has a diet of native frogs. Surveys confirmed the presence of four amphibian species (including the cane toad) in the Project Area; although frog activity throughout the Project Area was low in most areas. Cane toads (*Rhinella marina*); however, were frequently recorded and are a known threat to the ornamental snake due to poisoning after ingestion and they also compete with native amphibians for food, shelter and breeding sites. Wetlands and some riparian zones investigated during the field survey provided some microhabitat features suitable for ornamental snake with cracking clays and prey species present. However, habitat was considered to be marginal due to the abundance of cane toads, low abundance of woody debris, heavy weed infestation and lack of gilgai formation or brigalow communities.

During one evening of spotlighting in February 2019, over 21 keelbacks were recorded foraging on juvenile cane toads.

The following three amphibians were recorded during the field surveys:

- Desert tree frog (*Litoria rubella*)
- Eastern sedge frog (*Litoria fallax*)
- Roth's tree frog (*Litoria rothii*).

The only introduced amphibian identified during the field surveys was the cane toad (*Rhinella marina*). Native frog abundance was low relative to the high abundance of cane toads, especially in wetland areas.

3.5.8.5 Targeted Survey Results

Targeted field surveys were undertaken to confirm the presence of species predicted to be in the Project Area based on desktop assessment and recorded observations, but not recorded in previous field surveys for the Project.

3.5.8.5.1 Turtle Habitat Survey at Fitzroy River and Limestone Creek 2019

In June 2019 AECOM (AECOM, 2020e) undertook an aquatic ecology investigation for the Business Case phase of the Project. This assessment included a targeted survey aimed at establishing the presence or potential presence of two threatened turtle species:

- White-throated snapping turtle (*Elseya albagula*) listed as critically endangered under the EPBC Act and the NC Act
- Fitzroy River turtle (*Rheodytes leukops*) listed as vulnerable under both EPBC Act and NC Act.

The assessment identified the following:

- Two records of Fitzroy River turtle and six records of white-throated snapping turtle within 20 km of the Project Area
- Both species are highly likely to occur in the Fitzroy River
- Despite lack of riffle zones (i.e. areas of broken water with rapid current) and high-quality nesting habitat, the Fitzroy River within the Project Area does provide potential foraging and dispersal habitat for the White-throated snapping turtle
- Preferred habitat for the Fitzroy River turtle was not recorded however the species is known from the Fitzroy River and the Project Area may provide dispersal and foraging opportunities
- Lagoons in the Project Area did not provide suitable habitat
- No nesting habitats was recorded.

The Threatened Turtle & Fish Habitat Assessment (AECOM, 2020e) report is provided in Appendix B.

3.5.8.5.2 Turtle Habitat Survey at Fitzroy River and Limestone Creek 2021

In December 2020, Ecosure (Ecosure, 2021a) completed an assessment of habitat for the following two threatened turtle species within the Project Area at the Fitzroy River and Limestone Creek:

- White-throated snapping turtle (*Elseya albagula*) listed as critically endangered under the EPBC Act and the NC Act
- Fitzroy River turtle (*Rheodytes leukops*) listed as vulnerable under both EPBC Act and NC Act.

The turtle habitat assessment identified the following:

- Suitable foraging and dispersal habitat for the white-throated snapping turtle and the Fitzroy River turtle was identified on the western and eastern bank of the Fitzroy River
- Limestone Creek did not support suitable habitat for either threatened turtle species.

The Turtle Habitat Assessment (Ecosure, 2021a) report is provided in Appendix B.

3.5.8.5.3 Migratory Shorebird Species – 2019

The following five bird species, all of which are listed as ‘migratory’ under the EPBC Act, were recorded during the field survey undertaken in 2019 (AECOM, 2020d):

Latham's snipe (*Gallinago hardwickii*)

- During the 2019 migratory bird survey, 14 individuals were recorded in the main lagoon section of Pink Lily Lagoon. In the week prior to this survey, a single Latham’s snipe was recorded in the small lagoon directly east of Von Allmen Road considered to be part of Pink Lily Lagoon.

Caspian tern (*Hydroprogne caspia*)

- During the 2019 migratory bird survey, this species was recorded at Pink Lily Lagoon (approximately 10 individuals), Nelson (single individual flying overhead) and Murray Lagoon (single individual flying overhead).

Eastern osprey (*Pandion cristatus*)

- During the 2019 migratory bird survey, one individual of this species was recorded at Yeppen Lagoon, located east of the Project Area.

Glossy ibis (*Plegadis falcinellus*)

- During the 2019 migratory bird survey, this species was recorded at Pink Lily (three individuals), Lotus (single individual) and Nelson Lagoon (single individual) actively foraging in the shallow wetted areas where aquatic vegetation was abundant. Single individuals were observed at each lagoon.

Marsh sandpiper (*Tringa stagnatilis*)

- During the 2019 migratory bird surveys, a single individual of this species was recorded at Pink Lily Lagoon.

3.5.8.5.4 Migratory Shorebird Species – 2020

The following two bird species, all of which are listed as 'migratory' under the EPBC Act, were recorded during the 2020 migratory bird survey (AECOM, 2020b):

Latham's snipe (*Gallinago hardwickii*)

- During the 2019 migratory bird survey, 14 individuals were recorded in the main lagoon section of Pink Lily Lagoon. In the week prior to this survey, a single Latham's snipe was recorded in the small lagoon directly east of Von Allmen Road considered to be part of Pink Lily Lagoon.

Caspian tern (*Hydroprogne caspia*)

- During the 2019 migratory bird survey, this species was recorded at Pink Lily Lagoon (approximately 10 individuals), Nelson (single individual flying overhead) and Murray Lagoon (single individual flying overhead).

3.5.8.5.5 Migratory Shorebird Species – 2021

The following eight bird species, all of which are listed as 'migratory' under the EPBC Act, were recorded during the migratory bird survey (Jacobs SMEC Design Joint Venture, 2021a):

Latham's snipe (*Gallinago hardwickii*)

- A total of 45 individuals were recorded during Survey 1 across four wetlands (Woolwash Lagoon, Crescent Lagoon, Little Lion Lagoon, Murray Lagoon). Survey 2 saw only two individuals across two wetlands (Little Lion Lagoon, Woolwash Lagoon).

Caspian tern (*Hydroprogne caspia*)

- Eight individuals were observed overflying two wetlands during Survey 1. However, Survey 2 saw 14 individuals over seven wetlands.

Glossy ibis (*Plegadis falcinellus*)

- A total of 50 individuals were observed at five wetlands during Survey 1. Only 7 individuals were recorded across two wetlands during Survey 2.

Marsh sandpiper (*Tringa stagnatilis*)

- Four individuals were recorded at a single wetland (Padygole Lagoon) during Survey 2.

Sharp-tailed sandpiper (*Calidris acuminata*)

- A total of 22 individuals were recorded during Survey 1 across three wetlands (Sullivan Road Wetland, Crescent Lagoon, Lower Gracemere Lagoon). Survey 2 however saw only two individuals at one wetland (Sullivan Road Wetland).

Black-tailed godwit (*Limosa limosa*):

- A total of 40 individuals were recorded during Survey 1 at two wetlands (Padygole Lagoon, Lower Gracemere Lagoon). Survey 2 saw 20 individuals present at the same two wetlands.

Whiskered tern (*Chlidonias hydrida*):

- A total of 15 individuals were observed overflying four wetlands during Survey 1. A total of 12 individuals were observed over a single wetland during Survey 2.

White-winged black tern (*Chlidonias leucopteris*):

- Four individuals were observed flying over two wetlands during Survey 1, with only two individuals observed at a single wetland during Survey 2.

The locations where the above species were observed are shown on Figure 3-22.

3.5.8.5.6 Introduced Species

The following eight introduced fauna species were recorded during the field surveys:

- Asian house gecko (*Hemidactylus frenatus*)
- Brown hare (*Lepus capensis*)
- Common myna (*Sturnus tristis*)
- Cane toad (*Rhinella marina*)
- Cat (*Felis catus*)
- Feral pig (*Sus scrofa*)
- European rabbit (*Oryctolagus cuniculus*)
- European fox (*Vulpes vulpes*).

3.5.8.6 Fauna Habitats

The following eight habitat types (comprising eight REs and non-remnant vegetation) were identified within the Project Area during the field surveys:

- Lacustrine or palustrine wetland
- Riverine waterbody
- Fringing riparian woodland
- Fringing riparian woodland with *Eucalyptus raveretiana*
- Eucalyptus woodland on alluvial floodplains *with Eucalyptus tereticornis*
- Eucalyptus woodland on alluvial floodplain
- Eucalyptus woodland on metamorphics or granitic
- Brigalow woodland
- Modified grasslands.

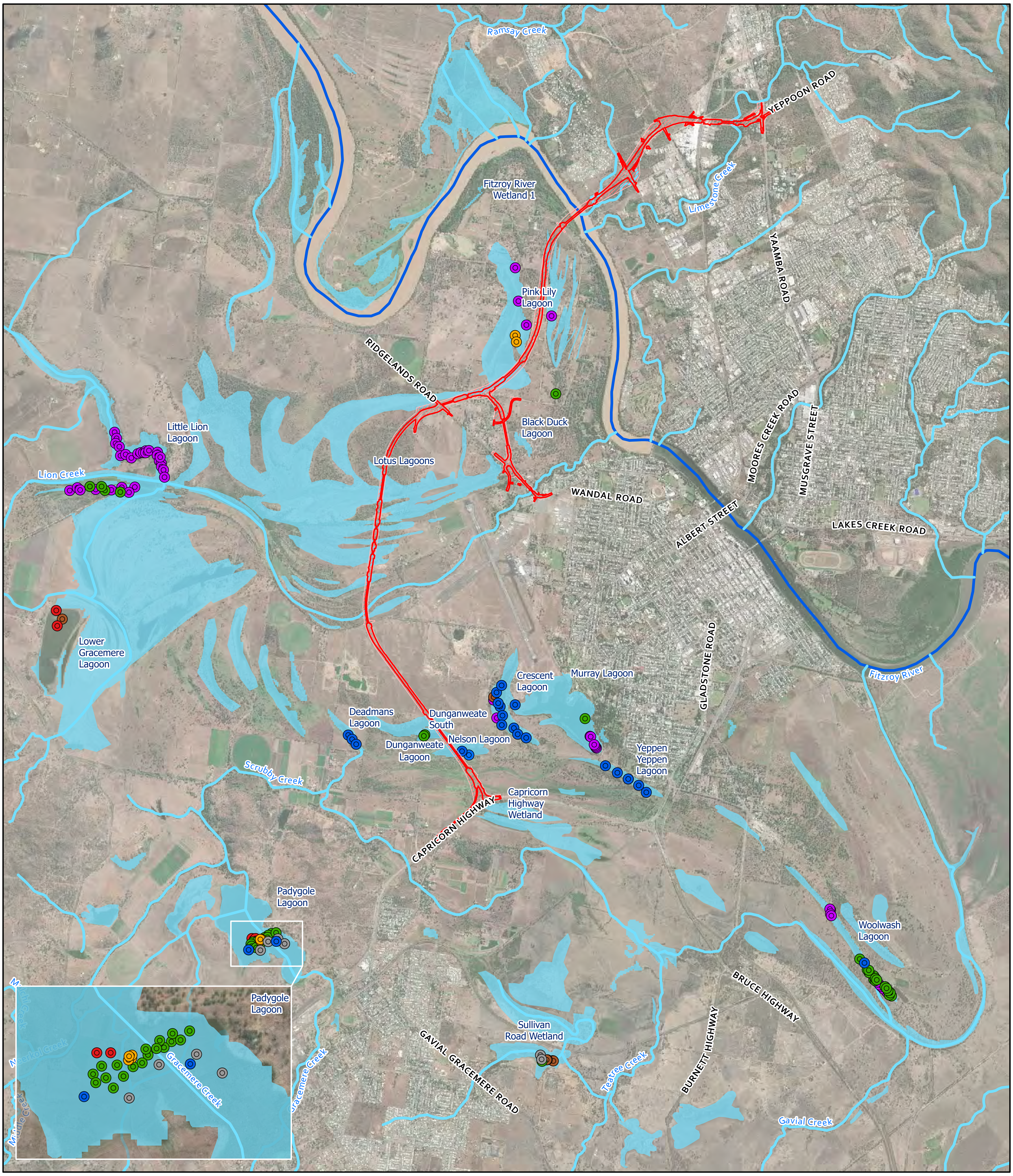
The fauna habitat types within the Project Area are shown in Figure 3-20 and Figure 3-21 and detailed in the following sections.

3.5.8.6.1 Lacustrine wetland

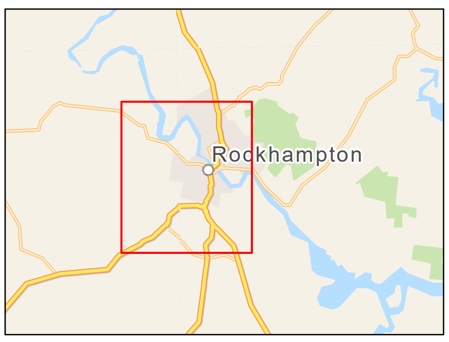
Lacustrine wetlands or lakes may have fringing vegetation, although the majority of the wetland area is open water. Natural lacustrine systems are generally over 8 ha in size and have deep, standing or slow-moving water. Lacustrine wetlands can exhibit ephemeral hydroperiods and support species adapted to these seasonal changes, while others remain inundated for long periods and provide a refuge for many species during periods of extended drought (Queensland Government Department of Environment and Science, 2021c).

Based on Queensland Department of Environment and Science Wetland*Info* mapping, the Project Area intersects one lacustrine wetland, Pink Lily Lagoon. There are two other lacustrine wetlands downstream of the Project Area, Crescent Lagoon and Murray Lagoon.

Figure 3-22: Observed fauna species



Legend
JSDJV observation locations
- Black-tailed Godwit
- Caspian Tern
- Glossy Ibis
- Latham's Snipe
- Marsh Sandpiper
- Sharp-tailed Sandpiper
- White-winged Black Tern
- Major Watercourse
- Minor Watercourse
- Project Footprint
- Project Area
- HES Wetlands



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GDA 1994 MGA Zone 56

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Kilometers

Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: Roads, Railways, Watercourses (2020); AECOM/SMEC/JV: Bird Records (2021); Metromap: Imagery (2020)

Analogous RE

This vegetation community is analogous to RE 11.3.27a.

Vegetation Description

Vegetation ranges from open water with or without aquatic and emergent vegetation species such as *Chara spp.*, *Nitella spp*., *Myriophyllum verrucosum*, *Nymphaea violacea*, *Pyrgillus javanicus*, *Potamogeton crispus*, *Potamogeton tricarinatus*, *Ottelia ovalifolia*, *Vallisneria caulescens* and *Nymphoides indica*. A narrow fringing woodland commonly dominated by *E. camaldulensis* or *E. coolabah* but also a range of other tree species may be present. In dry seasonal conditions, non-woody vegetation may be completely absent from ephemeral waterbodies, with only bare claypans present. During drying-off periods, herbaceous species such as *Sesbania cannabina*, *Glinus lotoides* and *Cullen spp*. may be present and dominant on drying lake margins (Queensland Government Department of Environment and Science, 2021d).

Habitat Features

Pink Lily Lagoon had some stags and aquatic vegetation in the littoral zone. A dense fringe of 1 – 2 m tall *Persicaria orientalis* and *Urochloa mutica* surrounded much of the wetland. However, this fringing vegetation did experience significant dieback during the dryer winter months between the first and second migratory bird surveys (AECOM 2020, 2021), and almost complete dieback over the 2020/2021 spring/summer period during which the wetland was completely dry (Jacobs SMEC Design Joint Venture, 2021a). Vegetation in riparian zones varied but was generally considered non-remnant due to thinning; large Eucalypt trees were often present although isolated.

Whilst generally providing a permanent source of water, this community provides refuge for a variety of species, including amphibians, macropods, some reptiles and waterbirds and shorebirds. Muddy margins around these waterbodies are common, at some locations providing suitable shallow roosting and foraging habitat for migratory shorebirds such as the marsh sandpiper (*Tringa stagnatilis*) which was observed at Pink Lily lagoon in the 2019 surveys (AECOM, 2020b). Where dense shrubs were present, these also provided refuge for the listed migratory species, Latham's snipe, with 14 individuals being recorded at Pink Lily lagoon in the 2019 surveys (AECOM 2020). In the March 2021 migratory bird surveys, Pink Lily Lagoon was completely dry, with even the lowest parts of the lagoon showing no signs of water from some time (Jacobs SMEC Design Joint Venture, 2021a).

Cracks in the muddy margins or riparian fringe were also recorded. These provide potential habitat opportunities for reptiles such as the keelback snake (*Tropidonophis mairii*). This species was recorded at Lotus Lagoon in high abundance (19 individuals in <0.5ha) utilising these features while hunting cane toads (*Rhinella marina*). Other reptiles such as Krefft's turtle (*Emydura macquarii krefftii*) were also observed in this habitat type.

Freshwater mussels (*Hyridella* sp.) were occasionally observed in the water's edge. Freshwater mussels are highly sensitive to disturbance and pollution and require habitat that includes dense vegetation and large woody debris or boulders to stabilise the streambed sediments. A fish population is also a key requirement for the freshwater mussels' development during the larval stage of their life cycle (New South Wales Government Department of Planning, Industry and Environment, 2018). The presence of the mussel shells indicates that this habitat recently held these features.

Canopy trees in the riparian zones were large, and some obvious signs of bird nesting was observed. All lacustrine wetlands however were impacted to some degree, with cattle pugging and evidence of pest species such as pig (*Sus scrofa*) and fox (*Vulpes vulpes*) recorded.

The majority of these wetlands within and adjacent to the Project Area are highly variable in terms of their size, depth, bank profile, water permanency, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer when the majority of migratory shorebird populations are in Australia. The presence of water is often a good initial indicator of habitat suitability for migratory shorebirds, however there are additional considerations. In the Fitzroy River floodplain, the associated wetland mosaic exhibits a high degree of ephemerality, that is, the routine annual drying and seasonal inundation of waterways and wetlands.

Much of the wetland ecosystem will be dependent on this annual wetland cycling, such that extended periods of inundation in these areas can be detrimental to both macrophyte and macroinvertebrate (i.e. small animals that live for all, or part, of their lives in water) diversity and abundance and have resultative effects on waterbird and shorebird diversity and abundance. In such conditions, regardless of there being water present, there may be limited foraging resources available to migratory birds and other waterbirds until such time that the wetland has dried and re-filled once again.

Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to migratory shorebirds, is also highly variable between years and within seasons. As a result, suitable habitat areas at any given wetland at one time may only be suitable once in a series of consecutive years and may not provide suitable habitat on a consistent or predictable annual basis. In the broader local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain and Delta are expected to collectively provide a range of suitable habitat in differing locations at different times - every wetland within the Fitzroy River floodplain is not expected to provide suitable habitat on an annual consistent basis.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened or migratory fauna species:

Known:

- Black-tailed godwit (foraging and roosting)
- Caspian tern (foraging and roosting)
- Eastern osprey (foraging).
- Glossy ibis (foraging and roosting)
- Latham’s snipe (foraging and roosting)
- Marsh sandpiper (foraging and roosting)
- Sharp-tailed sandpiper (foraging and roosting)
- White-winged black tern (foraging and roosting)

Possible:

- Australian painted snipe (foraging and roosting)
- Common greenshank (foraging and roosting)
- Common sandpiper (foraging and roosting)
- Curlew sandpiper (foraging and roosting)
- Eastern osprey (foraging)
- Little curlew (foraging and roosting)
- Ornamental snake (breeding, foraging and dispersal)
- Pectoral sandpiper (foraging and roosting)
- Red-necked stint (foraging and roosting)
- Estuarine crocodile (foraging and dispersal)
- White-throated needletail (aerial foraging).
- Wood sandpiper (foraging and roosting)

3.5.8.6.2 Palustrine wetland

Palustrine wetlands are generally less than 8 ha in overall size and are heavily vegetated, non-riverine or non-channel systems. They can include billabongs, swamps, bogs, springs, soaks and marshes and typically have more than 30% emergent vegetation. They provide foraging and refuge habitat and breeding areas for a wide variety of species (Queensland Government Department of Environment and Science, Queensland, 2021b).

Based on Queensland Department of Environment and Science Wetland*Info* mapping, the Project Area intersects three palustrine wetlands, Dunganweate Lagoons, Nelson Lagoon and Lotus Lagoons. There are three other palustrine wetlands adjacent to the Project Area, Deadmans Lagoon, Black Duck Lagoon and Capricorn Lagoon, and a palustrine wetland downstream of the Project Area, Yeppen Lagoon.

Analogous RE

This vegetation community is analogous to RE 11.3.27c.

Vegetation Description

Vegetation is dominated by mixed sedges or grasses with areas of open water with or without aquatic vegetation species. Dominated by a range of species including *Eleocharis spp., Nymphoides spp*. and sometimes *Phragmites australis*. During drying or drought periods, such ephemeral waterbodies may be dominated by herbaceous species such as *Glinus lotoides* or exist as bare claypan. Occurs on closed depressions on alluvial plains that are intermittently flooded (Queensland Government Department of Environment and Science 2021).

Habitat Features

At the time of the 2019 AECOM surveys (AECOM, 2020f), all palustrine wetlands (analogous with RE 11.3.27c) were dry or had significantly receded. During the 2020 AECOM surveys (AECOM, 2020b), many of these wetlands held water and widespread significant rainfall prior to the survey. During the March 2021 surveys (Jacobs SMEC Design Joint Venture, 2021a), the majority of these wetlands were dry, with only Dunganweate and Nelson Lagoons still holding water. These wetlands are ephemeral, and when holding water, are relatively shallow due to the flat terrain, depth and gradual sloping banks. Areas of this habitat varied in size. West of Lotus Lagoon, ephemeral palustrine wetlands are expansive and are expected to provide suitable habitat for waterbirds migratory birds when inundated. In many areas this vegetation was decaying due to the prevailing dry conditions. The vegetation in the riparian zones varied but was generally considered non-remnant due to historic thinning with Eucalypt trees often present although only in low densities.

Key habitat values recorded in this community include cracking clays (although generally rare), as well as occasional hollow logs and woody debris; especially in the adjacent fringing vegetation. In the fringing vegetation, large eucalypt canopy trees were also present with some bearing small hollows and providing nesting opportunities. These large trees shelter areas adjacent to waterbodies (where present) and provide refuge for arboreal (i.e. living in trees) mammals and hollow dependent birds and bats.

Also notable was the high frequency of freshwater mussel shells in the ground layer. As discussed in Habitat Features of Section 3.5.8.6.1, freshwater mussels are considered an important indicator of a habitat's aquatic health and are a food source for other animals. The presence of the mussel shells indicates that this habitat held the features required for their survival at some point in recent history.

Due to the historic thinning in riparian zones, weeds, ongoing cattle grazing and drought conditions this habitat was considered heavily impacted. However, it is likely that during flood conditions when wetlands are holding water, the habitat provides high value to a number of conservation significant species, in particular a range of listed migratory birds as well as providing substantial fauna dispersal and connectivity opportunities for aquatic fauna.

The majority of these wetlands within and adjacent to the Project Area are highly variable in terms of their size, depth, bank profile, water permanency, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions.

As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer when most migratory shorebird populations are in Australia. The presence of water is often a good initial indicator of habitat suitability for migratory shorebirds, however there are additional considerations. In the Fitzroy River floodplain, the associated wetland mosaic exhibits a high degree of ephemerality, that is, the routine annual drying and seasonal inundation of waterways and wetlands. Much of the wetland ecosystem will be dependent on this annual wetland cycling, such that extended periods of inundation in these areas can be detrimental to macrophyte and macroinvertebrate diversity and abundance and have resultative effects on waterbird and shorebird diversity and abundance. In such conditions, regardless of there being water present, there may be limited foraging resources available to migratory birds and other waterbirds until such time that the wetland has dried and re-filled once again.

Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to migratory shorebirds, is also highly variable between years and within seasons. As a result, suitable habitat areas at any given wetland at one time may only be suitable once in a series of consecutive years and may not provide suitable habitat on a consistent or predictable annual basis. In the broader local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain and Delta are expected to collectively provide a range of suitable habitat in differing locations at different times - every wetland within the Fitzroy River floodplain is not expected to provide suitable habitat on an annual consistent basis.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species:

- Australian painted snipe (foraging and roosting)
- Black-tailed godwit (foraging and roosting)
- Caspian tern (foraging and roosting)
- Common greenshank (foraging and roosting)
- Common sandpiper (foraging and roosting)
- Curlew sandpiper (foraging and roosting)
- Eastern osprey (foraging).
- Estuarine crocodile (breeding/nesting, foraging and dispersal)
- Glossy ibis (foraging and roosting)
- Koala (breeding, foraging and dispersal)
- Little curlew (foraging and roosting)
- Latham’s snipe (foraging and roosting)
- Marsh sandpiper (foraging and roosting)
- Ornamental snake (breeding, foraging and dispersal)
- Pectoral sandpiper (foraging and roosting)
- Red-necked stint (foraging and roosting)
- Sharp-tailed sandpiper (foraging and roosting)
- Squatter pigeon (foraging, roosting and dispersal)
- White-throated needletail (aerial foraging)
- Wood sandpiper (foraging and roosting).

3.5.8.6.3 Riverine waterbody

Riverine waterbodies are freshwater systems contained within a channel (e.g. river, creek) and the vegetation on the banks. Water levels in riverine waterbodies can be highly variable, holding water permanently, periodically or remaining dry for long periods, and due to this variability, the species they support can be highly variable. Riverine waterbodies can be natural or artificial, and can connect to lacustrine, palustrine, estuarine and marine wetlands (Queensland Government Department of Environment and Science, 2021a).

Analogous RE

This vegetation community is analogous to RE 11.3.25f.

Vegetation Description

Riverine waterbodies are river channels with open water or exposed stream beds and bars. Usually devoid of emergent vegetation although scattered trees and shrubs such as *Melaleuca viminalis* or *Melaleuca* spp. may be present and aquatic species may be abundant particularly in waterholes, lagoons and backwaters (Queensland Government Department of Environment and Science, 2021d).

Habitat Features

Where the alignment crosses the Fitzroy River, the river is a large permanently flowing waterway upstream of the Fitzroy Barrage, which prevents tidal water from moving upstream. The river has a wetted width of approximately 250 m and a narrow backwater on the southern (right) bank approximately 80 m wide. At the time of the June 2019 survey (AECOM, 2020e), the riparian zone on both banks was well developed and dominated by large native trees including *Eucalyptus tereticornis* (river red gum) and *Melaleuca leucadendra*. On the southern bank the macrophyte community was dominated by the exotic species *Eichhornia crassipes*, *Hymenachne amplexicaulis* and *Salvinia molesta*. On the northern (left) bank, macrophyte communities were dominated by exotic species *Pistia stratiotes* and *Eichhornia crassipes*.

At the time of the June 2019 survey (AECOM, 2020e), the river was experiencing low flow and the water was very turbid with no riffle habitat present. The permanent open water would provide dispersal and foraging habitat for listed aquatic species including freshwater turtles and estuarine crocodiles, together with listed piscivorous (i.e. feeds on fish) birds such as Caspian terns, eastern osprey and glossy ibis.

At the time of the June 2019 survey (AECOM, 2020e), the top of bank was approximately 0.7 m – 1 m above the water surface. The northern bank consisted of loamy soils (i.e. soil with a mix of clay and sand with organic matter) and was vegetated with exotic grasses. The southern bank was heavily vegetated with very little exposed soil. This nesting habitat is generally not suitable for freshwater turtles but could potentially be utilised by estuarine crocodiles as they nest on high banks above tidal inundation, however they tend to prefer isolated swamps.

The backwater would provide a variety of foraging and dispersal/refuge habitats for aquatic species including shallow margins, deeper pools, overhanging vegetation, macrophytes, and runs following rainfall.

Riparian woodlands are discussed separately (Section 3.5.8.6.4) however also contribute to riverine waterbody habitat. The riparian zone provided shading to the edges of the channel where undercut banks, root tangles, woody debris and macrophytes were present, which would provide shading/refuge and food for aquatic species, refuge and food for the freshwater turtles (particularly the Fitzroy River turtle), foraging habitat for the estuarine crocodile, and roosting/nesting and opportunities for birds.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species:

- Caspian tern (foraging, roosting and dispersal)
- Eastern osprey (breeding/nesting, foraging, roosting and dispersal)
- Estuarine crocodile (breeding/nesting, foraging and dispersal)
- Fitzroy River turtle (foraging and dispersal)

- Glossy ibis (foraging, roosting and dispersal)
- White-throated snapping turtle (foraging and dispersal).

3.5.8.6.4 Fringing riparian woodland

Analogous RE

This vegetation community is analogous to RE 11.3.25 and RE 11.3.25a.

Vegetation Description

The riparian woodland on alluvium habitat was observed to largely be dominated by eucalypt species in the canopy layer. Patches of this habitat across the Project Area are minimal, present only along the Fitzroy River and drainage lines in the north (Limestone Creek) and south (Lion Creek). In the areas along the Fitzroy River and Lion Creek, *Eucalyptus tereticornis* was the dominant canopy species (RE 11.3.25), with other tree species such as *Eucalyptus coolabah* and *Melaleuca leucadendra* also common.

In the areas surrounding Limestone Creek, *Eucalyptus raveretiana* and *Melaleuca fluviatilis* dominated (RE 11.3.25a). The lower tree and shrub layer were dense, comprised of *Acacia salicina* and other species. The ground layer was also dense, largely dominated by introduced grasses. In contrast, along Lion Creek both the shrub and ground layer were sparse due to ongoing cattle grazing and thinning.

Habitat Features

Habitat values recorded in this community included fine litter in the ground cover, occasional fallen logs, nectar producing trees, and hollows in trees. Suitable habitat for several turtle species was present in pool habitat with the potential for riffle zones to form when flowing. These values, especially for reptiles and amphibians, were more prevalent in the northern areas of the Project Area (Limestone Creek) due to the greater amount of water present in the creek and absence of grazing cattle.

Previous surveys conducted by AECOM in Limestone Creek for the Rockhampton North Upgrade confirmed the presence of multiple freshwater turtle species including the saw-shell turtle (*Wollumbinia latisternum*) and Krefft's river turtle (*Emydura macquarii krefftii*). Vegetation in the understory of the fringing zones of Limestone Creek was structurally complex primarily due to an abundance of exotic flora species. These dense conditions provide suitable complexity and cover for a variety of woodland bird species.

Where this habitat occurred in the south of the Project Area (Lion Creek and associated drainage lines), it was primarily dry with only small pools of disconnected water present. At this location, vegetation in the fringing areas was not structurally complex with only large eucalypt canopy trees present. Hollows were rare to occasional but where present provide nesting opportunities for small arboreal mammals and woodland birds.

Although heavily grazed in most areas, the grassy understory present in habitat associated with Lion Creek is likely to provide foraging opportunities for macropods. Fauna connectivity opportunities also exist in this habitat, with drainage lines providing flyways and foraging habitat suitable for a number of microchiropteran bats, birds and large-bodied mammals.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species

- Estuarine crocodile (foraging and dispersal)
- Fitzroy River turtle (foraging and dispersal on Fitzroy River and Limestone Creek only)
- Grey-headed flying-fox (roosting, foraging and dispersal)
- Koala (breeding, foraging and dispersal)
- Squatter pigeon (dispersal)
- White-throated snapping turtle (foraging and dispersal on Fitzroy River and Limestone Creek only)
- White-throated needletail (aerial foraging).

3.5.8.6.5 Eucalyptus woodland on alluvial floodplain with Eucalyptus tereticornis

Analogous RE

This vegetation community is analogous to:

- High value regrowth 11.3.3
- RE 11.3.4 (with *Eucalyptus tereticornis*)
- High value regrowth 11.3.4 (with *Eucalyptus tereticornis*)

Vegetation Description

This open woodland to low open woodland was typically dominated by *Eucalyptus tereticornis* or *Eucalyptus coolabah* in the canopy. Other tree species frequently recorded in the canopy layer were *Corymbia tessellaris* and *Eucalyptus crebra*. Scattered patches of this habitat occur across the Project Area on alluvial floodplains and include areas of high value regrowth (RE 11.3.3 and RE 11.3.4) and remnant (RE 11.3.4). The shrub layer was generally sparse and predominately comprised of the weeds *Leucaena leucocephala* and *Cryptostegia grandiflora* (rubbervine). The ground layer was dense, largely dominated by introduced grasses, especially *Megathyrsus maximus* (Guinea grass).

Disturbance across the habitat areas is prevalent, with historic clearing and thinning events as well as ongoing grazing evident.

Habitat Features

Key habitat values recorded in this community include fine litter in the ground cover, fallen logs and decorticating (i.e. peeling) bark. These microhabitat features provide habitat opportunities for a variety of common reptile species, four of which were recorded in this habitat. Koala food trees (*Eucalyptus* spp. and *Corymbia* spp.) were abundant, indicating the potential utilisation of this habitat by koalas. When in flower, these genera generally provide foraging opportunities for nectivorous (i.e. feeds on nectar) birds and flying-foxes. Mistletoes were also present on large trees in this habitat type. Mistletoe has dense foliage suitable for insects, provides nectar and fruit as well as nesting opportunities for woodland birds. Arboreal termitaria (i.e. termite colony) were occasionally recorded and provide nesting opportunities for birds such as the forest kingfisher (*Todiramphus macleayii*) which was recorded. Small hollows in large canopy trees were present, but generally rare. These may provide nesting opportunities for woodland birds and small arboreal mammals such as squirrel glider (*Petaurus norfolcensis*) which was observed in this habitat type. Large tree hollows, suitable for owls and cockatoos, were absent.

Although evidence of cattle grazing was present in majority of this habitat, the dense grassy understory also makes it well suited to macropod foraging and dispersal; the eastern grey kangaroo (*Macropus giganteus*) and agile wallaby (*Macropus agilis*) were both recorded.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species:

- Grey-headed flying-fox (roosting, foraging and dispersal)
- Koala (breeding, foraging and dispersal)
- Ornamental snake (breeding, foraging and dispersal)
- Squatter pigeon (southern) (dispersal)
- White-throated needletail (aerial foraging).

3.5.8.6.6 Eucalyptus woodland on metamorphics or granitic

Analogous RE

This vegetation community is analogous to RE 11.11.15.

Vegetation Description

This habitat type is a woodland dominated by *Eucalyptus crebra* (narrow-leaved ironbark) and *Corymbia dallachiana* (Dallachy's gum) in the canopy layer (approximately 14 m height), located on deformed and metamorphosed sediments (analogous with RE 11.11.15). Within the Project Area, this habitat occurs in two areas adjacent to an industrial precinct north of the Fitzroy River. The shrub layer was relatively sparse and included *Acacia decora* (western silver wattle), *Alphitonia excelsa* (soap tree) and *Vachellia bidwillii*. The ground layer was generally dense, dominated by native grasses such as *Themeda triandra* (kangaroo grass) and exotic species.

Habitat Features

Historical clearing has occurred in this habitat type, with trees in the canopy layer relatively young in age. As the trees within the canopy are relatively small, they are unlikely to bear hollows in the immediate or near future. Although nesting opportunities for arboreal mammals and hollow-dependent bird species are considered limited, a number of habitat values suitable for common reptiles were recorded in this community, including fallen logs, occasional course litter, decorticating bark and stones in the ground layer. These microhabitat features are considered important for small reptiles especially as they allow for refuge from predators and weather, and in some instances create microclimates (McGregor & Burnett, 2014).

Mistletoe and flowering tree species provide foraging opportunities for woodland birds, including the rainbow lorikeet (*Trichoglossus moluccanus*) and blue-faced honeyeater (*Entomyzon cyanotis*).

Within this habitat small gullies were also present which after rainfall events will hold water and provide habitat for amphibians. The abundance of grass (cover estimated to be greater than 70%) also provides suitable foraging habitat for macropods, evident from the presence of scats and tracks. As it is connected to a larger tract of vegetation in a northward direction, this habitat may also provide dispersal opportunities for a variety of fauna species.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species

- Grey-headed flying-fox (roosting, foraging and dispersal).
- Koala (breeding, foraging and dispersal)
- Ornamental snake (breeding, foraging and dispersal)
- Squatter pigeon (dispersal)
- White-throated needletail (aerial foraging)

3.5.8.6.7 Brigalow woodland

Analogous RE

This vegetation community is analogous to RE 11.3.1.

Vegetation Description

In February and October 2019 (AECOM, 2020f), this habitat type was found in one small, isolated patch within the Project Area just north of the Fitzroy River on alluvial plains and was characterised by regrowth *Acacia harpophylla* as the dominant species in the canopy and sub-canopy. Although these layers were quite low (up to 9 m in height), a review of satellite imagery confirmed that this patch has not been cleared for greater than 15 years. Although small, the area was in relatively good condition, with exotic perennial plants found only in the edges, comprising less than one percent of total vegetation cover. In July 2021 (Ecosure, 2021b) the habitat type was re-surveyed and found to be larger than that reported in 2019.

Habitat Features

This habitat type provides foraging opportunities for foliage-gleaning bird species and refuge for small reptiles, with high abundance of leaf-litter. A mature canopy layer was absent, and due to the age of trees present no hollows or deep crevices in the bark were present. Ground cover was relatively low, with areas of bare ground common and microhabitat features such as coarse woody debris and decorticating bark absent. Furthermore, *Acacia* sp. are not considered koala food trees, and as such koala is unlikely to occur in this community.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species

- Squatter pigeon (dispersal)
- White-throated needletail (aerial foraging).

3.5.8.6.8 Modified grasslands

Analogous RE

This vegetation community is analogous to areas mapped as non-remnant vegetation and is not analogous to any RE due to the lack of woody vegetation and highly disturbed/modified vegetation communities.

Vegetation Description

This vegetation community (non-remnant vegetation) is the result of historical clearing and current cattle grazing and dominates the Project Area (approximately 83% of the Project Area). Vegetation within this habitat type varied and included isolated paddock trees over exotic grasses and some riparian vegetation between lagoons and along drainage lines. The introduced pasture species *Cenchrus ciliaris* (buffel grass) dominates much of this community, although patches of native grass still exist in isolated places.

Habitat Features

Habitat values in this community were limited but included occasional tree hollows in riparian zones and high abundance of grass in the ground layer where grazing was restricted. Grasslands may provide habitat for small mammals, reptiles and granivorous (i.e. feeds on grain) birds. Larger mammal species such as the grey kangaroo also forage in this habitat. Isolated trees in paddocks may provide movement opportunities for koalas, possums, gliders and foraging habitat for grey-headed flying-fox.

Conservation Significant Fauna

This habitat type has the potential to support the following threatened fauna species:

- Ornamental snake (breeding, foraging and dispersal)
- Squatter pigeon (dispersal) – however, only when intact woodland vegetation occurs within 100 m
- White-throated needletail (aerial foraging).

3.5.8.7 Wetland Values

Pink Lily Lagoon

Of the wetlands surveyed, Pink Lily held the greatest habitat value due to its relatively minimal disturbance from grazing and large size, which at the time of the first survey (February 2019), provided an expansive inundated area. Shallow edging and muddy margins were common, providing foraging and roosting opportunities for a variety of waterbirds. Large sections of the wetland verge had dense, fringing vegetation; this feature is considered important for the listed migratory species, Latham’s snipe, which was recorded in relatively high numbers (14 individuals recorded in one survey).

Deep cracking in the soil was common in the wetland fringe, providing suitable habitat opportunities for reptile species such as the ornamental snake. Around the wetland perimeter there were multiple stags. These create perching and roosting opportunities for birds and bats, and when fallen become a substrate feature that provides refuge for aquatic species. Freshwater mussels, turtles and several waterbird species were observed at this location.

Listed migratory species recorded in this wetland included:

- One marsh sandpiper
- Latham's snipe in relatively high numbers (14 individuals recorded in one afternoon)
- Fifteen Caspian tern roosting in shallow waters
- Several glossy ibis.

Black Duck Lagoon

Although dry at the time of survey, the wetland was confirmed directly east of the Project Area by the presence of wetland vegetation and typical wetland landform. A narrow linear lagoon was also present in the south east of the mapped extent. This waterbody had significantly receded, lacked fringing low vegetation and had highly disturbed muddy margins due to unrestricted livestock access. Based on the landform present, the waterbody is likely shallow when inundated. Aquatic vegetation is common in the deepest areas of the lagoon, especially at the eastern end. Large riparian trees are also present and provide perching opportunities for predatory birds, as well as potential nesting for arboreal mammals and woodland birds.

Five common waterbird species were recorded at this location, however when fully inundated, this wetland is likely to support low abundances of other waterbirds and migratory shorebirds due to a reduction in shallow wading areas and exposed muddy margins.

Lotus Lagoon

Although the majority of this wetland was dry at the time of the survey, or had significantly receded, habitat values suitable to birds, reptiles, and amphibians were present. Soil cracking (although generally uncommon) was present along the fringes of some of the waterbodies associated with this wetland. A high abundance of keelback snakes (*Tropidonophis mairii*) were recorded during spotlighting utilising these cracks to forage. During the 2019 survey, a variety of waterbirds were recorded at the permanent waterbodies, including Australian pelican, great and intermediate egrets, several other waterfowl species, pied and little black cormorant as well as the migratory glossy ibis.

Where dry, the presence of freshwater mussel shells in the ground layer indicates the wetland was significantly larger in recent history. Adjacent riparian and shoreline zones were heavily impacted, especially in the northern-most section with exotic grass prevalent. Grazing activity was ongoing in the west of this wetland. When periodically inundated, this wetland may provide extensive, shallow, wetted habitat that may be utilised by a variety of migratory bird species.

During the 2021 migratory bird survey, Lotus Lagoon was completely dry.

Dunganweate Lagoons

This wetland was located within a disturbed and heavily grazed landscape, with riparian vegetation largely absent. The waterbody had moderately sloping banks, with a rocky and/or sandy ground layer in some areas. Some muddy margins were present and significant livestock pugging was observed.

Small patches of aquatic vegetation around the wetland fringes were recorded, but dense vegetation overall was absent. Fish activity was observed from the surface. Foraging opportunities exist for a range of waterbirds, such as egrets, cormorants and ducks. Overall, the habitat is sub-optimal for wading species due to very sparse cover of macrophytes or riparian vegetation. Water levels are also too deep to be suitable for foraging and roosting for most species, unless the wetland is at or over capacity which would create expansive shallow water margins, particularly along the northern shoreline.

Nelson Lagoon

This wetland is located within a disturbed and heavily grazed landscape. The waterbody is on higher ground, and is potentially shallower than the adjacent Dunganweate; however, too deep for foraging and roosting for most migratory bird species, with the exception of species which hunt for fish during flight such as the Caspian tern, which was observed here. Habitat is considered marginal for migratory shorebirds due to steep, heavily damaged banks, no fringing vegetation and deepwater pools with limited shoreline foraging opportunities.

Capricorn Highway Lagoon

This wetland was surveyed twice in March 2021. A permanent waterbody was present with shallow margins and varying level of low surrounding and fringing vegetation, and this could provide suitable foraging habitat for waterbirds and some migratory species.

Crescent Lagoon

This large crescent-shaped waterbody provides a variety of nesting and foraging opportunities for waterbirds and shorebirds with a high diversity of species recorded in this location. Sections of dense vegetation were present in various locations along the edges of the wetland shoreline during the 2021 surveys, in addition to expansive areas of shallow muddy shoreline.

Mudflats within the lagoon provide foraging opportunities for several migratory shorebird species such as sharp-tailed sandpiper and Latham's snipe which were both recorded during the 2021 surveys. The wetland is also a likely refuge for birds that have been flushed from the nearby Murray Lagoon, located less than 500m to the east.

Habitat suitability for migratory shorebirds is expected to be highly variable in this wetland in response to water level changes. Above the levels observed in March 2021, an increase of only 30 cm would significantly reduce the amount of suitable foraging habitat based on the bank profile around the wetland extent. If at or slightly over capacity, the wetland would provide expansive shallow water areas for foraging, particularly on the western bank.

Murray Lagoon

This large waterbody provides a host of nesting and foraging opportunities for waterbirds with a high diversity of species recorded in this location. Areas of dense vegetation were present along the fringes and on the spit on the western side suitable for Latham's snipe and Australian painted snipe both of which have been previously recorded in this location. Dependent on water levels within the wetland, shallow margins expansive mudflats within the lagoon provide foraging opportunities for several listed wading species such as black-tailed godwit, sharp-tailed sandpiper, red-necked stint and common greenshank which have all been previously recorded. The lagoon likely supports numerous reptiles including Krefft's river turtle (*Emydura macquarii krefftii*), which has been previously recorded.

3.5.9 Likelihood of Occurrence

Ecological surveys are generally undertaken over short durations and do not account for seasonal variation in habitat conditions and other variables which can influence threatened species presence. The absence of cryptic, seasonal or threatened species cannot be conclusively determined through the results of field surveys alone. A likelihood of occurrence assessment of threatened and migratory species can be undertaken based on the criteria shown in Table 3-12. For each species this process assesses the following parameters:

- Modelled presence from the Australian Government Department of Agriculture, Water and the Environment's Protected Matters Search Tool
- Available historical and recent database records, and anecdotal records (i.e. Birdata, eBird, WildNet, Atlas of Living Australia)
- Species specific habitat requirements
- Presence and quality of required habitat and assessment of landscape habitat connectivity.

Table 3-12 Likelihood of occurrence criteria

Likelihood	Description
Known/Recorded	Known/Recorded Species observed or recorded during the survey program. Species recorded previously within Project Area and known to persist via ongoing monitoring programs.
High	Species considered to have a high likelihood of occurrence include species that: ▪ have been recorded in the Project Area or surrounding area on a regular basis ▪ are dependent on or associated with habitat types that are present in the Project Area in good or unmodified condition ▪ are known to persist as resident sedentary populations in areas surrounding and contiguous with the Project Area ▪ are unlikely to persist in the Project Area, however, may use habitat within the Project Area on a seasonal, transient or opportunistic basis.
Moderate	Species considered to have a moderate likelihood of occurrence include species that: ▪ have been recorded in the Project Area or surrounding area on a rare or intermittent basis ▪ are dependent on or associated with specific types of habitat that are present in the Project Area in poor or modified condition ▪ are unlikely to persist in the Project Area, however, may seasonally use resources within the Project Area on a transient or opportunistic basis.
Low	Species considered to have a low likelihood of occurrence include species that: ▪ have not been recorded previously in the Project Area and surrounding area ▪ are well outside their known or documented distribution range ▪ are dependent or associated with specific types of habitat that are absent from the Project Area ▪ are considered locally or regionally extinct.

A likelihood of occurrence assessment was undertaken based on the results of the desktop assessment and habitat values identified during the field surveys (AECOM, 2020d). The resulting assessments identified 26 fauna species as 'moderate' or 'high' likelihood of occurring or having been recorded during the field surveys. This includes five migratory species that are 'known to occur' within the Project Area, as well as 11 threatened and 10 migratory species with the potential to occur.

Table 3-13 identifies the likelihood of occurrence assessment outcomes with Table 6-1 identifying the extent of potential habitat within the Project Area for threatened and migratory species which were assessed as having a 'moderate' or 'high' potential to occur or are 'known to occur'.

Table 3-13 Likelihood of occurrence summary table

Value	Likelihood of Occurrence		
	Moderate	High	Present
Threatened Fauna	Australasian bittern koala ornamental snake white-throated needletail	Australian painted snipe curlew sandpiper Fitzroy River turtle grey-headed flying-fox white-throated snapping turtle	squatter pigeon (southern)
Migratory Fauna	common sandpiper little curlew little tern pectoral sandpiper wood sandpiper	common greenshank estuarine crocodile red-necked stint	black-tailed godwit Caspian tern eastern osprey glossy ibis Latham's snipe marsh sandpiper sharp-tailed sandpiper white-winged black tern

3.6 Special Areas and Land Tenures

3.6.1 Land Tenure

The Project is predominantly located on freehold land, as well as intersecting state land, reserve land and unallocated state land (Figure 3-23).

3.6.2 Protected Areas

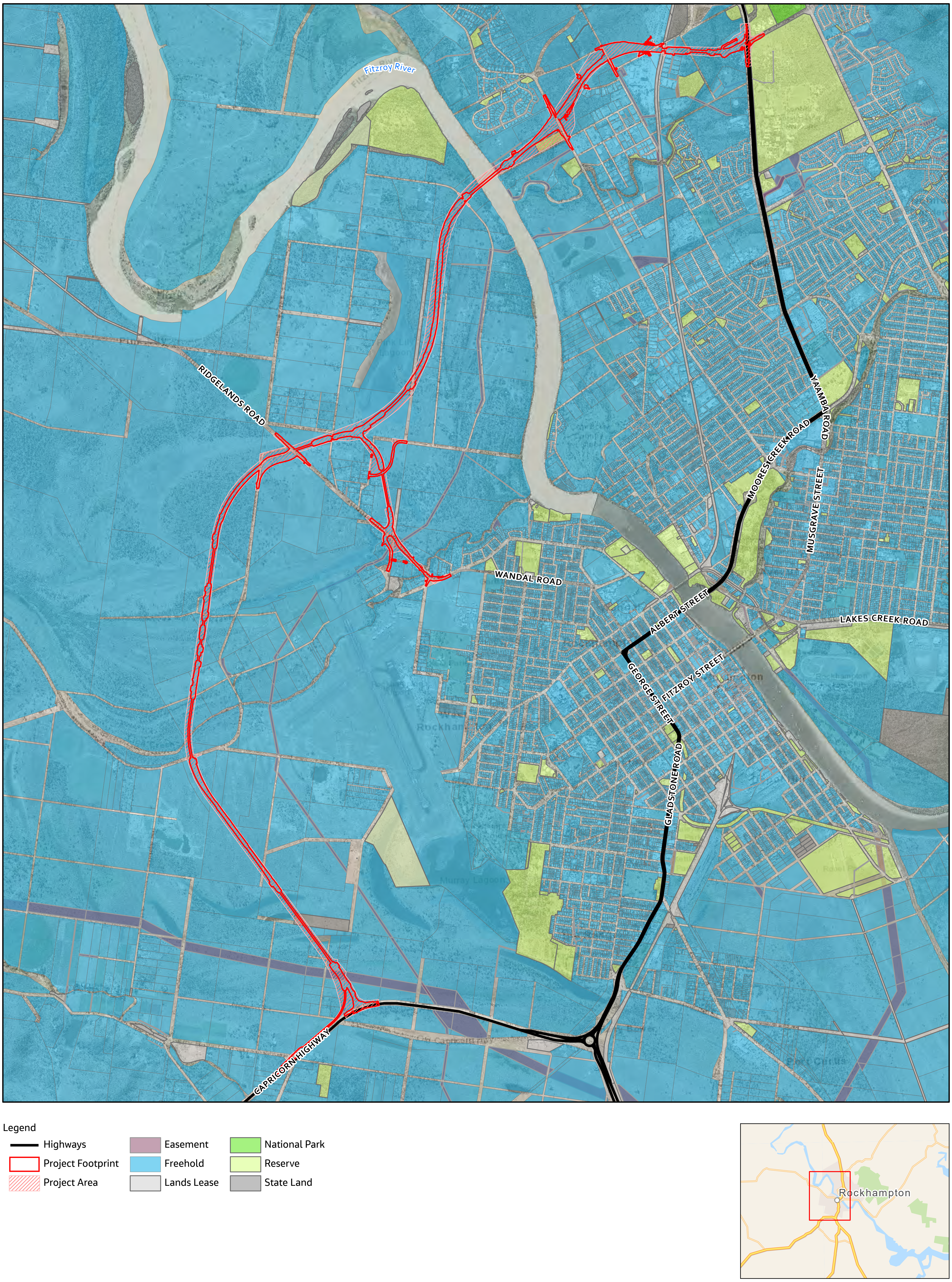
The Project Area is predominantly located within the Fitzroy River Floodplain, listed as a Nationally Important Wetland. The Great Barrier Reef World Heritage Property is approximately 55 km downstream of the Project Area (Figure 3-23). There are no Ramsar Wetlands within the Project Area.

3.6.3 State Development Area

The Project intersects with the Stanwell-Gladstone Infrastructure Corridor State Development Area. The Stanwell-Gladstone Infrastructure Corridor State Development Area supports the establishment of multiple underground pipelines. The approximately 90-kilometre-long corridor links Stanwell to Gladstone, and with an average width of 100 m, the corridor can accommodate up to seven underground pipelines for numerous purposes such as water (treated, raw or sea), gas, mineral slurries and telecommunication cables.

The Project Area will become a designated State Controlled Road Reserve under the *Queensland Transport Infrastructure Act 1994*. Provision will be made within the Road Corridor for services associated with the Stanwell Gladstone Infrastructure Corridor.

Figure 3-23: Special areas and land tenures



Rockhampton Ring Road

Source: Queensland Department of Resources: Roads (2020) Tenure (2021); Metromap: Imagery (2020)

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4. Description of the Action

4.1 Project Description

The Project will provide a western road link of the Bruce Highway to the west of Rockhampton, with key linkages into the city at the Capricorn Highway, West Rockhampton, Alexandra Street and Yaamba Road (Rockhampton – Yeppoon Road). The alignment will integrate with major infrastructure projects already completed, including Yeppen Floodplain Project (south) and Yeppen Floodplain Project (north), as well as current works in development including the Rockhampton Northern Access Upgrade and Capricorn Highway Duplication (Rockhampton – Gracemere).

The Project commences on the Capricorn Highway approximately 2 km west of the intersection of the Bruce Highway and Capricorn Highway at the Yeppen Roundabout and its alignment traverses north through the Western Yeppen Floodplain, sweeping around the Rockhampton Airport at Pink Lily lagoon and connecting to West Rockhampton near Ridgelands Road before crossing the Fitzroy River. After crossing the Fitzroy River, the alignment intersects Alexandra Street in Parkhurst and connects with the Bruce Highway at the Bruce Highway and Rockhampton – Yeppoon Road intersection.

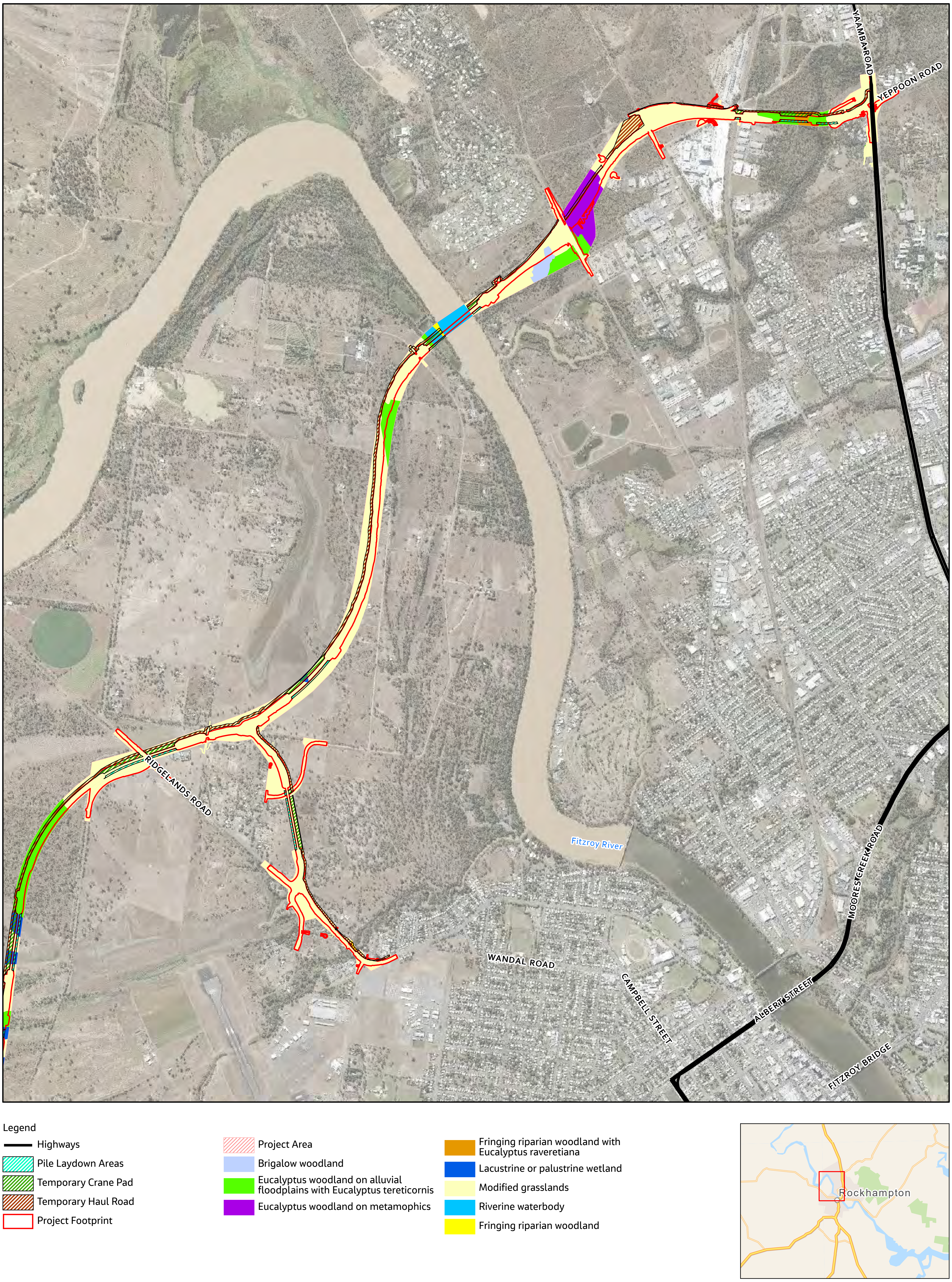
The Project proposes to deliver the following, which will provide a highway standard ring road:

- A nominal 80 m wide road corridor for the Rockhampton Ring Road sufficient to provide a footprint for the road, temporary access tracks for construction and clearance to the corridor boundary to allow maintenance during the operational phase of the road (Figure 4-1, Figure 4-2)
- Construction of roads including two lane section from Capricorn Highway to Rockhampton Connector Road and a four lane section from Rockhampton Connector Road to Yeppoon Road
- 18 new bridge structures, including a new four lane crossing of the Fitzroy River
- Construction of a new intersection at the Capricorn Highway, approximately 2 km west of the Yeppen Roundabout
- Construction of a new connection (Rockhampton Connector Road) to West Rockhampton at Pink Lily
- Construction of a new connection to Parkhurst at Alexandra Street by means of a grade separated interchange
- Reconfiguration of existing roads and streets to implement improved access at West Rockhampton and Alexandra Street
- Intersection upgrade for the connection to the intersection of the Bruce Highway and Rockhampton – Yeppoon Road
- 1% AEP flood immunity of the Rockhampton Ring Road and Rockhampton Connector Road
- Relocation and reconfiguration of affected Public Utility Plant (Figure 1-2)
- Intelligent transport systems including CCTV cameras, Bluetooth detection and electronic message signing
- Road lighting at intersections, ramps and the bridge over the Fitzroy River
- Widening of the drainage channel outside of the road corridor and at the southern end of the Rockhampton Airport
- Landscaping and revegetation of disturbed areas.

The total combined length of the Project is approximately 17 km (including the Rockhampton Connector Road). The length of the Project from the Capricorn Highway intersection to the Yeppoon Road intersection is approximately 14.7 km (excluding the Rockhampton Connector Road).

The Project Area and Project Footprint are shown in Figure 1-2. The Project Area generally aligns with the gazetted road corridor for the Rockhampton Ring Road. It is the area proposed to be disturbed, altered, or used for the construction or operation of the Rockhampton Ring Road. The Project Footprint is the area within the Project Area that will be used for the operation of the Rockhampton Ring Road. Works associated with the construction of the Project will generally be undertaken within the Project Area.

Figure 4-1: Temporary works in the northern Project Area



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: AECOM/Jacobs/SMEC: Fauna Habitats, Temporary Works (2021); Metromap: Imagery (2020)

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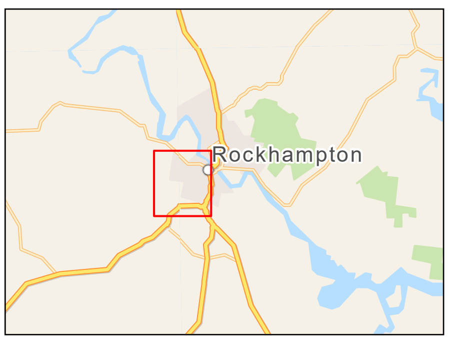
Figure 4-2: Temporary works in the southern Project Area



Legend

- Highways
- Pile Laydown Areas
- Temporary Crane Pad
- Temporary Haul Road
- Project Footprint
- Project Area
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Lacustrine or palustrine wetland
- Modified grasslands
- Fringing riparian woodland

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Changes to Public Utility Plant to accommodate the Project, such as electricity and telecommunications infrastructure, are unlikely to impact MNES as works do not require clearing of or substantial excavation within MNES fauna habitat such as wetlands or vegetation (remnant regional ecosystems (REs) or high value regrowth). Works are mostly within the Project Area or within road reserves where they are outside of the Project Area.

Vegetation trimming and clearing is proposed in for small areas to allow for changes to overhead electricity lines (solid yellow line on Figure 1-2) but this does not include remnant or high value regrowth. There are several areas of excavation, including trenching and underboring of electricity infrastructure (dashed yellow line on Figure 1-2), but these activities are outside of fauna habitat such as wetlands or remnant or high value regrowth. Changes to telecommunications and other infrastructure will not affect MNES as they are solely within the road reserve.

4.2 Flood Immunity and Flood Consideration in the Design

A Hydraulic Analysis Design Report (Jacobs SMEC Design JV, 2021b) has been developed to document the hydraulic assessment of the Project. The hydraulic assessment considered all aspects of the design relevant to flooding requirements for bridge and alignment fixing and wetland connectivity. Hydraulic modelling has been undertaken across the Project Area (Figure 4-3) to:

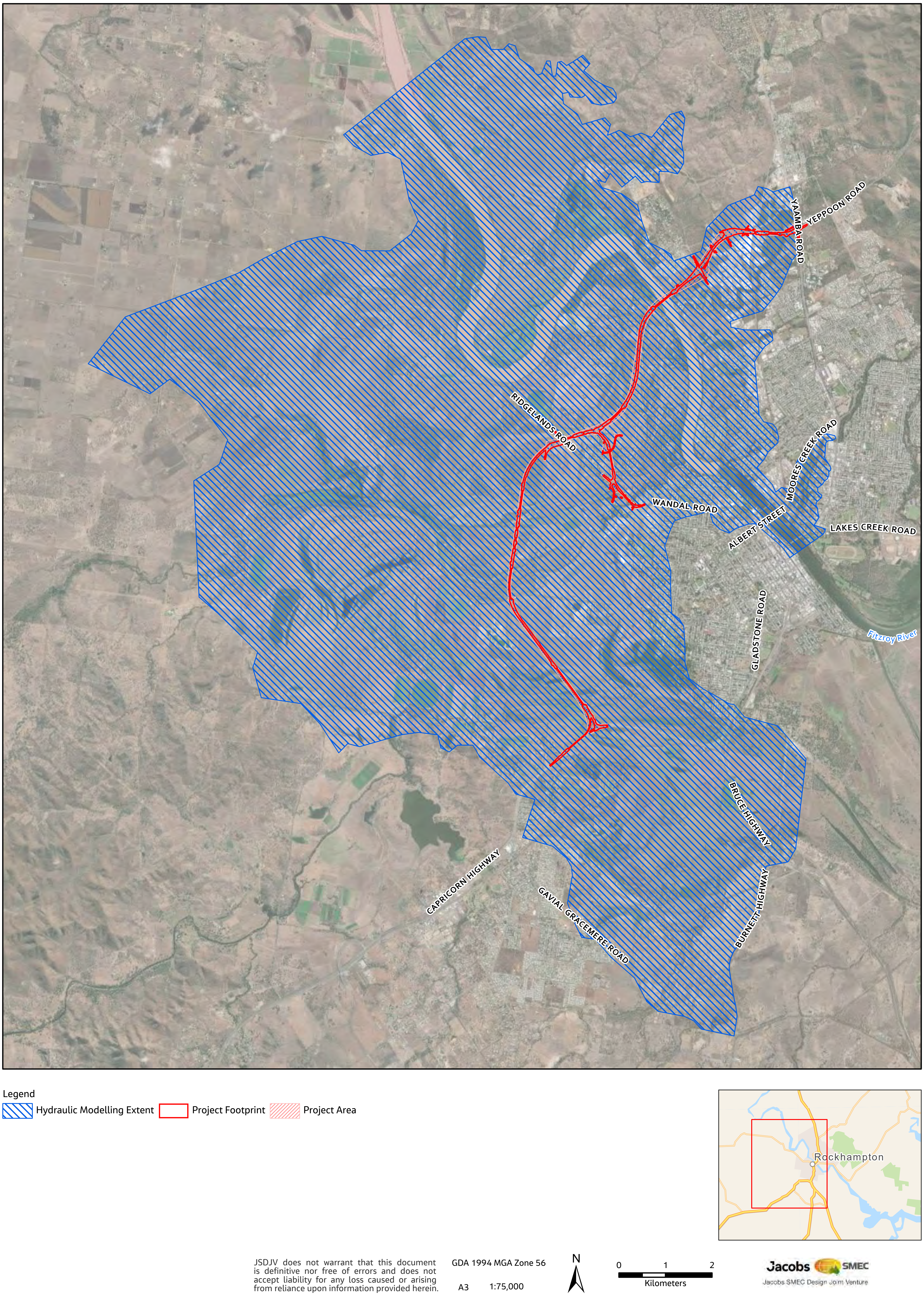
- Assess flood immunity of the upgraded infrastructure
- Assess and ensure hydraulic impacts on adjacent properties as a result of the new road alignment are within acceptable limits
- Undertake scour assessment to identify potential for scour and ensure bridge foundations are designed accordingly. The potential for scour in relation to bridges is the result of the erosive action of water, excavating and carrying away material from the bed and banks of streams and from around the piers and abutments due to contraction, pressure and localised vortices against the bridge elements.
- Assess operation of hydraulic structures and limit state loading
- Quantify flood conditions in major design flood events to facilitate structural design of road embankment, bridges and culverts
- Assess wetland connectivity.

The scale of floods, velocity and scour for the hydraulic assessment is for the full range of probabilities from small to large (10% AEP to a 1% AEP event) plus rarer 1 in 2000 AEP for limit state design and is inclusive of both local catchment rainfall events and Fitzroy River breakout events across the floodplain. The hydraulic assessment also focuses on the peak of the flood where the levels, velocities and scour can be expected to be maximal.

There is no published information available on the probability of the flood that should be used for assessing and minimising possible environmental damage to a stream or waterbody from the construction of a road crossing. Each site should be investigated for possible problems that might occur with a range of flood events, with emphasis on the more frequent events. The factors assessed include:

- Control of roadside drainage, where it enters the stream, to limit bank erosion
- Provision of an adequate waterway opening to limit backwater effects and excessive localised bed scour
- Provision of adequate waterway openings to maintain a natural supply of flood water to wetland areas
- Provision of an adequate number of waterway openings, in wide flood areas in arid regions, to ensure that water is not prevented from reaching areas downstream from the road, which could lead to the death of vegetation.
- Protection of banks from erosion resulting from the redirection of flow and turbulence, or from excessive increase in velocity
- Protection of natural vegetation, especially where it protects or stabilises natural banks.

Figure 4-3: Hydraulic modelling spatial extent



Source: Queensland Department of Resources: Roads (2020); HDR: Hydraulic Modelling Extent (2021); ESRI: Imagery (2020)

The scale of floods, velocity and scour/erosion for environmental assessment is thus for frequent probabilities (2 exceedances per year to 10% AEP). Additionally, the environmental assessment has been broadened from just the peak of the flood to look at the characteristics after the flood has passed through the floodplain to assess post-flood changes.

4.2.1 Flood Immunity

The hydraulic assessment shows that the Rockhampton Ring Road and Rockhampton Connector Road have an immunity of no less than a 1% AEP flood event. Local road connections have lower flood immunity.

4.2.1.1 Rockhampton Ring Road and Rockhampton Connector Road

The main alignment is not overtopped in the 1% AEP Fitzroy River event, with the exception of the Capricorn Highway roundabout at the southernmost end. The Capricorn Highway Roundabout is inundated for all events above and including the 10% AEP Fitzroy River, which is consistent with the immunity of the Capricorn Highway east and west of this roundabout. The Capricorn Highway to Rockhampton Ring Road on ramp bridge is immune up to the 0.05% AEP Fitzroy River event, providing sufficient access to the Capricorn Highway, and achieving immunity criteria.

4.2.1.2 Other State Controlled Roads

The connection of Rockhampton Ring Road to the Bruce Highway is not overtopped in any modelled event.

For state-controlled roads, a 2% AEP immunity criteria is suggested by the TMR Road Drainage Manual 2019, however, it is generally impractical to improve the flood immunity of short new sections without subsequent improvement of longer sections of road. Rockhampton ‑ Ridgelands Road under Rockhampton Ring Road is inundated for all events above and including the 20% AEP Local Catchments event and the 10% AEP Fitzroy River flood event. Flood immunity of the Rockhampton ‑ Ridgelands Road connection to Rockhampton Connector Road is 10% AEP in the Fitzroy River flood events, with the section completely inundated in the 0.05% AEP event. In the Local Catchments flood event, this section is flood immune until the 10% AEP event, with smaller sections immune to the 0.05% AEP event. The section of Capricorn Highway included in the permanent works for the Rockhampton Ring Road (i.e. the roundabout and on-ramp) have 10% AEP immunity to the Fitzroy River event and the Local Catchments event.

4.2.1.3 Local Roads

There are multiple local roads in the Project Area, usually below Rockhampton Ring Road bridges. The target immunity is 10% AEP for most of these roads, as outlined by the Capricorn Municipal Development Guidelines (Cardno Rockhampton, 2021), and local roads in the Project Area meet or exceed (i.e. to 1% AEP) this immunity.

4.2.2 Property Impacts

The hydraulic assessment included evaluation of potential flooding impacts to adjacent properties. Based on the outcomes of the assessment TMR has undergone an extensive consultation process with landowners and have agreed appropriate outcomes through consultation, including partial or full resumption. Land impacts have been minimised where practical.

4.2.3 Extreme Events

The Rockhampton Ring Road has an immunity for a 1% AEP event. A hydraulic assessment has been undertaken for 86.5% AEP (6 month ARI) to 1% AEP (100 year ARI) events. The change in hydraulics characteristics between the existing and Project cases is less for larger flood events as the floodplain is essentially drowned. Velocities for the more critical smaller events have been assessed and found to have only minor increases or decreases compared to the existing case without the Project. The absolute velocity with the Project in these smaller events is less than 0.6 m/s which is considered non erosive in terms of sparsely vegetated or exposed bed conditions. For larger events the change between the existing and Project cases are even smaller, and hence extreme flood events are expected to have minimal impacts on the wetlands.

4.3 Construction and Ancillary Activities

The proposed construction works are anticipated to commence construction in first quarter 2022, with the overall construction program for the Project expected to be approximately three years.

4.3.1 Construction Sequence

The general construction sequence is anticipated to include the following:

- Site establishment and survey set out
- Clearing vegetation
- Temporary erosion and sediment controls (as vegetation cleared)
- Temporary construction access tracks
- Earth drainage lines and preparation of existing ground surface
- Drainage (culverts) and construction of deep foundations (piles) / bridge substructures
- Bulk earthworks and retaining walls
- Road pavements and bridge superstructures
- Road surfacing and environmental protection treatments
- Road furniture, intersection lighting, traffic signals, Intelligent Transport Systems and active transport infrastructure
- Landscaping and disturbed area rehabilitation
- Site disestablishment and finalisation of construction defects.

It is anticipated orthodox construction equipment will be used during construction with specialist pile driving equipment used on site for bridge construction. Materials for construction are expected to be sourced from quarries in Rockhampton. Project activities are not expected to involve quarrying activities to supply construction material. Material may be required to be extracted from the banks of the creeks to facilitate the construction of the bridges.

During construction, temporary access tracks and haul roads will be required. The temporary haul roads are anticipated to have a 10 m wide road surface, plus batters, which will likely equate to an average of 15 m wide. The temporary haul road is proposed to be located to the west/north of the Project alignment.

Temporary bridges or barges are expected to be used to facilitate construction of the Fitzroy River bridge. At other bridge locations, approximately 23 m wide temporary crane pads and approximately 12 m wide temporary pile laydown areas will be required.

The total bridging equates to approximately 7 km, with the construction of the bridges to be sequenced throughout the Project duration. Construction timeframes will vary for each bridge, with the longest timeframe of 14 months anticipated. The contractor would be required to construct access tracks and temporary working pads to facilitate the bridge works. Temporary waterway barriers are likely to be required to assist with bridge construction.

The Contractor will be encouraged to use non-potable water for construction works where feasible. No raw water or treated effluent lines are located near the Project Area.

Temporary site offices, stockpiles and laydown areas will generally be located within the Project Area or other suitable land (e.g. Department of Transport and Main Roads (TMR) acquired properties or road reserve).

Highway traffic will be able to continue to use the existing road network during construction.

4.3.2 No-go Zones

No-go zones have been incorporated into the Project design to minimise potential impacts during construction and will be shown on design drawings. The no-go zones have been delineated around sensitive environmental areas to minimise the potential for construction activities to impact these areas. The no-go zones will be marked on site at the commencement of construction in that area using high visibility temporary fencing/bunting rope (or similar) and include the following areas:

- Along the length of the retained brigalow TEC to minimise removal of habitat beyond that required to construct the works
- Along the length of the retained *Eucalyptus raveretiana* (black ironbox) habitat at Limestone Creek to minimise removal of habitat beyond that required to construct the works.

4.3.3 Rehabilitation Works

All areas temporarily disturbed during construction will be stabilised following completion of the works (Figure 4-4 and Figure 4-5). During construction, exposed areas not being actively worked will be stabilised (e.g. polymer, grass seeded, jute matting) to minimise erosion processes. Once construction is complete, rehabilitation activities, including initial monitoring and maintenance, will be completed as part of the major works contract which is expected to be approximately three years. Following contract award, the construction contractor will prepare a detailed program identifying the staging of rehabilitation activities over the three year construction period.

Active rehabilitation will be undertaken within the riparian zone of Fitzroy River, Lion Creek, Limestone Creek, wetlands and the area of retained brigalow (*Acacia harpophylla* dominant and co-dominant) vegetation community near Alexandra Street. At these locations, rehabilitation works will aim to reinstate temporarily disturbed areas to the pre-disturbance vegetation community and minimise weed intrusion.

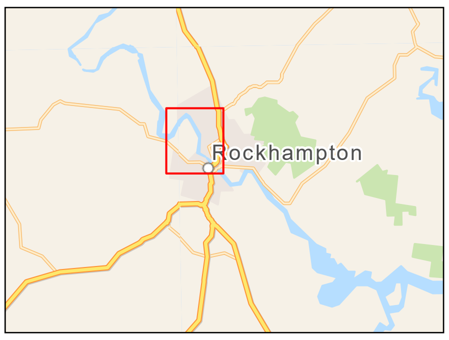
Rehabilitation works will generally be undertaken in accordance with TMR specification for Landscape and Revegetation Works. This includes minimum requirements for establishment and monitoring periods, reporting and success criteria. Rehabilitation works will be undertaken progressively, if appropriate.

4.3.4 Dewatering and Groundwater Levels

Dewatering may be undertaken in association with installation of bridge pile caps (a concrete slab approximately 1.5 m thick that sits on top of underground piles and provides the foundations for the aboveground bridge piers) (Figure 4-6). Excavation will most likely be to a depth of 2 m and lateral extent will range from approximately 20 x 8 m to approximately 15 x 27m depending on the containment method as discussed below. The duration of works for each pier is expected to be approximately 6 weeks. Dewatering will occur intermittently as bridge works progressively occur during the approximate three year construction period. Duration and timing will depend on factors such as the Contractor’s chosen construction method, staging of works and rainfall.

Figure 4-4: No-go zones and areas to be rehabilitated in the northern Project Area

Legend
- Highways
- Project Footprint
- No-Go Zones (Black Ironbox and Brigalow)
- Rehabilitation Area



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Source: Queensland Department of Resources: Roads (2020); AECOM: No-Go Zones (2021); Jacobs: Rehab Area (2021); Metromap: Imagery (2020)

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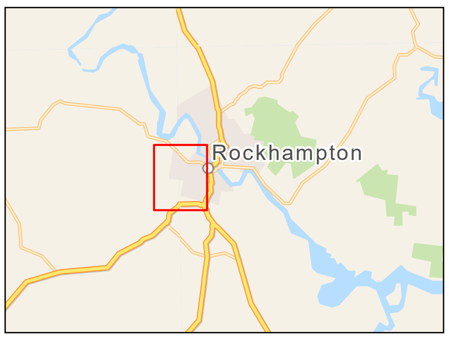
Figure 4-5: No-go zones and areas to be rehabilitated in the southern Project Area

Legend
- Highways
- Project Footprint
- No-Go Zones (Black Ironbox and Brigalow)
- Rehabilitation Area



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: Queensland Department of Resources: Roads (2020); AECOM: No-go Zones (2021); Jacobs: Rehab Areas (2021); Metromap: Imagery (2020)

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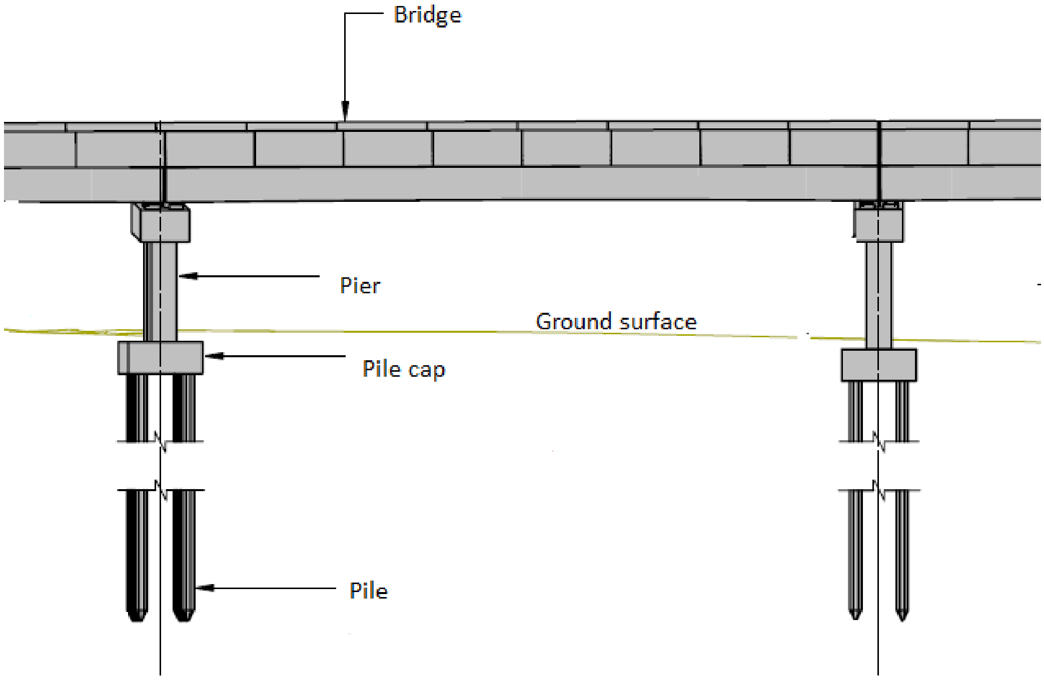


Figure 4-6 Schematic diagram showing the pile, pile cap and pier arrangement that provide the foundation for the bridges

There are 18 bridges in total:

- Bridges in the north are unlikely to require dewatering as the pile caps sit above the groundwater level and dewatering would only be required following a heavy rainfall or where waterways are holding surface water. A simple battered excavation (approximately 15 x 27 m laterally and 2 m deep) will most likely be undertaken where minimal to no water is encountered.

- The piles for the Fitzroy River bridge will be poured into casings installed in the river bed, and the pile caps formed using precast concrete shells installed on the piles. Dewatering of the shells will be limited to pumping the river water from the shells once they are sealed to the piles.

The floodplain bridges over waterways and wetland will have piles driven into the ground, with dewatering only required if groundwater or surface water is encountered, or if there is a heavy rainfall during installation. Groundwater and/or surface water is more likely to be encountered in association with near-permanent wetlands on the southern floodplain (i.e. northern Dunganweate Lagoon and Nelson Lagoon). A simple battered excavation (up to approximately 15 x 34 m laterally and 2 m deep) will mostly likely be undertaken where minimal to no water is encountered, and sheet piles (approximately 20 x 8 m laterally and 2 m deep) or a bund (up to approximately 15 x 34 m laterally and 2 m deep) will most likely be used to contain the excavation for dewatering where more water is encountered.

Dewatering of surface water will be required for the Fitzroy River Bridge as the Fitzroy River is a permanent waterbody. Dewatering will otherwise be avoided, for example by not undertaking works during periods of heavy rainfall. Surface water may be encountered at the more permanent wetlands (i.e. north Dunganweate Lagoon or Nelson Lagoon), or following heavy rainfall.

Dewatering to 2 m is unlikely to encounter groundwater in most areas at most times of the year, based on Project groundwater data and groundwater data available for the southern floodplain (collected by Fulton Hogan from July 2019 to July 2021). Groundwater levels typically follow the surface topography and during the September 2019 survey (C&R Consulting, 2020) most bores held water at approximately 7 m below ground level, with southern bores at >9 m below ground level. Data from 2019 to 2021 (Fulton Hogan, 2021) recorded groundwater ranging from approximately 5.8 to 7 m below ground level. Project data recorded levels from

3.9 to 10.5 m below ground level in June to July 2021, and levels at least 6 m below the ground level during September 2021. A regional assessment identified water levels within the alluvial aquifers of the floodplain as typically ranging from 5 to 15 m below ground level, with the alluvial base up to 35 m below ground level (Pearce & Hansen, 2006).

Any activity that extracts groundwater may cause groundwater drawdown, which can have important ecological consequences. Drawdown is a change in groundwater level due to an applied stress. Coal seam gas extraction, mining, and pumping of groundwater for irrigation are examples of such activities (Australian Government Department of Environment and Energy, 2018a) and potential impacts to MNES associated with this project are discussed for each MNES in Section 6, and further in Section 7.

4.3.5 Acid Sulfate Soils

There are areas of extremely low, low and high probability of acid sulfate within the Project Area. Preliminary acid sulfate soil investigations undertaken at bridge and culvert locations have identified some areas that require further investigation to confirm the presence of acid sulfate soils.

Desktop and preliminary field results will be used to determine the location and intensity of future investigations and sample collection for laboratory analysis in the associated areas.

Potential impacts and mitigation measures associated with acid sulfate soils, as relevant to MNES, are discussed in Section 7. Further details on acid sulfate soil management are provided in the Construction Acid Sulfate Soil Sub Plan within the Environmental Management Plan (Appendix A), including performance criteria and management measures should acid sulfate soil be encountered during construction.

Additional acid sulfate soil testing is proposed to be undertaken by the construction Contractor prior to commencement of earthworks. Further details on acid sulfate soil management will be developed as part of the Environmental Management Plan (Construction) if acid sulfate soils are observed, e.g. treatment pad design and liming rates based on the preliminary testing and preferred treatment methodology of the Contractor.

4.4 Operational Phase Activities

The Project is expected to be operational approximately three years following the commencement of construction in first quarter 2022.

Once operational, the road will be maintained in accordance with TMR standards, which is anticipated to include the following:

- Vegetation maintenance works including weed control
- Culvert and bridge maintenance works
- General road maintenance works.

4.5 Decommissioning

There are currently no plans to decommission the road. However, in the event that the road became obsolete, the road will be completely removed, and all land previously occupied by the road will be rehabilitated. All removed materials will be disposed of appropriately or reused if possible.

4.6 Project Delivery

The Project design is anticipated to be delivered as a Transport Infrastructure Contract – Construct Only. The Project is anticipated to commence construction in first quarter 2022, with the overall construction program for the Project expected to be approximately three years.

4.7 Total Size of the Action

The total size of the action is as follows:

- Project Area – 211 ha
- Project Footprint– 107 ha.

5. Legislative Approvals

Table 5-1 identifies the legislative requirements relevant to the Project.

Table 5-1 Relevant legislative requirements for the Project

Legislative Trigger	Regulatory Authority	Project Relevance
Federal		
Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*		
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Referral Potential significant impacts on Matters of National Environmental Significance	Australian Department of Agriculture, Water and the Environment	A referral under the EPBC Act has been lodged with the Department of Agriculture, Water and the Environment (DAWE) for potential impacts to Matters of National Environmental Significance. The Project has been deemed a controlled action and is being assessed via this Preliminary Documentation.
Queensland *Aboriginal and Cultural Heritage Act 2003*		
A duty of care obligation by all persons undertaking an activity.	Queensland Department of State Development, Manufacturing, Infrastructure and Planning	A Cultural Heritage Risk Assessment was undertaken based on the findings of an Aboriginal cultural heritage site inspection by Extent Heritage Pty Ltd and desktop assessment undertaken by AECOM (AECOM, 2019). The cultural heritage party is the Darumbal People. The Cultural Heritage Risk Assessment identified the need for a further cultural heritage survey assessment and consultation with the Darumbal People. TMR has subsequently undertaken consultation with the Darumbal People and cultural heritage field surveys, which found that the Project Area contains mature trees of cultural heritage significance. A Cultural Heritage Management Agreement is currently being finalised.
Queensland *Biosecurity Act 2014*		
Individuals and organisations whose activities pose a biosecurity risk must: ▪ take all reasonable and practical steps to prevent or minimise each biosecurity risk	Queensland Department of Agriculture and Fisheries	Field surveys confirmed 23 listed weed species, including 11 Weeds of National Significance, 19 restricted species and 23 declared species under the Rockhampton Regional Council Biosecurity Plan. Eight introduced fauna species were also recorded within the Project Area during the field surveys, with an additional two species identified as likely to occur. Under the *Biosecurity Act 2014*, all Queenslanders have a general biosecurity obligation to manage biosecurity risks and threats that are under their control, they know about or they are expected to know about. The Environmental Management Plan (Construction) is required to consider the presence and potential spread of invasive species associated with the works.

Legislative Trigger	Regulatory Authority	Project Relevance
▪ 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. For restrictive invasive plants this includes not distributed the invasive plant either by sale or gift, release it into the environment.		A Biosecurity Management Plan will be required to be developed to manage biosecurity risks during construction.
Queensland *Environmental Protection Act 1994*		
The removal of contaminated soil from a Contaminate Land Register (CLR) or Environmental Management Register (EMR) lot for treatment or disposal purposes.	Queensland Department of Environment and Science	The Project Area contains lots listed on the Queensland Environmental Management Register and other lots that may contain areas of potential contamination (Jacobs SMEC Design Joint Venture, 2021c). A contaminated land field sampling program will be undertaken to assess areas of potential contamination and the findings of the assessment will be used to develop management measures during construction to minimise human health and environmental risks. Where the proposed works involve the removal of contaminated soil from a lot listed on the Environmental Management Register, a soil disposal permit will need to be obtained. Note, where soil meets the definition of regulated waste under the *Environmental Protection Act 1994* waste will need to be transported by a suitably licensed contractor.
A duty of care obligation by all persons undertaking an activity.	Queensland Department of Environment and Science	General environmental duty and duty to notify environmental harm apply. This requirement will be included in the Environmental Management Plan (Construction).

Legislative Trigger	Regulatory Authority	Project Relevance
Queensland *Heritage Act 1992*		
A duty of care obligation by all persons undertaking an activity.	Queensland Department of Environment and Science	The Project Area does not traverse a mapped Queensland Heritage Place. The nearest Queensland Heritage Place is Saint Aubins which is located approximately 0.7km south of the Project Area. The Cultural Heritage Risk Assessment (AECOM, 2020c) identified potential historic features including: ▪ A possible 19th Century Chinese Camp ▪ Wells. TMR, in consultation with the Queensland Department of Environment and Science, are assessing the significance of the historic features to determine the required management actions. If during construction an item of heritage significance is found Section 89 of the *Queensland Heritage Act 1992* requires a person to notify Department of Environment and Science of an archaeological artefact that is an important source of information about an aspect of Queensland history.
Queensland *Planning Act 2016*		
Development Permit: (Operational Works) High Impact Earthworks in a Wetland Protection Area	Queensland Department of State Development, Manufacturing, Infrastructure and Planning Queensland Department of Environment and Science	The Project Area traverses Wetland Protection Areas. The construction of a new road would be considered high impact earthworks. High impact earthworks in a Wetland Protection Area is prohibited development for transport infrastructure under the Planning Regulation 2017 unless the works can achieve compliance with the accepted development requirements in Schedule 14 of the Planning Regulation 2017. Consultation with the relevant State Government departments is currently being undertaken to outline compliance and management measures proposed for the Project and to propose and confirm an accepted development strategy with the regulators.

Legislative Trigger	Regulatory Authority	Project Relevance
Development Permit: (Operational Works) Waterway barrier works Constructing or raising permanent waterway barrier works within an assessable waterway	Queensland Department of Environment and Science	The Project alignment intersects the following waterways shown on spatial data layer *Queensland Waterways for waterway barrier works* (State of Queensland, 2019): ▪ Limestone Creek (high – red) ▪ Two unnamed waterways (low – green) ▪ Fitzroy River (major – purple) ▪ Lion Creek (major – purple) – 2 crossings. The Project involves the construction of new bridges, new culverts and drainage works on these identified waterways.
Development Permit: (Operational Works) Constructing or raising temporary waterway barrier works within an assessable waterway.	Queensland Department of Agriculture and Fisheries	The Project alignment intersects waterways shown on the spatial data layer *Queensland Waterways for waterway barrier works* (State of Queensland, 2019). Constructing a bridge within a waterway may require temporary waterway barrier works to facilitate a range of construction activities. These may include temporary bunds, silt curtains, access tracks etc. Construction of some bridges are anticipated to exceed 180 days therefore it is unlikely works within the waterways can comply with the Accepted development requirements for operational work that is constructing or raising waterway barrier works (date effective 1st October 2018). Where compliance cannot be achieved, a development permit will be required.
Development Permit: (Operational Works) Works that take water in a watercourse, lake or spring.	Queensland Department of Resources	Under Section 23 and 24 of the Water Regulation 2016, a constructing authority may take water to construct or maintain infrastructure in line with the Exemption requirements for the taking of water without a water entitlement, under the Water Regulation 2002 (OSW/2020/5467). The Fitzroy River is within a Resource Operations Licence area for water supply associated with the barrage. Written approval to take water from an area subject to a Resource Operations Licence must be obtained from the licensee.
Queensland *Nature Conservation Act 1992*		
If the proposed works are within a 'high risk area' and clearing is proposed.	Queensland Department of	The northern most extent of the Project Area is located within a high-risk trigger area for protected plants. A survey was undertaken in February 2019, identifying no protected plants. A subsequent exemption notification was lodged with the Queensland Department of Environment and Science.

Legislative Trigger	Regulatory Authority	Project Relevance
A flora survey undertaken by a certified botanist is required to determine the actual presence of protected threatened plants. If threatened protected plants are present a clearing permit is required.	Environment and Science	Since this time, the Project Area has been amended. An additional survey was undertaken in December 2020 and no protected plants (under the *Nature Conservation Act 1992*) were identified. An Exempt Clearing Notification will be lodged with Department of Environment and Science prior to clearing works.
Queensland *Water Act 2000*		
Riverine Protection Permit Excavation, fill and / or removal of vegetation within a mapped watercourse.	Queensland Department of Resources	Construction of the Project is likely to involve a range of excavation and fill activities within watercourses. The construction methodology should consider the requirements to meet the RPP exemption requirements (WSS/2013/726). These requirements will be built into the construction specification and environmental management plans to ensure compliance (if achievable). Where the requirements of the Riverine protection permit exemption requirements (WSS/2013/726) cannot be achieved, a permit would be required.

5.1 Australian International Agreements for Migratory Birds

The EPBC Act is also the key mechanism for meeting Australia's obligations and responsibilities under a number of international agreements. Australia is a signatory to the following international agreements relating to migratory shorebird conservation:

- The Convention on Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention)
- Bilateral agreements for the conservation of migratory birds between the Government of Australia and the Government of Japan (JAMBA), the Government of China (CAMBA) and the Government of the Republic of Korea (ROKAMBA)
- The Convention on Wetlands of International Importance (also known as the Ramsar Convention).

Where species are listed on the above agreements, the species are obligated to be listed as 'migratory' species under the EPBC Act. Once listed as 'migratory' under the EPBC Act, they are afforded the protections offered by the EPBC Act and it becomes an offence under the EPBC Act to kill, injure, take or move the species in Commonwealth areas.

The provisions of the EPBC Act reflect the protections provided to migratory species listed under the above international agreements and includes the prohibition on the taking of these species (except in very limited circumstances). Therefore, as the EPBC Act protects species listed as 'migratory' under the Act, where an action is undertaking in accordance with the EPBC Act, the action is consistent with the above international agreements.

5.2 Other International Agreements

Australia is a signatory to several international agreements which seek to conserve the environment, including the following:

- The Biodiversity Convention
- The Convention on Conservation of Nature in the South Pacific (Apia Convention)
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The EPBC Act provides for the protection of the environment, especially those aspects of the environment that are MNES. Generally, it is an offence for a person to take an action which has, will have, or is likely to have a significant impact on matter of national environmental significance. Where a matter is listed on the above conventions, the Commonwealth government is required to consider the matter's conservation, which is typically done by listing the matter under the EPBC Act. Therefore, where an action is undertaken in accordance with the EPBC Act, the action is consistent with the above conventions.

6. Matters of National Environmental Significance

This section details the habitat assessments undertaken for all matters of national environmental significance (MNES) known or likely to occur within the Project Area, and includes the following information:

- An assessment of the potential habitat available within, adjacent to and/or downstream of the Project Area
- A discussion of the vegetation composition and structure on suitable soils (such as specific tree species, riparian areas and microhabitat features, etc.) and/or waters and association with habitat types of a species
- MNES and their habitat within the Project Area including:
  - known records of individuals (or evidence of individuals) derived from desktop analysis and/or field surveys
  - area (in hectares) and habitat condition
  - any breeding, foraging, dispersal, refuge/shelter, suitable habitats, roosting, known important habitat
  - for migratory species known Important Bird Area and Directory of Important Wetlands of the Fitzroy floodplain and delta.

The habitat assessment has been undertaken for the following MNES identified in the Preliminary Documentation RFI together with additional species identified during the survey program or previously recorded in database searches:

Flora

- Black ironbox (*Eucalyptus raveretiana*) – Vulnerable
- Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC – Endangered
- Coolibah – black box woodlands of the Darling Riverine Plains and the Brigalow Belt south bioregions TEC – Endangered
- Marlborough blue (*Cycas ophiolitica*) – Endangered
- Weeping Myall woodland – Endangered

Aquatic species

- Estuarine crocodile (*Crocodylus porosus*) – Migratory, Marine
- Fitzroy River turtle (*Rheodytes leukops*) – Vulnerable
- White-throated snapping turtle (*Elseya albagula*) – Critically Endangered

Terrestrial species

- Australasian bittern (*Botaurus poiciloptilus*) – Endangered
- Australian painted snipe (*Rostratula australis*) – Endangered, Marine
- Grey-headed flying-fox (*Pteropus poliocephalus*) – Vulnerable
- Koala (*Phascolarctos cinereus*) (combined populations of Queensland, New South Wales and the Australian Capital Territory) – Vulnerable
- Ornamental snake (*Denisonia maculata*) – Vulnerable
- Squatter pigeon (*Geophaps scripta scripta*) – Vulnerable
- White-throated needletail (*Hirundapus caudacutus*) – Vulnerable

Migratory Species

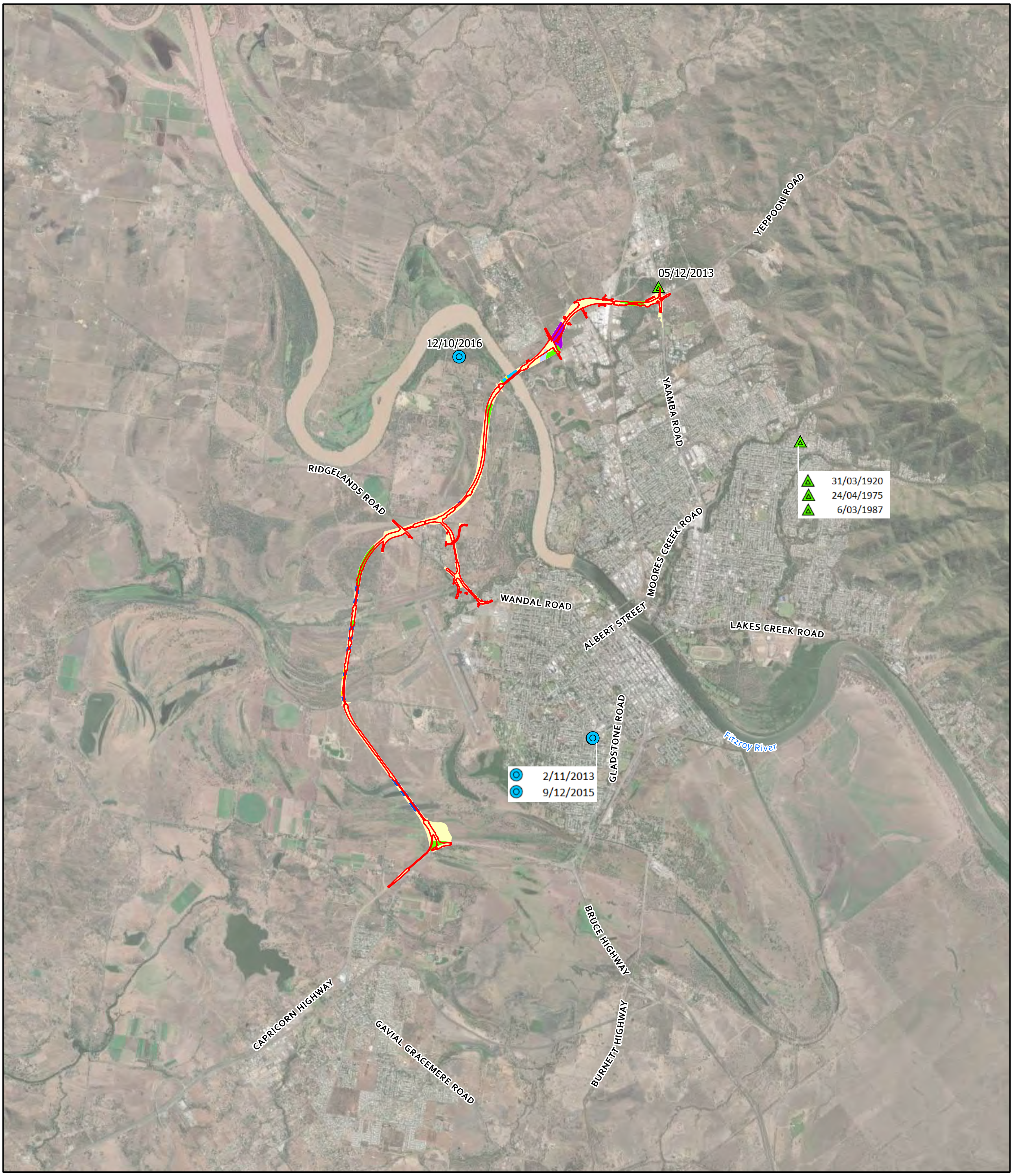
- Black-tailed godwit (*Limosa limosa*) – Migratory, Marine
- Caspian tern (*Hydroprogne caspia*) – Migratory, Marine
- Common greenshank (*Tringa nebularia*) – Migratory, Marine

- Common sandpiper (*Actitis hypoleucos*) – Migratory, Marine
- Curlew sandpiper (*Calidris ferruginea*) – Critically Endangered, Migratory, Marine
- Eastern osprey (*Pandion haliaetus*) – Migratory, Marine
- Glossy ibis (*Plegadis falcinellus*) – Migratory, Marine
- Latham’s snipe (*Gallinago hardwickii*) – Migratory, Marine
- Little curlew (*Numenius minutus*) – Migratory, Marine
- Little tern (*Sterna albifrons*) – Migratory, Marine
- Marsh sandpiper (*Tringa stagnatilis*) – Migratory, Marine
- Pectoral sandpiper (*Calidris melanotos*) – Migratory, Marine
- Red-necked stint (*Calidris ruficollis*) – Migratory, Marine
- Sharp-tailed sandpiper (*Calidris acuminata*) – Migratory, Marine
- White-winged black tern (*Chlidonias leucopterus*) – Migratory, Marine
- Wood sandpiper (*Tringa glareola*) – Migratory, Marine

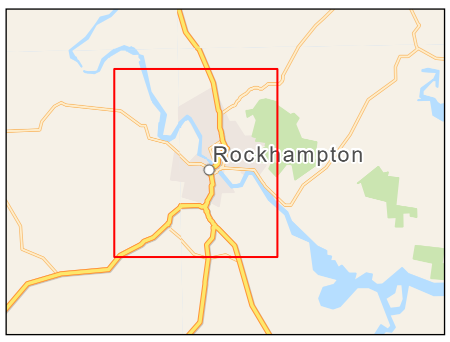
The approximate extent of potential habitat in the Project Area for listed species with the potential to occur is provided in Table 6-1 and the condition of potential habitat in the Project Area for listed species is provided in Table 6-2.

Desktop records for listed flora and TECs, aquatic and terrestrial fauna and migratory birds are presented on Figure 6-1, Figure 6-2 and Figure 6-3 respectively.

Figure 6-1: Threatened flora desktop records



Legend
WildNet records
black ironbox
Atlas of living Australia records
Cycad Blue
Brigalow woodland
Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
Eucalyptus woodland on alluvial floodplains
Eucalyptus woodland on metamophics or granitics
Fringing riparian woodland with Eucalyptus raveretiana
Lacustrine or palustrine wetland
Modified grasslands
Riverine waterbody
Fringing riparian woodland
Project Footprint
Project Area



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Source: Queensland Department of Resources: Roads (2020); Wildnet/ALA: Species Records (2021); ESRI: Imagery (2020)

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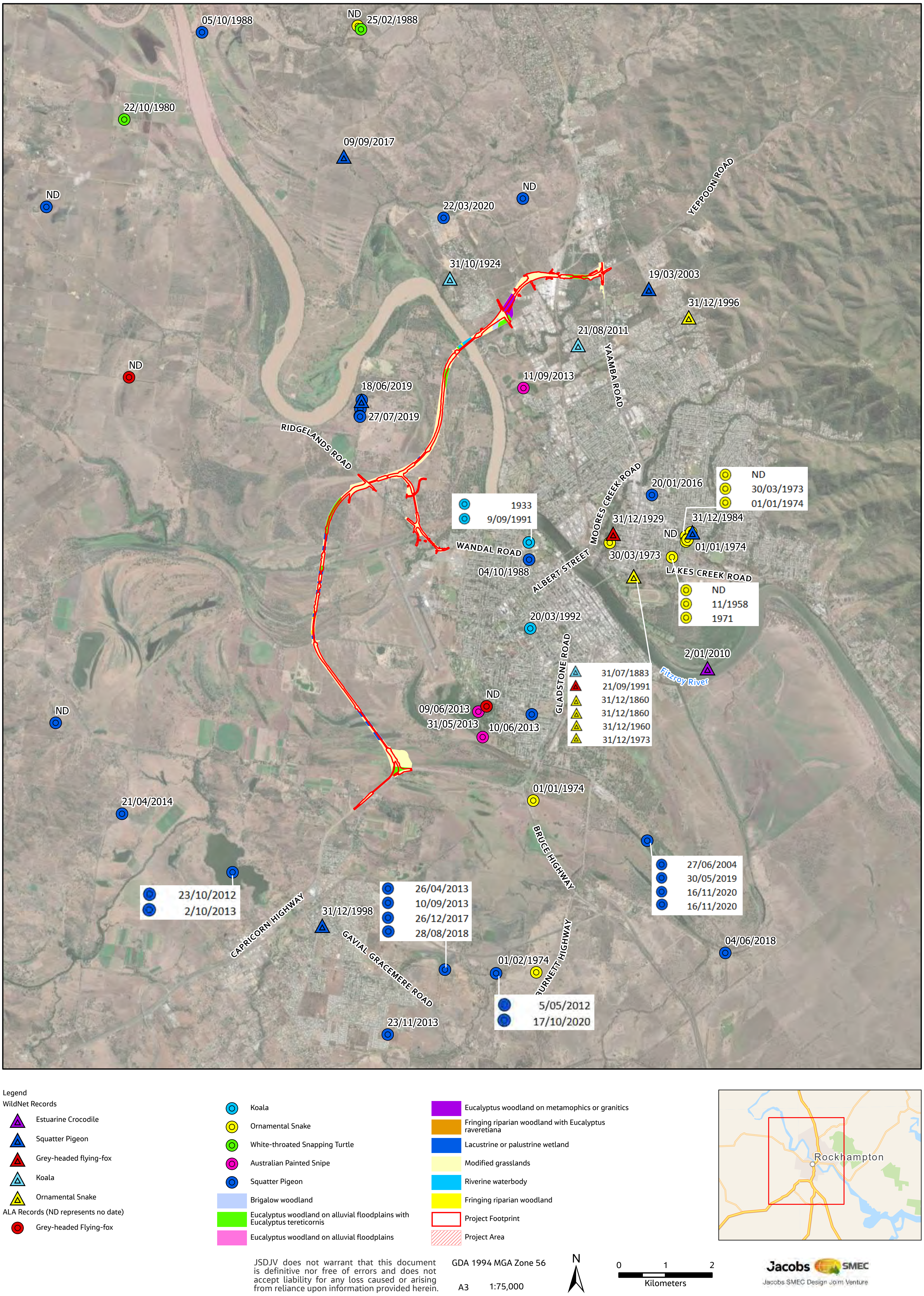
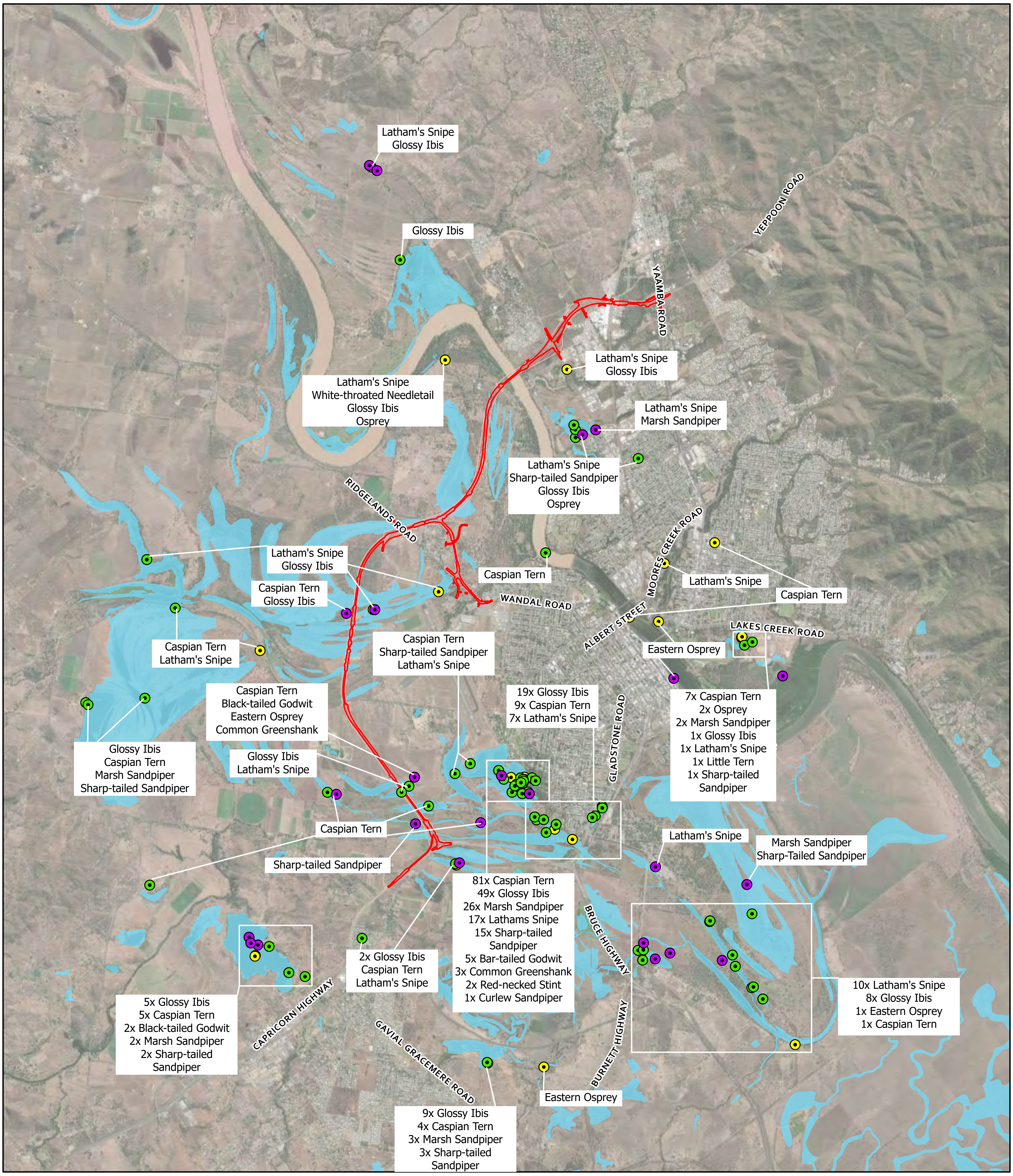
Figure 6-2: Threatened aquatic and terrestrial fauna desktop records



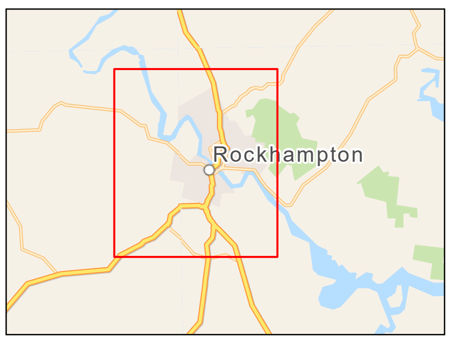
Source: AECOM: Habitat Types (2021); Queensland Department of Resources: Roads, Wildnet Records, Watercourses (2020); ESRI: Imagery (2020)

Figure 6-3: Migratory bird desktop records



Legend

- WildNet Migratory Bird Records
- eBird Migratory Bird Records
- Birdata Migratory Bird Records
- Project Footprint
- Project Area
- High ecological significance Wetlands



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: Roads, Wildnet Records, Watercourses, Wetlands (2020); Metromap: Imagery (2020)

6.1 Flora

6.1.1 Black Ironbox (*Eucalyptus raveretiana*) – Vulnerable

Black ironbox (*Eucalyptus raveretiana*) is a medium sized tree (to 25 m tall) with rough bark on the trunk and largest branches with other branches smooth, white, grey or pale blue. Flowers are formed in terminal clusters and fruit is the smallest of any eucalypt at approximately 2 mm long and wide (Australia Government Department of Agriculture, Water and the Environment, 2021).

Black ironbox has a wide distribution in coastal and sub-coastal areas of Queensland, from south of Townsville to Nebo, and around Rockhampton in areas 100 km west of the city. It has been recorded from about 23 sites in two main areas: Nebo to Ayr and Aps Creek to Rockhampton with most occurrences are on roadsides, freehold land and leasehold land however, it is present in reserves. Records have been made from the tributaries of the Fitzroy River (Mackenzie, Isaac and Connors Rivers, and the Funnel, Boothill, Nebo and Denison Creeks), the Suttor River (and its upper tributaries) and the Bowen, Burdekin, Don, Bogie, Broughton, Haughton, O'Connell and Andromache Rivers. Population data is limited (Australia Government Department of Agriculture, Water and the Environment, 2021).

Black ironbox usually grows along watercourses, and sometimes on river flats or open woodland and is salt tolerant. It occurs on variable soils from sand through to heavy clay up to 300 m above sea level in sub-tropical climates with an annual rainfall of 650 – 1,100 m (Australia Government Department of Agriculture, Water and the Environment, 2021).

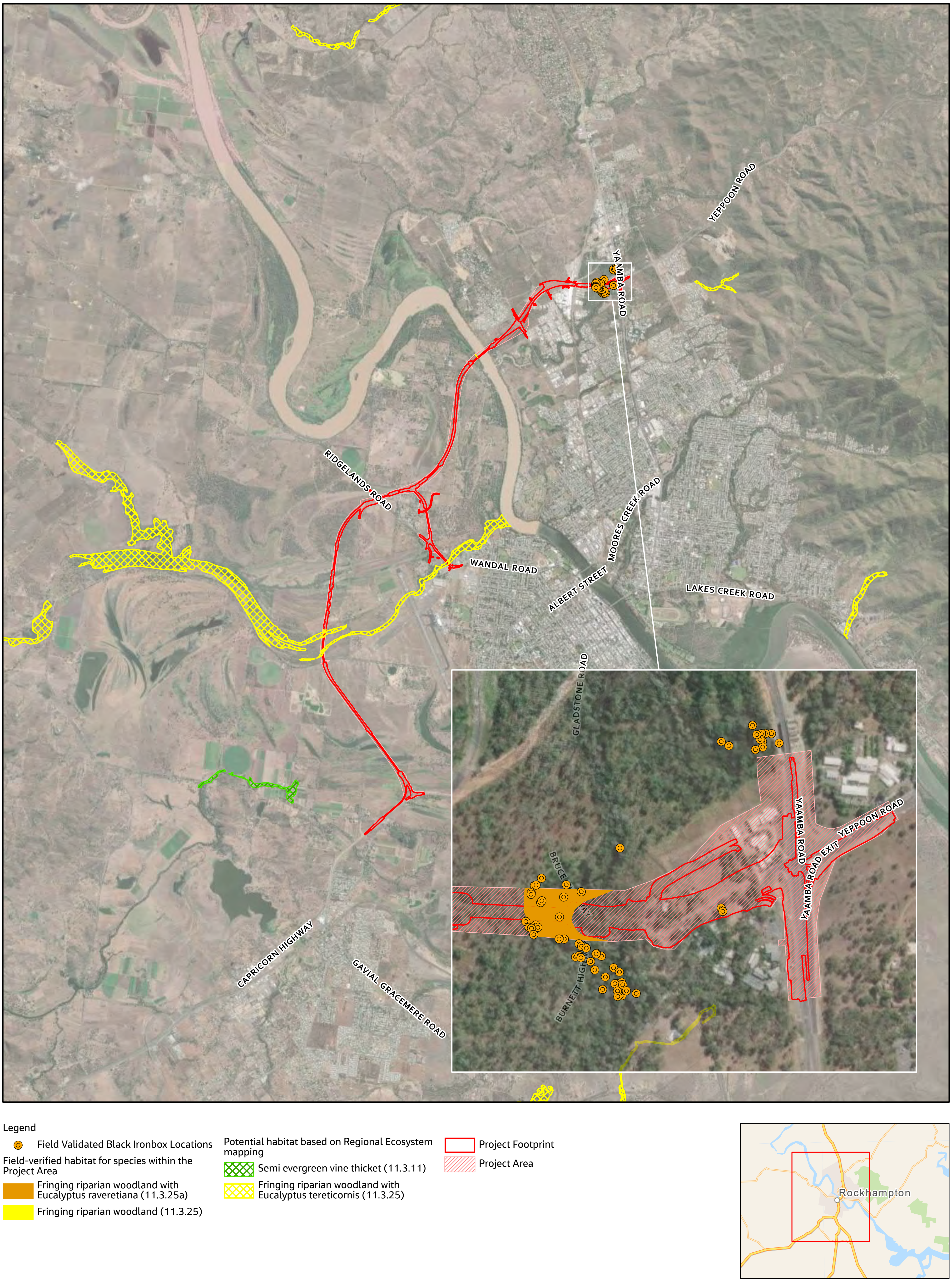
Black Ironbox is typically co-dominant with species such as broad-leaved tea tree (*Melaleuca leucadendra*), *Melaleuca fluviatilis*, forest red gum (*Eucalyptus tereticornis*), carbeen (*Corymbia tessellaris*) (RE 11.3.25a). It can also co-occur with semi evergreen vine thicket on alluvial plains with bottle trees (*Brachychiton australis, Brachychiton rupestris*), scrub wilga (*Geijera salicifolia*) and *Lysiphyllum* spp. (RE 11.3.11), river red gum (*Eucalyptus camaldulensis*), Moreton Bay ash (*Corymbia tessellaris*) and river oak (*Casuarina cunninghamiana*).The distribution of black ironbox overlaps with the EPBC Act-listed TEC Brigalow (*Acacia harpophylla* dominant and co-dominant) (Australia Government Department of Agriculture, Water and the Environment, 2021).

The field surveys undertaken for the Project in December 2020 (Jacobs SMEC Design Joint Venture, 2021f) identified that black ironbox was present as the dominant canopy species in a narrow fringing riparian open forest along Limestone Creek. Other associated species in the canopy include *Melaleuca fluviatilis, Casuarina cunninghamiana* and *Corymbia clarksoniana*. The understorey was dominated by the weed species *Leucaena leucocephala* (leucaena), while the sparse to mid-dense groundcover was dominated by weedy grasses. This vegetation community was assessed as being analogous with RE 11.3.25a (AECOM, 2020f; Ecosure, 2021b).

Within the Project Area, there is approximately 1.0 ha of potentially suitable habitat (i.e. regional ecosystem 11.3.25a) along Limestone Creek (Figure 6-4) (Jacobs SMEC Design Joint Venture, 2021f). Approximately 0.3 ha of black ironbox habitat (regional ecosystem 11.3.25a) will be lost in the Project Footprint. In the Project Area there is an additional approximately 0.7 ha of potentially suitable habitat outside of the Project Footprint (totalling 1.0 ha across the Project Area). The area to the south of the bridge over Limestone Creek is declared a no-go-zone, the area to the north of the bridge is to be actively rehabilitated.

As black ironbox is associated with fringing riparian woodland with *Eucalyptus* raveretiana (RE 11.3.25a), it is possible that fringing riparian woodland (RE 11.3.25) also supports potential habitat for black ironbox, as RE 11.3.25a is a sub RE of RE 11.3.25. Black ironbox can also occur in semi-evergreen vine thicket RE 11.3.11, which is mapped within the broader area. Therefore, there is approximately 1,152 ha of potential habitat for black ironbox within the broader area based on RE mapping. Furthermore, black ironbox trees are also anticipated to be present outside of the surveyed area, as indicated by the number of trees recorded along Limestone Creek. That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

Figure 6-4: Black ironbox (Eucalyptus raveretiana) habitat within the Project Area and potential habitat in the broader area



Rockhampton Ring Road

Source: Queensland Department of Resources: Roads (2020); AECOM: Ironbox Habitat (2021); Metromap: Imagery (2020)

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6.1.2 Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC – Endangered

Brigalow is the commonly accepted name for the species *Acacia harpophylla* and the vegetation in which this species is dominant or co-dominant. Of the 16 REs that comprise the Brigalow TEC, the following could occur in the Project Area (i.e. bioregion 11):

- RE 11.3.1 *Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains
- RE 11.4.3 *Acacia harpophylla* and/or *Casuarina cristata* shrubby open forest on Cainozoic clay plains
- RE 11.4.7 Open forest of *Eucalyptus populnea* with *Acacia harpophylla* and/or *Casuarina cristata* on Cainozoic clay plains
- RE 11.4.8 *Eucalyptus cambageana* open forest with *Acacia harpophylla* or *Acacia argyrodendron* on Cainozoic clay plains
- RE 11.4.9 *Acacia harpophylla* shrubby open forest with *Terminalia oblongata* on Cainozoic clay plains
- RE 11.4.10 *Eucalyptus populnea* or *Eucalyptus pilligaensis, Acacia harpophylla, Casuarina cristata* open forest on margins of Cainozoic clay plains
- RE 11.5.16 *Acacia harpophylla* and/or *Casuarina cristata* open forest in depressions on Cainozoic sand plains/remnant surfaces
- RE 11.9.1 *Acacia harpophylla-Eucalyptus cambageana* open forest on Cainozoic fine-grained sedimentary rocks
- RE 11.9.5 *Acacia harpophylla* and/or *Casuarina cristata* open forest on Cainozoic fine-grained sedimentary rocks
- RE 11.9.6 *Acacia melvillei* ± *Acacia harpophylla* open forest on Cainozoic fine-grained sedimentary rocks
- RE 11.11.14 *Acacia harpophylla* open forest on deformed and metamorphosed sediments and interbedded volcanics
- RE 11.12.21 *Acacia harpophylla* open forest on igneous rocks; colluvial lower slopes (Threatened Species Scientific Committee, 2013).

This TEC is characterised by the presence of *Acacia harpophylla* as one of the three most abundant tree species, with or without co-dominant species such as *Casuarina cristata*, or *Acacia* spp. or *Eucalyptus* spp.. Occasionally other species may be more common than *Acacia harpophylla*. Eucalyptus trees may be scattered or form an emergent layer that is taller than the *Acacia harpophylla* canopy, and common species include:

- *Eucalyptus argophloia* (Chinchilla white-gum)
- *Eucalyptus brownii* (Reid River box)
- *Eucalyptus cambageana* (blackbutt, coowarra box, Dawson gum)
- *Eucalyptus largiflorens* (black box)
- *Eucalyptus microcarpa* (grey box)
- *Eucalyptus moluccana* (grey-topped box)
- *Eucalyptus pilligaensis* (gum-topped box, ribbon gum, mallee box, Molly box, narrow-leaved grey box)
- *Eucalyptus populnea* (poplar box, bimble box), or
- *Eucalyptus thozetiana* (mountain yapunyah)
- *Eucalyptus coolabah* (coolibah) or *Eucalyptus orgadophila* (mountain coolibah).

Other tree species that may occur include:

- *Lysiphyllum carronii* (red bauhinia)
- *Brachychiton rupestris*
- *Acacia melvillei* (yarran, Melville's wattle)
- *Acacia omalophylla* (yarran)
- *Acacia argyrodendron*

- *Acacia melvillei*
- *Acacia omalophylla.*

The TEC occurs on flat to gently undulating Cainozoic (i.e. the most recent geological era) clay plains that are not associated with current alluvium, or in gently undulating landscapes on sedimentary rocks, however approximately 10% of remnants are associated with river and creek flats. The vegetation types that make up the TEC grow on both acidic and salty clay soils. *Acacia harpophylla* tends to dominate on deep cracking clay soils with a pattern referred to as gilgai (or melon holes) which intermittently fill with water, whereas *Eucalyptus* spp. tend to co-dominate on texture-contrast soils (i.e. soils with an abrupt change in texture between the surface and subsoil soils) (Threatened Species Scientific Committee, 2013).

The TEC typically occurs within areas that receive predominantly summer rainfall, with a total of 500 – 750 mm per year. Vegetation structure ranges from open forest to open woodland with a tree height of approximately 9 m in low rainfall to approximately 25 m in higher rainfall areas, together with a prominent shrub layer (Threatened Species Scientific Committee, 2013).

The Brigalow TEC can include vegetation considered to be non-remnant, that is, regrowth vegetation not included in RE mapping, which allows for the regeneration of the TEC. Areas of brigalow regrowth are not considered part of the EPBC Act listed Brigalow TEC if they are of poor quality, which is attributes to one or more of the following:

- vegetation that has been comprehensively cleared (not just thinned) within the last 15 years
- vegetation in which exotic perennial plants (weeds) have more than 50% cover, assessed in a minimum area of 0.5 ha (100 m by 50 m), or
- individual patches of Brigalow that are smaller than 0.5 ha (Threatened Species Scientific Committee, 2013).

Not all vegetation in which Brigalow is prominent is included within the listed Brigalow TEC. The following REs of the Brigalow Belt area are excluded under the EPBC Act:

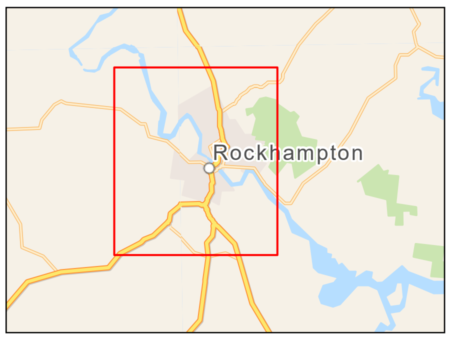
- RE 11.3.17 *Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains
- RE 11.9.10 *Acacia harpophylla, Eucalyptus populnea* open forest on fine-grained sedimentary rocks
- RE 11.9.11 *Acacia harpophylla* shrubland on fine-grained sedimentary rocks
- RE 11.11.16 *Eucalyptus cambageana, Acacia harpophylla woodland* on old sedimentary rocks with varying degrees of metamorphism and folding (Threatened Species Scientific Committee, 2013).

There is approximately 1.9 ha of the brigalow (*Acacia harpophylla* dominant and co-dominant) TEC within the Project Area (Ecosure, 2021b), with only a small portion of the habitat inside the Project Footprint (approximately 0.3 ha) (Figure 6-5). The vegetation is brigalow regrowth with species composition and structural elements broadly typical of RE 11.3.1 (*Acacia harpophylla* and/or *Casuarina cristata* open forest on alluvial plains) and meets all of the criteria and condition thresholds in the conservation advice for the TEC (Threatened Species Scientific Committee, 2013). The alignment of the road was refined during the Preliminary Design to avoid this TEC, however following the re-survey of the habitat in July 2021, approximately 0.3 ha is within the Project Footprint. The remaining habitat in the Project Area will be demarcated as a no-go zone and protected during construction.

Figure 6-5: Brigalow (Acacia harpophylla dominant and co-dominant) TEC within the Project Area and potential habitat in the broader area

Legend

- Field-verified habitat for Brigalow Threatened Ecological Community within the Project Area
- Potential habitat based on Regional Ecosystem mapping
- Project Area
- Project Footprint



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: Roads (2020); AECOM: Brigalow Habitat (2021); ESRI: Imagery (2020)

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The Brigalow TEC in the Project Area occurs as a fragmented patch in a significantly modified landscape. Locally, the TEC has been heavily cleared and degraded, although regrowth is present in the area. As a result, there is little connectivity with adjacent vegetation, and it has relatively low value within the context of the broader landscape. *Acacia harpophylla* was dominant in the tree layer with tree height 5 – 9 m with 74% crown cover (which does not reach the required 10.6m height that is 70% of the 15.1m average canopy of remnant vegetation). Satellite imagery indicates this vegetation has not been cleared for at least 15 years. Exotic perennial plants comprise < 1% of the total vegetation cover and are mainly concentrated on the edges. A mature canopy layer was absent, and due to the age of trees present no hollows or deep crevices in the bark were present. Leaf litter was abundant however groundcovers were relatively low, with areas of bare ground common and microhabitat features such as coarse woody debris and decorticating bark absent (AECOM, 2020f; Ecosure, 2021b).

There are approximately 284.1 ha of potential brigalow TEC habitat outside of the Project Area based on RE mapping. It is possible that there are also other areas of brigalow regrowth in the broader Project Area. Areas of regrowth are likely to be located where land is not being used for grazing as these areas are largely cleared and dominated by weeds, and not in association with current alluvium, which extends across the floodplain. Regrowth is more likely to occur on sedimentary rocks in the northern parts of the broader area. That is, there is likely to be larger areas of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

6.1.3 Coolibah – Black Box Woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions TEC – Endangered

Regrowth comprised of RE 11.3.3 (*Eucalyptus coolabah* woodland on alluvial plains) was mapped along the alignment. RE 11.3.3 corresponds with the coolibah – black box woodlands of the Darling Riverine Plains and Brigalow Belt south bioregions TEC. This patch of regrowth was mapped outside the Brigalow Belt south bioregion, north of the Fitzroy River, and therefore does not meet the criteria of the TEC.

The Project is therefore not anticipated to impact this TEC.

6.1.4 Marlborough Blue (*Cycas ophiolitica*) – Endangered

Cycas ophiolitica (Marlborough blue) grows on hills and slopes in sparse, grassy open forest at altitude ranges from 80 – 400 m above sea level. It is a trunked cycad that typically grows to 2 m but can reach 4 m tall. It is known from Marlborough in the north to the Fitzroy River near Rockhampton in the south. There are two known populations concentrated in these two areas (Marlborough and Rockhampton) with an apparently natural adjunct between the two populations. The degree of genetic continuity within and between populations of this species is not known (Australian Government Department of Agriculture, Water and Environment, 2021u).

Marlborough Blue occurs in:

- woodland or open woodland dominated by eucalypts and often on serpentinite substrates (with *Corymbia dallachiana, Corymbia erythrophloia, Corymbia xanthope, Eucalyptus fibrosa*), but also
- on mudstone (with *Corymbia dallachiana, Corymbia erythrophloia and Eucalyptus crebra*) and
- on alluvial loams (with *Corymbia intermedia, Eucalyptus drepanophylla and Eucalyptus tereticornis*).

The species may co-occur with either *Macrozamia serpentina* (serpentinites) or *Macrozamia miquelii* (mudstone or alluvial loams) (Australian Government Department of Agriculture, Water and Environment, 2021u).

Populations can be locally dense (large number of plants) but the boundaries can be sharp with no apparent change in habitat, indicating dispersal-limited distribution. The distribution of individual plants tends to be strongly clumped with most seed dispersal extremely local and near to the parent plants. Effective pollination is critical for long-term survival however very little information is known about pollination. Seeds ripen from March onwards but are not ready to germinate for at least nine months. Limited dispersal of ripe seeds from cycad species may occur via mammals such as possums, rodents or fruit bats, however cycad seeds are highly toxic and few vertebrates disperse seed or fruit of a similar size to cycad seed now exist in Australia (Australian Government Department of Agriculture, Water and Environment, 2021u).

Of the 16 known populations, only five have more than 3,500 plants (which is the minimum viable population size for the allied *Cycas megacarpa*). Most of these large populations occur in the southern part of the species range (i.e. around Marlborough) and do not include the bluish forms that are have suffered decline due to cycad collection (Australian Government Department of Agriculture, Water and Environment, 2021u).

Most cycads are fire-dependent for reproduction, but fire-sensitive to mortality of seeds and seedlings. Understanding the effects of fire frequency, intensity and time of burn on the reproductive capacity of each species and its pollinators is essential for long-term management (Australian Government Department of Agriculture, Water and Environment, 2021u).

It is noted that some cycad species can occur in lower elevation areas down to 10m (*Macrozamia lomandroides*) or 5 m (*Macrozamia pauli-guilielmi*) (Queensland Herbarium, 2007) but there is no evidence that Marlborough Blue occurs below 40 m elevation. The Project Area is below 40 m above sea level and dominated by a largely cleared alluvial floodplain (<10 m above sea level). There are small areas of co-dominant alluvial species, mostly *Eucalyptus tereticornis* along the Fitzroy River, however this area is unlikely to provide habitat given the dominance of weeds and disturbance (and low elevation).

The species was not recorded during the field surveys undertaken as part of the Project and the field surveys identified no suitable habitat for this species within the Project Area. There are Atlas of Living Australia recordings of Marlborough Blue in the vicinity of the Project (1992 and 2001), however accurate locations are not available given the sensitivity of the species to collection.

Potential habitat may be available in the Project Area in association with RE 11.3.4, 11.3.25 and 11.11.15, with these REs representing approximately 31 ha in the Project Area (Figure 6-6). The broader area includes approximately 9,856.7 ha of several REs (11.11.3, 11.12.1, 11.12.2, 11.12.3, 11.12.6a) that could provide potential habitat for Marlborough blue. That is, there is a large area of potential habitat outside of the Project Area and a small area of potential habitat in the Project Area which does not currently support Marlborough Blue.

The Project is not anticipated to impact this species given it was not recorded within the Project Area, and there are relatively large areas of potential habitat in the broader area.

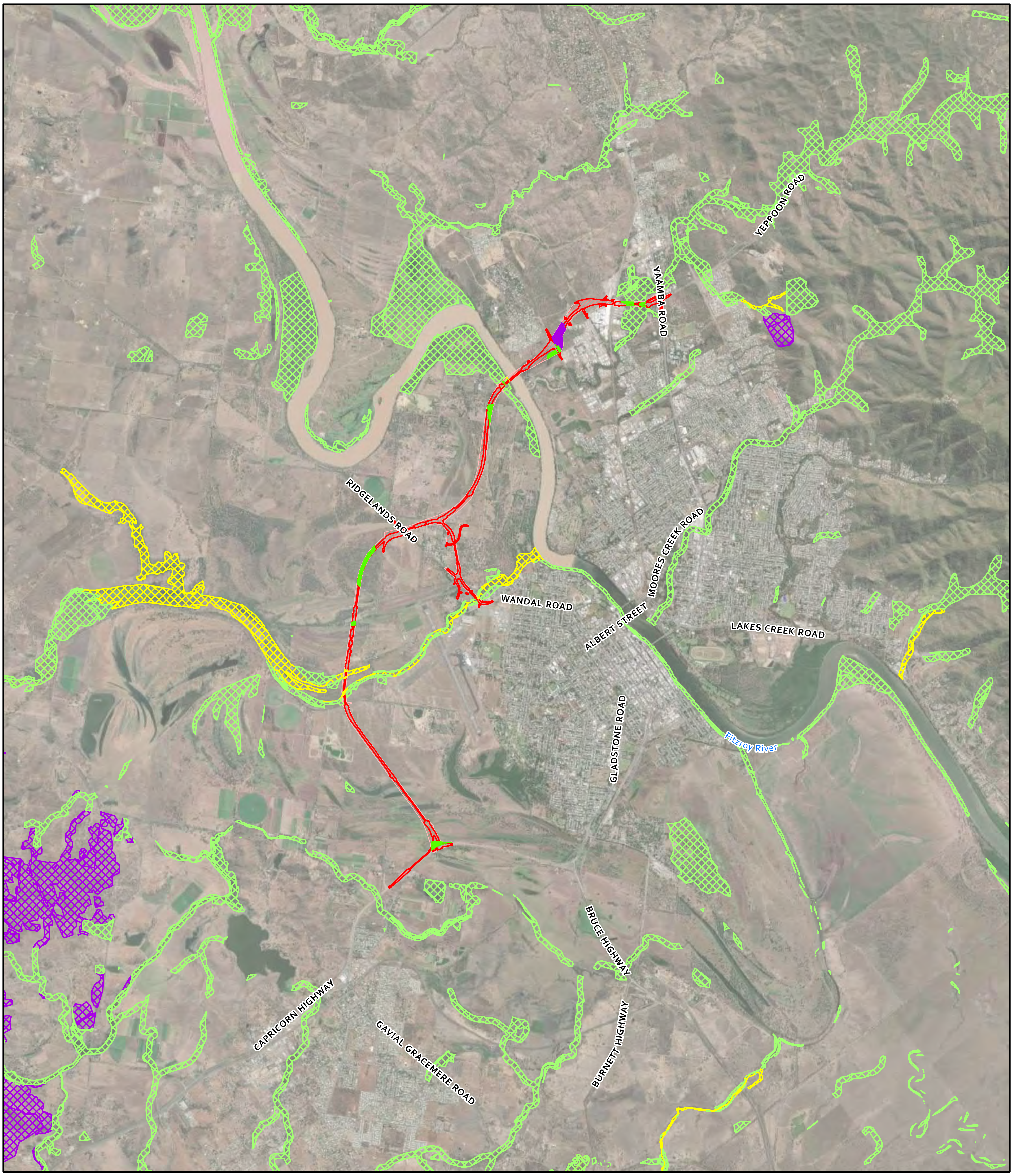
6.1.5 Weeping Myall Woodland TEC – Endangered

Acacia pendula is known as myall, however it shares this common name with other Acacia species and hence the TEC is referred to as weeping myall. The weeping myall woodland TEC occurs in a range of habitats from open woodlands to woodlands in which weeping Myall trees are the sole or dominant overstorey species at 4 – 12 m tall. The TEC occurs on inland alluvial plains west of the Great Dividing Range including the Brigalow Belt South and Brigalow Belt North Interim Biogeographic Regionalisation for Australia (IBRA) bioregions, which include the Project Area. The TEC currently occurs in small pockets throughout this range, on highly fertile and arable soils where there is substantial pressure to clear for cropping or grazing (Department of the Environment, Water, Heritage and the Arts, 2008; Australian Government Department of the Environment, Water, Heritage and the Arts, 2009)

Weeping myall trees often occur in monotypic stands (i.e. the only species present in a stand). Other vegetation may occur, though not as dominant species, including *Alectryon oleifolius subsp. elongatus* (western rosewood), *Eucalyptus populnea* (poplar box) or *Eucalyptus largiflorens* (black box) or *Amyema quandang* (grey mistletoe) on branches. The understorey often includes an open layer of shrubs above an open ground layer of grasses and herbs, however, in many areas, the shrub layer has been destroyed through overgrazing and dieback, and the TEC has a primarily grass understorey (Threatened Species Scientific Committee, 2009; Australian Government Department of the Environment, Water, Heritage and the Arts, 2009).

Community structure varies throughout the TEC range, with open woodlands typical in higher rainfall areas and more sparse woodlands or scattered stands of woodland occurring in discrete bands along wetter area in lower rainfall areas. The TEC generally occurs as part of a mosaic of woodlands, shrublands and grasslands, on flat areas, shallow depressions or gilgais on alluvial plains that are not associated with creek lines and are rarely if ever flooded, however it can occur as relatively narrow strips along floodplain woodland margins (or in minor depressions adjacent to sandhills). It occurs on black, brown, red-brown or grey clay or clay loam soils (Threatened Species Scientific Committee, 2009; Australian Government Department of the Environment, Water, Heritage and the Arts, 2009).

Figure 6-6: Potential Marlborough blue (Cycas ophiolitica) habitat within the Project Area and potential habitat in the broader area

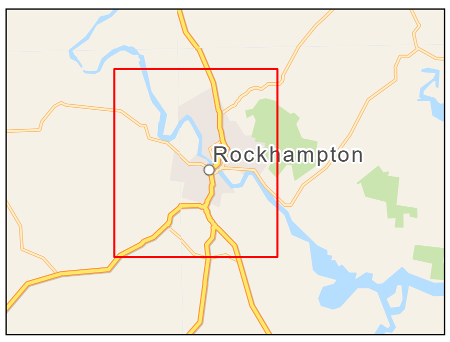


Legend

Field-verified habitat for species within the Project Area
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on metamorphics or granitic
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on metamorphics or granitic
- Fringing riparian woodland

- Project Area
- Project Footprint



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

Acacia pendula occurs widely in Queensland however the weeping myall woodlands TEC is restricted to small patches that occur within two REs:

- 11.3.2 *Eucalyptus populnea* woodland on alluvial plains and
- 11.3.28 *Casuarina cristata* ± *Eucalyptus coolabah* open woodland on alluvial plains.

Small patches of weeping myall trees may also occur in RE 11.9.3a and 4.9.6, however these occurrences are on different landscape and soil types (undulating country on fine grained sedimentary rocks) than the former REs which occur on alluvial plains and are not considered to be part of the listed TEC.

Weeping myall goes through regular cycles of senescence (i.e. aging and death) and regeneration and are susceptible to defoliation by bag-shelter moth (*Ochrogaster lunifer*) caterpillars and are often lopped for cattle feed. The TEC can therefore be dominated by trees that are in a living, defoliated or dead state. Most examples of the TEC in good condition are located in areas with limited grazing or cropping such as road reserves, stock routes and reserves, which tend to be relatively small areas within a matrix of agricultural development with poor landscape connectivity (Threatened Species Scientific Committee, 2009).

Historical accounts suggest that land use and plant and animal introductions post European settlement have resulted in rapid changes to the structure, function and composition of this TEC. The precise nature of these changes remains unknown, however in many cases, clearing and lopping for feed during dry conditions has destroyed the TEC. Seedlings of weeping myall are also highly palatable to stock and the vast majority of regeneration is consumed before plants can grow out of the reach of cattle and other herbivores. This has resulted in little to no regeneration of trees over its range where grazing is prevalent. Grasslands and shrublands that now lack weeping myall trees are excluded from the current EPBC listing, and areas where the understorey is not native, or areas that have been cultivated more than once in the last 30 years (e.g. a single tree in a paddock) are considered to be so highly degraded that they cannot be returned to a state in which they could be considered part of the listed TEC (Threatened Species Scientific Committee, 2009).

A patch is defined as ‘a continuous area that entirely consists of an ecological community. Areas of other ecological communities such as woodlands dominated by other species are not included in a patch. The patch extends over the area up to 10 m beyond the dripline of the outermost trees where the understorey criteria are satisfied.’ A patch must fit the following criteria in order to be included in the listed TEC:

- the tree canopy is dominated (at least 50% of trees present) by living, dead or defoliated weeping myall trees, and
- the overstorey must have at least 5% tree canopy cover or at least 25 dead or defoliated mature weeping myall trees/ha, and
- the area is at least 0.5 ha in size, and
- the patch has either: more than two layers of regeneration of weeping myall present; or the tallest layer of living, dead or defoliated weeping myall trees is at least 4 m tall and of the vegetative cover present, 50% is comprised of native species (Threatened Species Scientific Committee, 2009; Australian Government Department of the Environment, Water, Heritage and the Arts, 2009).

Assessment of a patch should be done wherever possible when 10 per cent or more of the area is covered with either native or exotic vegetation, whether dead or alive (this accounts for situations such as drought). Assessment timing should be related to rainfall patterns so that it coincides with flowering of the understorey species wherever possible, noting that in the Project Area (i.e. northern extent of the TEC), the understorey is dominated by grass species such as Mitchell grass (*Astrebla* spp.) and Queensland blue grass (*Dichanthium sericeum*) which respond to summer rainfall (Australian Government Department of the Environment, Water, Heritage and the Arts, 2009). This TEC was surveyed in February 2019 (i.e. after the wet season) and October 2019 (AECOM, 2020f).

The weeping myall woodland TEC was not recorded within the Project Area, and there are no Atlas of Living Australia records of *Acacia pendula* in the broader area with the nearest record located approximately 250 km to the west of the Project. There may be potential habitat in the Project Area in association with RE 11.3.2, with this RE representing approximately 2.0 ha of the Project Area (Figure 6-7). The broader area includes approximately 1,460 ha of RE 11.3.2 that could provide potential habitat for weeping myall, outside of the Project Area.

The Project is not anticipated to impact this TEC given it was not recorded within the Project Area, there are no Atlas of Living Australia records in the broader area, and there are relatively large areas of potential habitat in the broader area.

6.2 Aquatic Fauna

6.2.1 Estuarine Crocodile (*Crocodylus porosus*) – Migratory, Marine

The estuarine crocodile mostly occurs in tidal rivers, coastal floodplains and channels, billabongs and swamps up to 150 km inland from the coast. In Queensland, this species inhabits reef, coastal and inland waterways from Gladstone on the east coast, throughout the Cape York Peninsula, and west to the Queensland-Northern Territory border. The species is usually restricted to coastal waterways and floodplain wetlands, preferring to nest on elevated, isolated freshwater swamps that do not experience tidal influence. Estuarine crocodiles feed primarily on crustaceans and insects but are also known to consume a variety of prey including birds, fishes, flying-foxes, cats, dogs, pigs, cattle, horses and infrequently humans (Australian Government Department of Agriculture, Water and Environment, 2021f).

Rockhampton is the southern extent of the species range and abundance is comparatively low (Read, Miller, Bell, & Felton, 2004). However estuarine crocodiles are known to occur in the Fitzroy River and its tributaries hundreds of kilometres upstream (Australian Government Department of Agriculture, Water and Environment, 2021f), and there are anecdotal records for Pink Lilly Lagoon following large flood events (pers. comms, Department of Environment and Science, 2019).

This species was not recorded during field surveys in February 2019 (AECOM, 2020d), however it is likely to occur in low abundance within the Project Area, in the Fitzroy River and larger tributaries such as Lion and Limestone creeks, together with larger lagoons following major flood events. These waterways provide suitable foraging or dispersal habitat for this species, and breeding/nesting habitat is provided by elevated, isolated freshwater lagoons.

A study was conducted on the Wenlock River, Cape York Peninsula, Australia to better understand home range utilisation and long-range movement of estuarine crocodiles during the breeding and nesting season. The study involved six months of tracking over the breeding and nesting period. The study concluded that during breeding, the tagged females (4 individuals) occupied an area <1 km length of river, but to nest they travelled up to 54 km away from the breeding area. The study found that the larger tagged males exhibited a 'site-fidelic' (i.e. the tendency for an individual to return to a previously occupied location) strategy and moved within well-defined zones around the female home range areas. In contrast, the smaller males exhibited 'nomadic' behaviour where they travelled continually throughout hundreds of kilometres of waterway. The study argues that the site-fidelic males patrolled territories around the female home ranges to maximise reproductive success, whilst the nomadic males were subordinate (i.e. lower in rank or position, in this case likely due to size) animals that were forced to range over a far greater area in search of unguarded females (Campbell, Dwyer, Irwin, & Franklin, 2013).

For much of the year and during extended dry periods, movement of this species is likely to be restricted by the Fitzroy Barrage, which is approximately 4 km downstream of where the Project crosses the river. During flood events, when the barrage overtops and the floodplain and its lagoons are inundated and connected, estuarine crocodiles would disperse up the river and across the floodplain to access breeding (and foraging and dispersal) habitat. Movements of relocated animals demonstrate their ability to make long distance movements of up to 280 km. Crocodiles nest during the wet season, between November and May, with a peak between January and February. Hatchlings remain near the nest for up to two months (Australian Government Department of Agriculture, Water and Environment, 2021f).

All habitat within the Project Area meets the criteria of important habitat based on the location of the Project at the southern extent of the species range. This habitat does not meet the other important habitat criteria as outlined in the Commonwealth Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013), as the Project Area does not support an ecologically significant portion of the population, and there is no available evidence of species decline in the catchment or large extents of habitat that is critically important to the life-cycle of the species.

The Project is not anticipated to impact this TEC given it was not recorded within the Project Area, there are no Atlas of Living Australia records in the broader area, and there are relatively large areas of potential habitat in the broader area.

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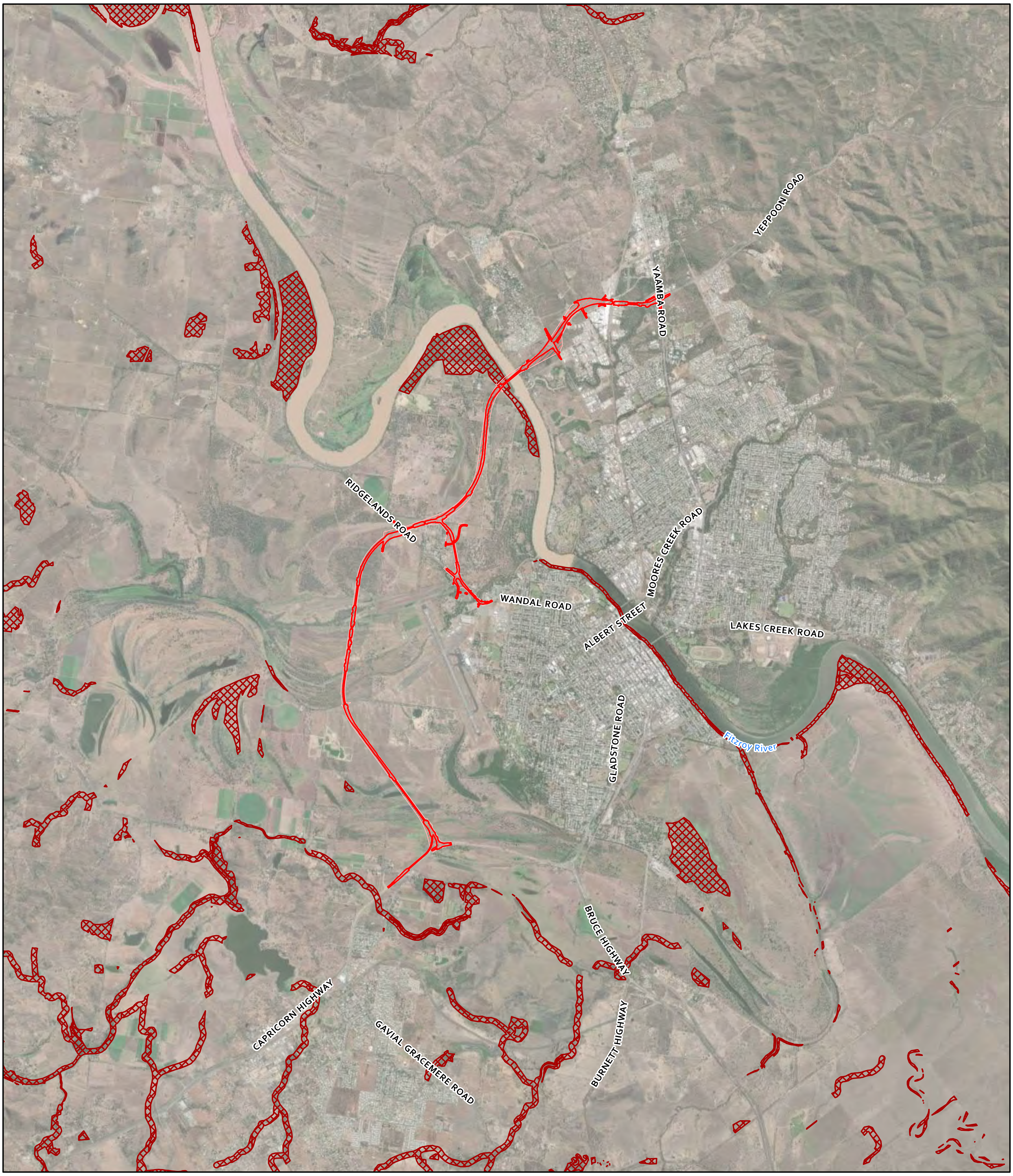
For much of the year and during extended dry periods, movement of this species is likely to be restricted by the Fitzroy Barrage, which is approximately 4 km downstream of where the Project crosses the river. During flood events, when the barrage overtops and the floodplain and its lagoons are inundated and connected, estuarine crocodiles would disperse up the river and across the floodplain to access breeding (and foraging and dispersal) habitat. Movements of relocated animals demonstrate their ability to make long distance movements of up to 280 km. Crocodiles nest during the wet season, between November and May, with a peak between January and February. Hatchlings remain near the nest for up to two months (Australian Government Department of Agriculture, Water and Environment, 2021f).

All habitat within the Project Area meets the criteria of important habitat based on the location of the Project at the southern extent of the species range. This habitat does not meet the other important habitat criteria as outlined in the Commonwealth Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013), as the Project Area does not support an ecologically significant portion of the population, and there is no available evidence of species decline in the catchment or large extents of habitat that is critically important to the life-cycle of the species.

Figure 6-7: Potential weeping myall woodland TEC habitat within the Project Area and potential habitat in the broader area



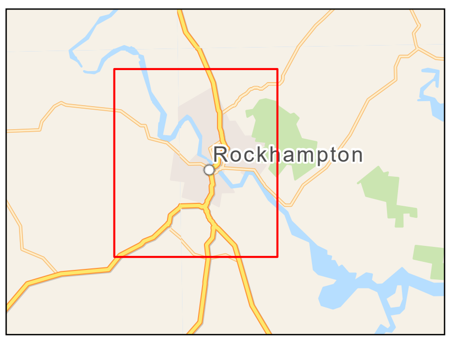
Legend

Potential habitat based on Regional Ecosystem mapping

Eucalyptus populnea woodland on alluvial floodplains

Project Footprint

Project Area



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Jacobs SMEC Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: RE (2020);Metromap: Imagery (2020)

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Approximately 12.9 ha of potentially suitable breeding/nesting, foraging and dispersal for this species is present within the Project Area, including riverine waterbodies and lacustrine or palustrine wetlands (Figure 6-8). There is approximately 5,570.5 ha of potential habitat (i.e. riverine and estuarine waterbodies, lacustrine or palustrine wetlands and mangroves and saltmarsh) in the broader area, which could provide habitat for the estuarine crocodile. That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

There is approximately 9.5 ha of potential breeding habitat (lacustrine or palustrine wetlands) in the Project Area and approximately 4,041.5 ha in the broader area (Figure 6-9). Given the large size of the potential breeding habitat in the broader area, potential impacts to a small portion of potential breeding habitat is unlikely to have a substantial effect on the breeding success of the estuarine crocodile.

6.2.2 Freshwater Turtles

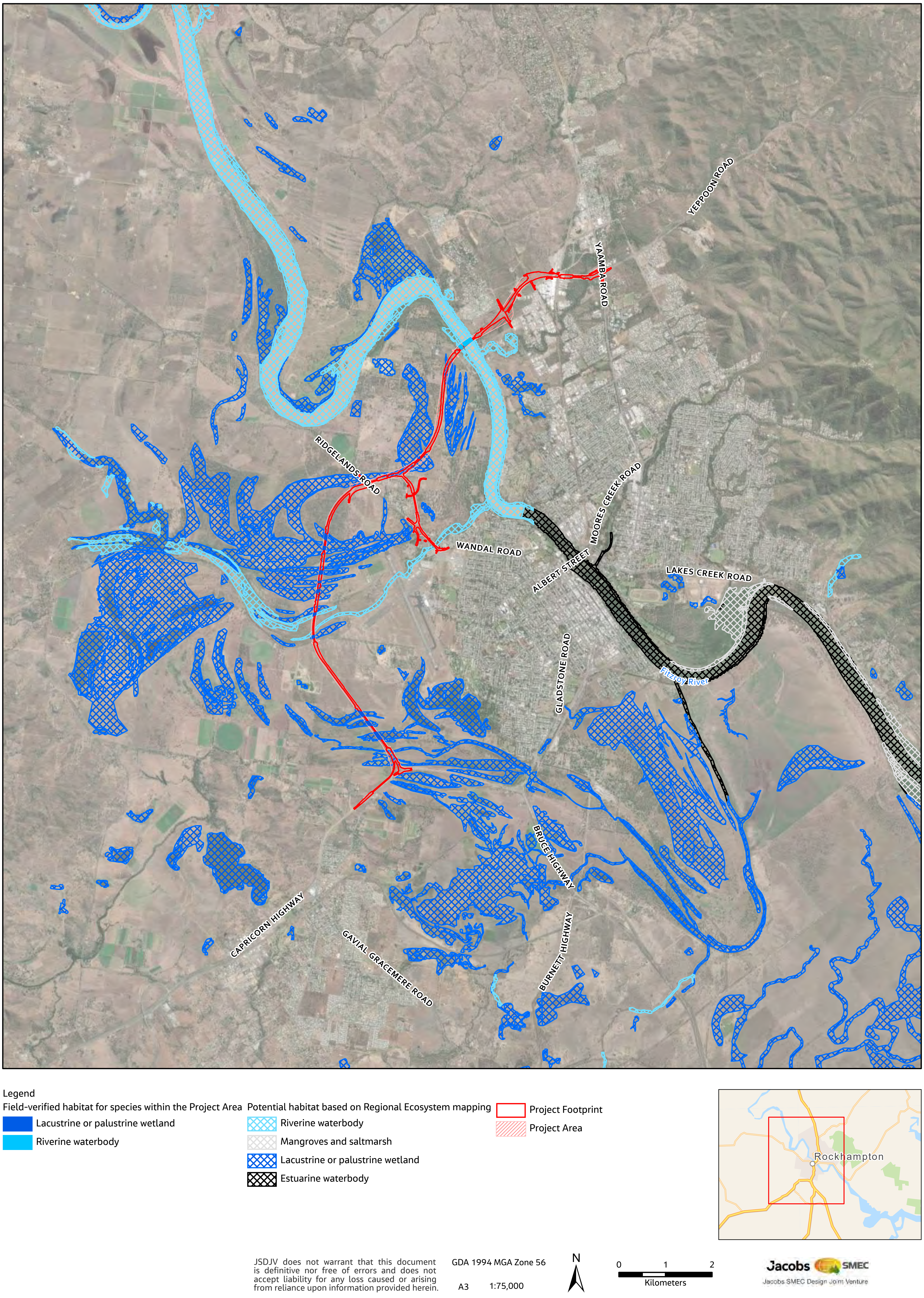
Listed freshwater turtles may occur in the Fitzroy River or Limestone Creek but are unlikely to occur in the wetlands of the Project Area. Surveys in June 2019 (AECOM, 2020e) and December 2020 (Ecosure, 2021a) assessed habitat and occurrence of the Fitzroy River turtle (*Rheodytes leukops*), which is endemic to the Fitzroy Basin, and the white-throated snapping turtle (*Elseya albagula*), which is endemic to the combined Fitzroy-Burnett-Mary basins.

Where the alignment crosses the Fitzroy River, the river is a large permanently flowing waterway, with a wetted width of approximately 250 m and a narrow backwater on the southern bank approximately 80 m wide. At the time of the June 2019 survey (AECOM, 2020e), the riparian zone on both banks was well developed and dominated by large native trees including *Eucalyptus tereticornis* (river red gum) and *Melaleuca leucadendra*. The riparian zone provided shading to the edges of the channel where undercut banks, root tangles, woody debris and macrophytes are present. On the southern bank the macrophyte community was dominated by the exotic species *Eichhornia crassipes*, *Hymenachne amplexicaulis* and *Salvinia molesta*. On the northern bank, macrophyte communities were dominated by exotic species *Pistia stratiotes* and *Eichhornia crassipes*. The river was experiencing low flow and the top of bank was approximately 0.7 m – 1 m above the water surface. The northern bank consisted of loamy soils and was vegetated with exotic grasses. The southern bank was heavily vegetated with very little exposed soil. The backwater would provide a variety of habitats including shallow margins, deeper pools, overhanging vegetation, macrophytes and runs following rainfall. There was no riffle habitat.

Limestone Creek is an ephemeral waterway (i.e. holds water after wet season rainfall events and dries over the course of the year), which at the time of survey in June 2019 (AECOM, 2020e) included a series of large shallow pools in an otherwise dry channel. The riparian vegetation was primarily open forest of *Eucalyptus raveretiana* and *Melaleuca fluviatilis* (river tea tree) over *Casuarina cunninghamiana* (river she-oak) and exotic *Leucaena leucocephala* (leucaena). The riparian weed *Ruellia simplex* (Mexican petunia) was common in the ground layer. Submerged woody debris was common, and emergent woody debris suitable for turtle basking was also noted at several locations. The substrate was dominated by cobbles, with sections of narrow, cobbled bed between the isolated pools likely to form short reaches of shallow riffle zones during times of flow. Where the Project crosses Limestone Creek, the stream bed and vegetation community have been highly impacted by construction. Alteration to the channel has raised the bed and it is now disconnected from the downstream reaches and the Fitzroy River except in very high flow conditions.

The majority of the wetlands in the Project Area are highly variable in terms of their size, depth, bank profile, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold.

Figure 6-8: Field-verified habitat for the estuarine crocodile in the Project Area and potential habitat in the broader area



Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

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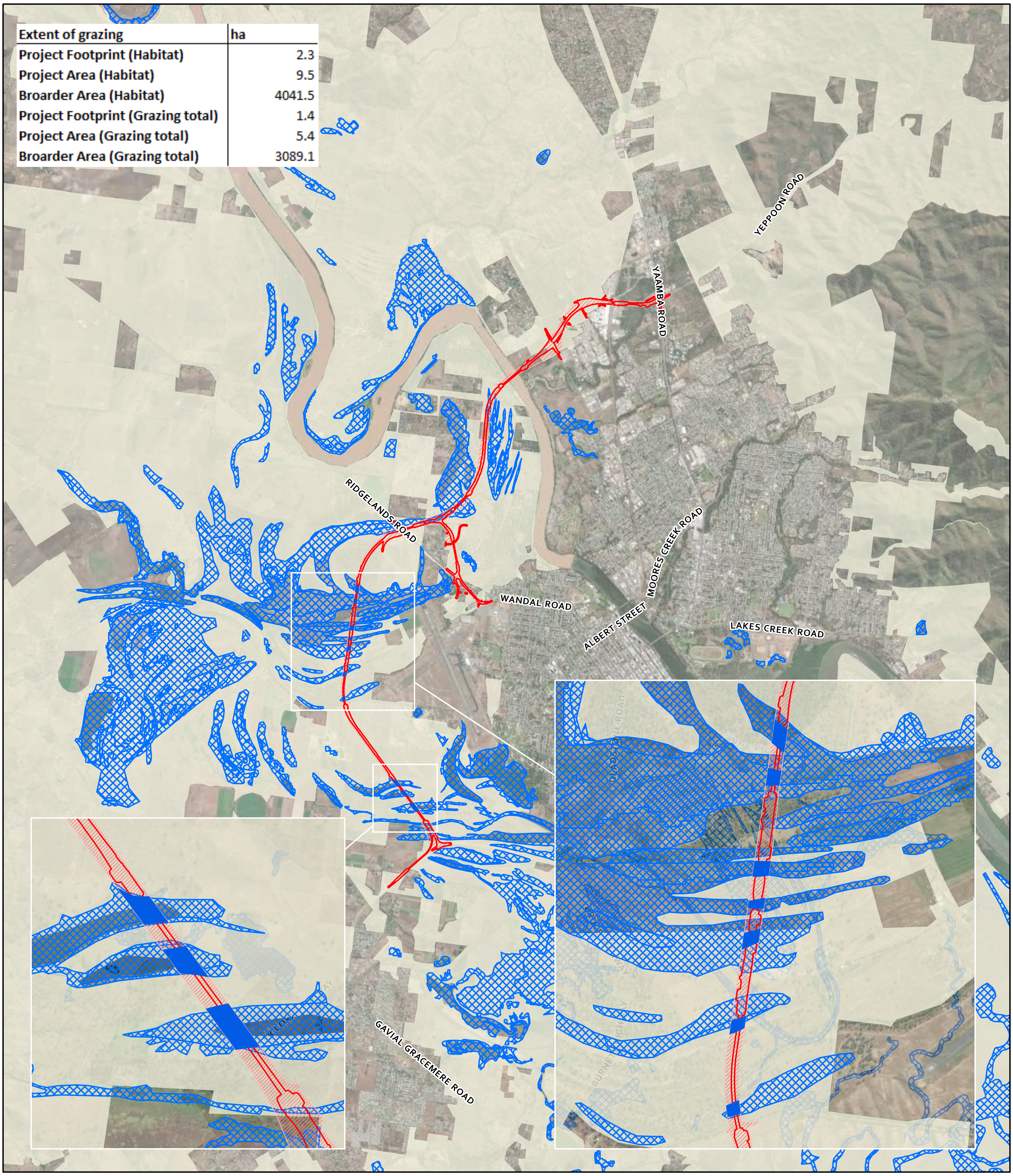
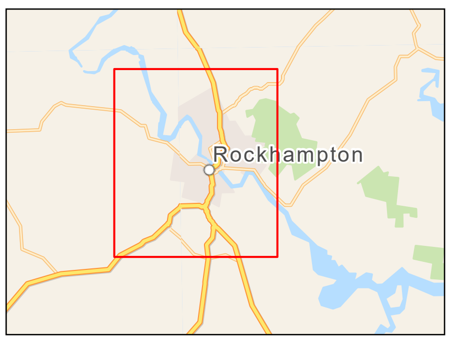
Figure 6-9: Field-verified lacustrine or palustrine wetlands in the Project Area and potential habitat in the broader area

Extent of grazing	ha
Project Footprint (Habitat)	2.3
Project Area (Habitat)	9.5
Broarder Area (Habitat)	4041.5
Project Footprint (Grazing total)	1.4
Project Area (Grazing total)	5.4
Broarder Area (Grazing total)	3089.1



Legend
- Field-verified lacustrine or palustrine wetlands for species within the Project Area
- Lacustrine or palustrine wetlands based on Queensland Wetland Mapping
- Project Footprint
- Project Area
- Grazing native vegetation land use



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

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Pink Lily Lagoon is a wetland complex with semi-permanent (i.e. holds water for more than one wet season) and episodic (i.e. holding water following rainfall episode or events) waterbodies. At the time of the June 2019 survey (AECOM, 2020e), the lagoon was separated into two distinct pools. Both pools were characterised by shallow sloping, black cracking clay banks with depths reaching up to 1.6 m in the centre of the large pool and only 0.4 m in the small pool. Riparian vegetation was dominated by *Persicaria orienta*lis (princes feathers) and *Urochloa mutica* (para grass)*,* which retreat and encroach dependent on the water level. No submerged, or floating macrophytes or undercut banks were recorded. Snags and woody debris were limited to occasional inundated stumps and fence posts on the western edge of the lagoon. Periphyton (i.e. mixture of algae, cyanobacteria, etc. attached to submerged surfaces) was observed in the water column, however no filamentous algae (i.e. colonies of microscopic plants that join together to form threads or mesh) were present. The substrate consisted of silts and clay.

Dunganweate Lagoons is a moderate sized wetland with two elongated and interconnected waterbodies. The northern waterbody is near-permanent, noting that it has only dried once since 1988 in 2007 and the southern waterbody is semi-permanent. The lagoons are located within a disturbed and heavily grazed landscape with riparian vegetation largely absent. The waterbodies have moderately sloping banks which are dominated by clay soils with occasional rocks or sand patches. At the time of the June 2019 survey (AECOM, 2020e), the lagoons were the deepest within the Project Area with a maximum depth of 2.8 m recorded. Dense patches of the floating lily *Nelumbo nucifera* (lotus) were present covering less than 10% of the lagoon and small amounts of submerged ribbonweed (*Vallisneria* sp.) was also recorded in shallow margins. Occasional woody debris was present primarily associated with a disused timber ramp and some algae and detritus were observed. The water was well-oxygenated, and turbidity was significantly lower than Pink Lily Lagoon.

Nelson Lagoon is a small semi-permanent waterbody located directly south of Dunganweate Lagoons. The wetland is within a heavily disturbed grazing landscape with vegetation dominated by open *E. tereticornis* woodland. At the time of the June 2019 survey (AECOM, 2020e), the lagoon reached depths of up to 1 m. The water had high oxygen levels and was moderately turbid. No aquatic macrophytes or complex structure was recorded, however some woody debris was present in the form of narrow, inundated snags.

*6.2.2.1 Fitzroy River Turtle (*Rheodytes leukops*) – Vulnerable*

Undercut banks, root tangles, woody debris, riparian vegetation and macrophytes, particularly ribbonweed beds, are preferred sheltering and foraging habitat features of the Fitzroy River turtle. It shows preference for clear water and riffles (Cogger, Cameron, Sadlier, & Eggler, 1993) but will retreat to non-flowing, potentially isolated pools during the dry season (Tucker, et al., 2001), however is not known to occur in deep water areas (> 5 m), due to very low oxygen levels, little or no light penetration and cold temperatures, or in off-stream habitats such as farm dams, billabongs, or flood plains (Limpus, 2011). Common riparian vegetation associated with this species include *Eucalyptus tereticornis*, *Casuarina cunninghamiana*, *Melaleuca viminalis* (weeping bottlebrush) and paperbark species including *Melaleuca linariifolia* (Tucker, et al., 2001).

Nests have all been located on river sandbanks 1 – 4 m above the water level (Cann, 1998), which was not recorded in the Project Area during the June 2019 (AECOM, 2020e) or December 2020 (Ecosure, 2021a) surveys. The Project Area is in the Fitzroy Barrage impoundment, approximately 4 km upstream of the barrage. There is an important nesting habitat (for the Fitzroy River turtle and white-throated snapping turtle) on a large sand bank at the Alligator Creek confluence (i.e. junction), at the upper reaches of the Fitzroy Barrage impoundment, approximately 45 km upstream of the Project Area. This bank supports the largest known Fitzroy River turtle nesting aggregation (GHD, 2015). However this species is sedentary, often remaining in the same location for days, with very small home ranges associated with riffle zones (mean distance of 258 – 359 m to a riffle zone) and the Project Area is therefore unlikely to support an important population given there are no riffle zones (Australian Government Department of Agriculture, Water and the Environment, 2021l).

This species is known to inhabit the Fitzroy River (GHD, 2015), and the river and major tributaries would provide dispersal and foraging opportunities. In June 2019 (AECOM, 2020e) and December 2020 (Ecosure, 2021a), suitable habitat on the western bank consisted of areas of underwater refuge (undercut banks and woody debris) and flowing sections of the river in the shallow margins only. The Fitzroy River turtle would occur within the shallow edges of the Fitzroy River as the species is known to avoid areas of deep water (>5 m). The eastern bank also consisted of underwater refuge areas for this species. No suitable breeding habitat was identified.

Limestone Creek was assessed as providing marginal foraging habitat in June 2019 (AECOM, 2020e), and as not providing suitable nesting or foraging habitat in December 2020 (Ecosure, 2021a). At the time of the June 2019 survey (AECOM, 2020e), there was no nesting or foraging habitat identified in Limestone Creek in the Project Area, however there was marginal foraging habitat in a large pool downstream of the Project Area, which could represent likely habitat in the Project Area following rain. In this pool, water depth was up to approximately 2.5 m with large stands of floating and submerged macrophytes. Abundant submerged woody debris in some areas could provide potential feeding resources, and riparian species associated with Fitzroy River turtle habitat are common in the riparian zone. Several sections of dry, cobbled bed both upstream and downstream of the pool have the potential to form riffles in periods of high flow.

In June 2019 (AECOM, 2020e), Pink Lily Lagoon did not contain suitable habitat for the Fitzroy River turtle. The lagoon was used heavily for watering of cattle, which present a major risk to nest trampling. Due to the isolated nature of the lagoon, lack of accessibility to riffle zones and lack of sandy banks and complex feeding habitat, this species is unlikely to occur within Pink Lily Lagoon.

In June 2019 (AECOM, 2020e), suitable nesting habitat was absent at Dunganweate Lagoons. Some substrate and complex surfaces suitable for scrape feeding were present with occasional rocks and woody debris associated with the disused timber ramp. Log tangles were absent. The lagoons are disconnected from potential habitat in the Fitzroy River and is not within overland migration distance. Due to the isolated nature of the lagoons, lack of riffle zones and lack of nesting habitat and complex feeding habitat, this species is unlikely to occur within Dunganweate Lagoons. The banks were composed of cracking black clays with no defined riparian zone, which are unsuitable for nesting for this species. Substrate and complex surfaces suitable for scrape feeding were limited to rare woody debris, with no rocks, log tangles or sponges recorded. The lagoon is disconnected from potential habitat in the Fitzroy River and is not within overland migration distance. Due to the isolated nature of the lagoon, lack of accessibility to riffle zones and lack of sandy banks and complex feeding habitat, this species is unlikely to occur within Nelson Lagoon.

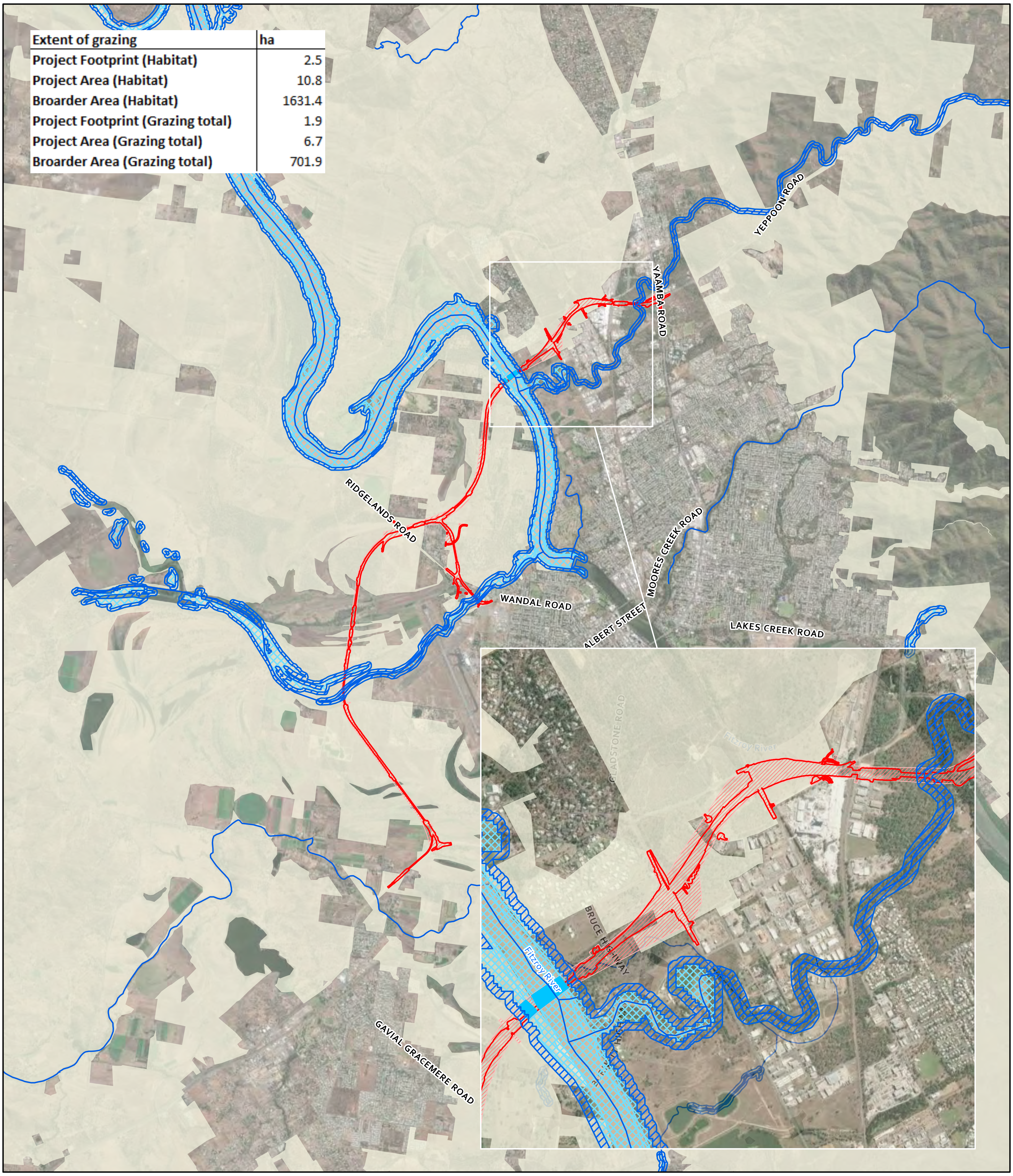
The Fitzroy River turtle was not recorded during the December 2020 (AECOM, 2020e) or June 2019 (AECOM, 2020e) field survey, and the nearest known records are approximately 20 km up and downstream of the Project Area and are more than 10 years old (Atlas of Living Australia, 2021). Essential habitat under the Queensland *Vegetation Management Act 1999* is mapped approximately 3.5 km downstream of the proposed Fitzroy River bridge. Areas of essential habitat are regulated vegetation associated with an animal that is 'endangered' or 'vulnerable' under the *Nature Conservation Act 1992*. Essential habitat does not indicate presence of a species. The Project will not clear or impact this area of vegetation.

Of the five waterbodies assessed within the Project Area, the Fitzroy River provides foraging and dispersal habitat and Limestone Creek was assessed as potentially providing marginal foraging habitat, following rain. The Project Area includes approximately 10.8 ha of potentially suitable habitat (i.e. riverine waterbody including the 50 m buffer), with approximately 1,631.4 ha of potentially suitable riverine habitat in the broader area (Figure 6-10). That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and the Project is unlikely to impact the local community.

Breeding habitat was not recorded in the Project Area. Breeding habitat is likely to be present in the broader area however this area was not surveyed as part of the Project and is likely to change of time with the re-working during flow events It is therefore not possible to map potential breeding habitat in the broader area. During the Project surveys, the nearest suitable freshwater turtle nesting bank was approximately 1 km upstream of the Project Area and there is an important nesting site at the Alligator Creek confluence, approximately 45 km upstream of the Project Area.

Figure 6-10: Potential freshwater turtle habitat within the Project Area and broader area

Extent of grazing	ha
Project Footprint (Habitat)	2.5
Project Area (Habitat)	10.8
Broarder Area (Habitat)	1631.4
Project Footprint (Grazing total)	1.9
Project Area (Grazing total)	6.7
Broarder Area (Grazing total)	701.9



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GDA 1994 MGA Zone 56

A3 1:75,000

N

0 1 2 Kilometers

Jacobs SMEC Jacobs SMEC Design Joint Venture

Rockhampton Ring Road

Source: Queensland Department of Resources: RE (2020); AECOM: Turtle Habitat (2021); Metromap: Imagery (2020)

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6.2.2.2 White-throated Snapping Turtle (*Elseya albagula*) – Critically Endangered

The white-throated snapping turtle is one of the largest short-necked freshwater turtles in Australia, and is found only in the Fitzroy, Mary and Burnett rivers and associated smaller drainages in south eastern Queensland. Habitat preferences are unclear, however it is generally considered to prefer clear, flowing, highly oxygenated water due to the physiological adaption to extract oxygen from water via cloacal respiration (i.e. respiration through the posterior orifice which typically serves as the opening for digestive, reproductive, and urinary tracts). The species is however known to occur in non-flowing waters but at much lower densities, and not in farm dams, ephemeral swamplands or brackish waters.

The species has been recorded almost exclusively in reaches of streams with permanent water, with no records from ephemeral water bodies away from main watercourses (Australian Government Department of Agriculture, Water and the Environment, 2020b).

The species has been observed in both clear and turbid waters, including in abundance in the upstream Fitzroy River Barrage pool, which is highly turbid. Based on distribution records in the Fitzroy catchment, the species appears to be suited to the oxygenated margins of large slow-flowing reaches and large non-flowing pools. It has been recorded in many Fitzroy catchment impoundments including the Fitzroy River Barrage, Glebe Weir, Eden Bann Weir and Emerald Town Weir (Australian Government Department of Agriculture, Water and the Environment, 2020b).

Some studies have indicated that the white-throated snapping-turtle prefers riffle habitats. Records from the Fitzroy (and Mary) catchment indicate that the species is regularly associated with submerged log entanglements during the day and shallow riffle zones at night, however records from the Queensland Turtle Conservation database does not support this observation (Australian Government Department of Agriculture, Water and the Environment, 2020b).

The white-throated snapping turtle strongly prefers steep undercut banks, overhanging riparian vegetation and submerged boulders and/or log jams, which are used for shelter. It is also often found in areas with aquatic macrophytes, although there are also records in areas without macrophytes. The species is rarely found in reaches without suitable refuges, however it is abundant in the upstream reaches of the Fitzroy River Barrage, which is not associated with habitat features such as rocks, logs and undercut banks (Australian Government Department of Agriculture, Water and the Environment, 2020b).

The species has relatively small home ranges of <1 km with isolated long distance movements of up to 10 km also recorded. Studies suggest it does not have distinct breeding and non-breeding zones with nesting occurring locally rather than by migration, however unpublished data suggests it may use traditional nesting areas (Australian Government Department of the Environment and Energy, 2017) with breeding aggregations restricted to a number of sites and high density aggregations recorded in the upper reaches of the Fitzroy River Barrage impoundment (Australian Government Department of Agriculture, Water and the Environment, 2020b).

The majority of nesting tends to occur following rainfall events and is thought to be closely associated decreasing autumn water temperature, between March and September. Almost all nesting occurs on alluvial banks composed of sand to loamy soils, which are deposited by floodwaters. Nests have been recorded in loose or compact soils, under a closed or more open canopy, with dense grass to sparse or no vegetation. Nests are located anywhere from 1 to 86 m (17 m average) from the water's edge, mostly on sloped banks (based on studies in the Fitzroy catchment) and at up to 8 m (average height of 3 m) above water level (based on studies in the Burnett catchment). The tops of steep sloping banks with sand to loamy soils appear to be important nesting habitat (Australian Government Department of Agriculture, Water and the Environment, 2020b). Most recent studies targeting the white-throated snapping turtle within the Fitzroy River have shown nesting generally occurs at the top of steep slopes in sand and soil substrates approximately 5 m from the water's edge and 3 m above water level (GHD, 2016). There is an important nesting habitat (for the Fitzroy River turtle and white-throated snapping turtle) on a large sand bank at the Alligator Creek confluence, at the upper reaches of the Fitzroy Barrage impoundment (GHD, 2015), approximately 45 km upstream of the Project Area.

Life histories are characterised by long life spans, slow growth to maturity, multiple breeding events in a defined season and no parental care. Age at first breeding is approximately 15 – 20 years with approximately all adult females breeding each year, unless the turtle has been injured or debilitated or riverine habitat has been severely depleted. Females lay a single clutch of eggs per annual breeding season, averaging 14 eggs per clutch. Egg and young juvenile survival are low and compensated by high adult survivorship. The population growth (or decline) rate is highly responsive to changes in adult survivorship because although the probability of any individual egg reaching maturity is low, once adulthood is reached there is the potential for large numbers of breeding events (Australian Government Department of the Environment, 2014a).

All field surveys over the past decade have failed to find any natural nesting habitat where successful incubation produces more than a trivial number of hatchlings. Abundant evidence of nesting can be found in all three catchments but almost all eggs are trampling by stock or lost to feral (foxes, dogs, pigs, cats) or native (water rats, varanids) predators. There is a severe depletion of immature turtles with a substantial failure to recruit new breeding females into populations, and present populations are dominated by aging adults. Given this is a slow growing species, this population structure suggests that excessive egg loss has been occurring for at least 20 years (Australian Government Department of the Environment, 2014a).

The diet of the species is not clear. It appears to forage on benthic (i.e. associated with or occurring on the bottom of a body of water) material with a broad diet including plant material such as fruits and buds of riparian vegetation (such as *Livistona* spp., *Ficus* spp., *Syzygium* spp., *Celtis chinensis and Castanospermum australe*), leaves and stems of terrestrial plants, tree roots, filamentous algae (including Mougeotia and Spirogyra) and instream macrophytes (such as *Vallisneria* spp., *Schoenoplectus* spp. and *Nitella spp.*). Adults appear to change their diet from being largely carnivorous (i.e. feeds on animals) and feeding on benthic invertebrates when young, to largely herbivorous (i.e. feeds on plants) when carapace length reaches about 6 cm, however adults are known to feed on small quantities of animal material including freshwater sponges, carrion (i.e. decaying flesh of dead animals), cane toads and insect larvae. A contrasting stable isotope analysis (provides a quantifiable dietary life history of an individual) found that adult females primarily feed on filamentous algae and crustaceans obtained from the muddy and vegetated shallow margins of deep water pools (Australian Government Department of Agriculture, Water and the Environment, 2020b).

There are conflicting reports regarding the species' habitat use, however the following can be regarded as representing habitat critical to the survival of the species:

- parts of riverine systems with permanent water, including pools, within the species' distribution that contain shelter and refuges (e.g. bank overhangs, overhanging riparian vegetation, macrophyte beds, moderate to high densities of submerged boulders and/or log jams)
- all currently known and new aggregated nesting sites (all nesting sites should be considered to be part of an aggregation unless it can be demonstrated otherwise).

There is therefore approximately 10.8 ha of habitat critical to the survival of the species (i.e. riverine waterbody including 50 m buffer) (Figure 6-10) as discussed further below.

The principal threat to the white-throated snapping turtles is loss of eggs and hatchlings. Other major threats include the construction of dams and weirs which act to:

- fragment preferred habitat and create deep water reaches that typically contain water with low oxygen levels
- obstruct migration to nesting sites
- flood traditional nesting areas
- injure or kill individuals during over-topping, water releases or entrapment in filter screens
- reduce riparian vegetation and associated fruit as food (Australian Government Department of Agriculture, Water and the Environment, 2020b)

Other threats to the white-throated snapping turtle include:

- stocking of fish for recreational fishing that predate on juvenile turtles
- recreational fishers catching and injuring turtles
- dense aquatic weeds and weeds on river banks, which can alienate breeding turtles from nesting habitat
- extended drought periods resulting in low water levels and poor water quality, and presumably reduced breeding rates and increased mortality (Australian Government Department of the Environment, 2014a; Australian Government Department of Agriculture, Water and the Environment, 2020b)
- climate change (Australian Government Department of Agriculture, Water and the Environment, 2020b).

This species is likely to occur in the Rockhampton region and known to occur approximately 40 km upstream of the Project based on mapping in the *National Recovery Plan for the White-throated Snapping Turtle (Elseya albagula).* The closest Atlas of Living Australia record is approximately 15 km upstream and north-west of the Project, near Mount Zion, and is more than 10 years old.

All white-throated snapping turtle populations within the Mary, Burnett and Fitzroy River catchments are considered important, with important habitat defined as all in-stream and adjacent banks to within approximately 50 m. The Fitzroy River population is currently fragmented due to numerous weirs and the Fitzroy Barrage, and impacted by poor water quality in impoundments (Australian Government Department of the Environment, 2014a).

This species was not recorded during the March 2021 (AECOM, 2020e) or June 2019 (AECOM, 2020e) field survey, however the white-throated snapping turtle is known from the Fitzroy River and the river would provide dispersal opportunities. In June 2019 (AECOM, 2020e) and December 2020 (Ecosure, 2021a), the Fitzroy River was assessed as providing suitable foraging habitat for this species with both banks providing areas of underwater refuge (undercut banks and woody debris) and flowing water but nesting habitat was not present given the habitat characteristics outlined below.

Fitzroy River eastern bank:

- compact loam soils with gravel (2 – 16 mm) and pebbles (16 – 64 mm)
- low profile with a sharp 90 degree edge on the bank.

Fitzroy River western bank:

- compact sandy loam soils
- low profile
- highly vegetated and shaded
- extensive *Melaleuca quinquenervia* root masses that would inhibit nesting.

Limestone Creek banks:

- very steep (45 – 90 degrees) banks
- approximately 5 m high banks
- compacted loam soil with gravel (2 – 16 mm), pebbles (16 – 64 mm) and cobbles (64 – 256 mm)
- heavily vegetated with grasses, weeds and large trees.

In summary, no alluvial sand deposited banks were present within the Project Area. The low-profile banks of the Fitzroy River are unfavourable for nesting due to the likelihood of nests being flooded. While the compact soils, significant vegetation and extensive root masses at both locations are unfavourable due to the difficulty to dig nests (~ 23 cm deep). The nearest suitable nesting bank with preferred nesting bank conditions (alluvial sand deposits, reduced bank slope, bank height ~ 3-5 m and less than 50 % canopy cover) on the Fitzroy River is approximately 1 km upstream of the Project Area. There is a known aggregation of nesting white-throated snapping turtles at the upstream extent of the Fitzroy River Barrage pool, approximately 45 km upstream of the Project Area.

Limestone Creek was assessed as providing marginal foraging habitat in June 2019 (AECOM, 2020e) but as not providing suitable nesting or foraging habitat in December 2020 (Ecosure, 2021a). In June 2019 (AECOM, 2020e), there was no flow and relatively shallow water with low oxygen levels however the water was clear and some cobbled areas may form riffles following rain. However this species has not been recorded where there are no permanent pools during the dry season, and has not been recorded inhabiting ephemeral waterbodies away from main watercourses (Threatened Species Scientific Committee, 2014). There was no nesting habitat in the Project Area, however there may be marginal foraging habitat following rain, based on habitat in pools located downstream of the Project Area during the June 2019 survey.

In June 2019 (AECOM, 2020e), Pink Lily Lagoon did not contain suitable habitat for the white-throated snapping turtle, as this lagoon is a highly turbid wetland with no undercut banks, log tangles or irregular rocky substrata, and banks consisting of black cracking clacks, unsuitable for nesting. Although some food sources are likely present, including insect larvae and cane toads, primary food sources for adult turtles (i.e. riparian vegetation, filamentous algae, freshwater sponges and instream macrophytes) were not recorded. The species has limited capacity to cross dry paddocks or streambeds (Threatened Species Scientific Committee, 2014), and therefore would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, and limited foraging resources and unsuitable nesting habitat, this species is considered unlikely to occur in Pink Lily Lagoon.

In June 2019 (AECOM, 2020e), Dunganweate Lagoons did provide some habitat features preferred by the white-throated snapping turtle, including well oxygenated water, woody debris and emergent macrophytes, however the lack of a defined riparian zone, tree roots or filamentous algae does limit the foraging potential for this species.

Although there was some sand on the banks, it was not sufficient for nesting purposes and cattle pugging covered most of the bank. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, and limited foraging resources and unsuitable nesting habitat, this species is considered unlikely to occur in Dunganweate Lagoons

In June 2019 (AECOM, 2020e), habitat in Nelson Lagoon was not suitable for white-throated snapping turtle. Foraging resources were very limited with no defined riparian zone, tree roots or filamentous algae. Nesting habitat was absent with heavily pugged clay banks. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, limited foraging resources and unsuitable nesting habitat, this species is considered unlikely to occur in Nelson Lagoon.

Of the five waterbodies assessed within the Project Area, the Fitzroy River provides foraging and dispersal habitat and Limestone Creek was assessed as potentially providing marginal foraging habitat following rain (Figure 6-10). The Project Area includes approximately 10.8 ha of potentially suitable habitat (i.e. riverine waterbody including the 50 m buffer), with approximately 1,631.4 ha of potentially suitable habitat in the broader area. That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

Breeding habitat was not recorded in the Project Area. Breeding habitat is likely to be present in the broader area however this area was not surveyed as part of the Project and is likely to change of time with the re-working during flow events. It is therefore not possible to map potential breeding habitat in the broader area. During the Project surveys, the nearest suitable freshwater turtle nesting bank was approximately 1 km upstream of the Project Area and there is an important nesting site at the Alligator Creek confluence, approximately 45 km upstream of the Project Area.

6.3 Terrestrial Fauna

6.3.1 Australasian Bittern (*Botaurus poiciloptilus*) – Endangered

The Australasian bittern was not recorded during the survey program (AECOM, 2020d) and there are no local records. This species is highly unlikely to occur in the Project Area as it is outside of the known range and 400 km north of the nearest confirmed sighting in Hervey Bay (2018) (eBird, 2021).

6.3.2 Australian Painted Snipe (*Rostratula australis*) – Endangered, Marine

The Australian painted snipe was not recorded during the survey program, however, has been recorded in 2013 approximately 2 km east of the Project at Murray Lagoon (Birdlife Australia, 2021).

The Australian painted snipe breeds on small exposed islands with freshwater wetlands with a combination of exposed muddy areas and dense vegetative cover (Australian Government Department of Agriculture, Water and the Environment, 2021a). Foraging habitat includes palustrine and lacustrine wetlands with shallow waters and muddy margins. Based on the specific habitat requirements of the species, shallow wetlands in eastern Australia are considered habitat critical to the survival of the species (Australian Government Department of Agriculture, Water and the Environment, 2021a).

present, including insect larvae and cane toads, primary food sources for adult turtles (i.e. riparian vegetation, filamentous algae, freshwater sponges and instream macrophytes) were not recorded. The species has limited capacity to cross dry paddocks or streambeds (Threatened Species Scientific Committee, 2014), and therefore would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, and limited foraging resources and unsuitable nesting habitat, this species is considered unlikely to occur in Pink Lily Lagoon.

In June 2019 (AECOM, 2020e), Dunganweate Lagoons did provide some habitat features preferred by the white-throated snapping turtle, including well oxygenated water, woody debris and emergent macrophytes, however the lack of a defined riparian zone, tree roots or filamentous algae does limit the foraging potential for this species.

Although there was some sand on the banks, it was not sufficient for nesting purposes and cattle pugging covered most of the bank. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, and limited foraging resources and unsuitable nesting habitat, this species is considered unlikely to occur in Dunganweate Lagoons

In June 2019 (AECOM, 2020e), habitat in Nelson Lagoon was not suitable for white-throated snapping turtle. Foraging resources were very limited with no defined riparian zone, tree roots or filamentous algae. Nesting habitat was absent with heavily pugged clay banks. The species has limited capacity to cross dry paddocks or streambeds and as such would only be present if stranded after a major flood event which connected the lagoon to the Fitzroy River. Due to the lagoon's isolation from suitable habitat, limited foraging resources and unsuitable nesting habitat, this species is considered unlikely to occur in Nelson Lagoon.

Of the five waterbodies assessed within the Project Area, the Fitzroy River provides foraging and dispersal habitat and Limestone Creek was assessed as potentially providing marginal foraging habitat following rain (Figure 6-10). The Project Area includes approximately 10.8 ha of potentially suitable habitat (i.e. riverine waterbody including the 50 m buffer), with approximately 1,631.4 ha of potentially suitable habitat in the broader area. That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

Breeding habitat was not recorded in the Project Area. Breeding habitat is likely to be present in the broader area however this area was not surveyed as part of the Project and is likely to change of time with the re-working during flow events. It is therefore not possible to map potential breeding habitat in the broader area. During the Project surveys, the nearest suitable freshwater turtle nesting bank was approximately 1 km upstream of the Project Area and there is an important nesting site at the Alligator Creek confluence, approximately 45 km upstream of the Project Area.

6.3 Terrestrial Fauna

6.3.1 Australasian Bittern (*Botaurus poiciloptilus*) – Endangered

The Australasian bittern was not recorded during the survey program (AECOM, 2020d) and there are no local records. This species is highly unlikely to occur in the Project Area as it is outside of the known range and 400 km north of the nearest confirmed sighting in Hervey Bay (2018) (eBird, 2021).

6.3.2 Australian Painted Snipe (*Rostratula australis*) – Endangered, Marine

The Australian painted snipe was not recorded during the survey program, however, has been recorded in 2013 approximately 2 km east of the Project at Murray Lagoon (Birdlife Australia, 2021).

The Australian painted snipe breeds on small exposed islands with freshwater wetlands with a combination of exposed muddy areas and dense vegetative cover (Australian Government Department of Agriculture, Water and the Environment, 2021a). Foraging habitat includes palustrine and lacustrine wetlands with shallow waters and muddy margins. Based on the specific habitat requirements of the species, shallow wetlands in eastern Australia are considered habitat critical to the survival of the species (Australian Government Department of Agriculture, Water and the Environment, 2021a).

Wetlands within the Project Area are all part of the Fitzroy River Floodplain and Delta Important Bird Area or Key Biodiversity Area. The majority of these wetlands are highly variable in terms of their size, depth, bank profile, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer. This is particularly evident by reviewing wetland conditions and resultative bird diversity and abundances observed over the course of the migratory bird survey program (February 2019 – one survey, March 2020 – one survey, March 2021 – two surveys). In a local and regional landscape context, the wetland mosaic affords visiting migratory and nomadic shorebirds an abundance of options when arrive in the region, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until conditions deteriorate naturally (i.e. water levels), foraging resources are depleted, or, for migratory species, it is time to depart northwards to trans-equatorial breeding areas.

This species is considered likely to occur at most lacustrine or palustrine wetlands in the Project Area subject to water levels and availability of exposed muddy margins. In optimal conditions, there is approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, of which 2.41 ha is within the Project Footprint, and there is approximately 4,041.5 ha of potentially suitable habitat in the broader area (Figure 6-9). Therefore, there is a very large area of potential habitat outside of the Project Area compared to the small area potentially impacted in the Project Footprint.

While there are wetlands within the broader area that may provide suitable conditions for breeding, no breeding records exist for the Australian painted snipe in the region based on available datasets (Birdlife Australia, 2021). This is despite records of multiple individuals (6 birds) being observed in 2011 over a month-long period at Lake Balnagowan (more than 30km away) and up to 23 birds being observed in 2013 over a month-long period at Murray Lagoon (Birdlife Australia, 2021). These are the only two observations in the region in available datasets of multiple individuals, and based on similar observations in other parts of the country, the presence of multiple individuals at a given location is not indicative that breeding is likely to or will occur.

Habitat critical to the survival of Australian painted snipe comprises wetland areas which are known to be utilised for nesting or breeding, and those which consistently support large proportions of the species population, repeatedly and predictably between seasons (site fidelity) and/or for prolonged periods of time (site persistence). Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to Australian painted snipe, is also highly variable between years and within seasons. As a result, suitable habitat areas present at any given wetland at a given time may only be suitable once in a series of consecutive years and are unlikely to provide suitable habitat on a consistent or predictable annual basis.

6.3.3 Grey-headed Flying-fox (*Pteropus poliocephalus*) – Vulnerable

The grey-headed flying-fox is a canopy-feeding frugivore (i.e. feeds on fruit) and nectarivore, which utilises vegetation communities including rainforests, open forests, closed and open woodlands, melaleuca swamps and banksia woodlands to forage. It requires foraging resources and roosting sites. The grey-headed flying-fox typically roosts and breeds near water, including rainforest patches, stands of melaleuca, mangroves and riparian vegetation but also highly modified vegetation in urban and suburban areas. The primary food source is blossom from *Eucalyptus* spp. and related genera but in some areas it also utilises a wide range of rainforest fruits (Australia Government Department of Agriculture, Water and the Environment, 2021o). This ephemeral food source has led to high mobility to seek foraging resources and there is regular exchange between roosting camps, often over long distances. Thus, all grey-headed flying-fox belong to one population across their distribution range.

There are two undated Atlas of Living Australia records and a WildNet record in 1929 and 1991 of the grey-headed flying fox in the broader area (Figure 6-2). Based on long-term flying fox monitoring these records are likely to be misidentifications as there are roosts of black and little red flying fox in the vicinity of the records but no records of roosts of the grey-headed flying fox in this long-term data set. The grey-headed flying-fox was not recorded during surveys either, however applying the precautionary approach it is categorised as potentially occuring within the Project Area due to the presence of suitable habitat.

Approximately 33.9 ha of potential foraging, opportunistic roosting and dispersal habitat for this species is present within the Project Area, with approximately 14,056.7 ha of potentially suitable habitat in the broader area (Figure 6-11). That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

The Species Profile and Threats (SPRAT) database does not identify important populations of the grey-headed flying-fox (Australia Government Department of Agriculture, Water and the Environment, 2021o). Therefore, any population potentially occurring within the Project Area has been assessed against the generic definition in the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Significant Impact Guidelines 1.1. The SPRAT profile states that there are no separate or distinct populations of this species due to the constant genetic exchange and movement between camps throughout their entire geographic range.

Although the Project Area does not contain a known roost, it may occur at the northern limit of the species range. Although the species are highly mobile and move throughout their range, any population potentially present within the Project Area is considered an important population.

As detailed on the SPRAT, habitat critical to the survival of the grey-headed flying-fox is considered to be spring foraging and roosting resources, as reliable resources during late gestation, birth and early lactation are required to avoid rapid weight loss in adults and poor reproductive success (Australia Government Department of Agriculture, Water and the Environment, 2021o). As spring-flowering canopy trees (*E. tereticornis* and *Eucalyptus crebra)* are present in the potential habitat of the Project Area, this habitat is considered habitat critical to the survival of the species. That is, there is approximately 33.9 ha of habitat critical to the survival of the species in the Project Area.

6.3.4 Koala (*Phascolarctos cinereus*) (combined populations of Qld, NSW and the ACT) – Vulnerable

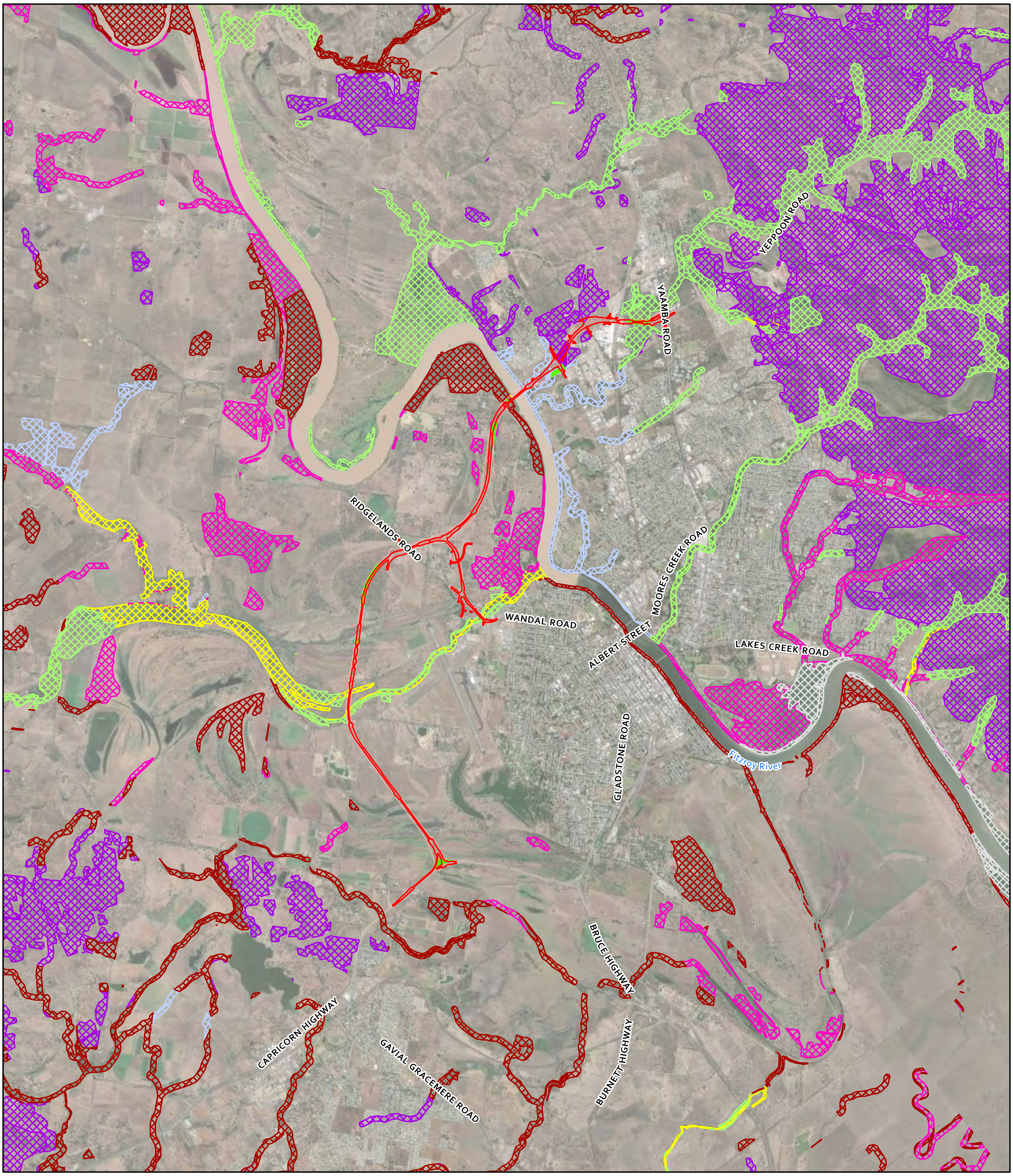
The koala inhabits a range of temperate, sub-tropical and tropical forests, woodlands and semi-arid communities. Its diet is restricted mainly to foliage of *Eucalyptus* spp.; however, it may also consume foliage of related genera, including *Corymbia* spp., *Angophora* spp. and *Lophostemon* spp., and may, at times, supplement its diet with other species, including *Leptospermum* spp. and *Melaleuca* spp.

The Project is situated near the city of Rockhampton, with an average annual rainfall of approximately 815 mm (Australian Government Bureau of Meteorology, 2019), which indicates that koala habitat is to be assessed with respect to the coastal context described in the koala EPBC Act referral guidelines (Australian Government Department of the Environment, 2014b). Therefore, koala habitat is defined as including large, connected areas of native vegetation including forests and woodlands where logging has altered tree species composition. These areas may be remnant, regrowth or plantation vegetation. Habitat also includes small, isolated patches of native vegetation in rural, urban or peri-urban areas, windbreaks and narrow areas of native vegetation along riparian areas or linear infrastructure and isolated food and/or shelter trees (i.e. on farmlands, in suburban streetscapes, parks and yards).

Koala habitat within the Project Area is considered to be all remnant and high value regrowth communities which contain koala food trees including the primary food tree *Eucalyptus tereticornis* and other known food trees such as *Eucalyptus coolabah* and *Eucalyptus populnea*. All habitat is potentially suitable for foraging, breeding and dispersal which equates to approximately 31.9 ha within the Project Area, with approximately 13,640.5 ha of potentially suitable habitat in the broader area (Figure 6-12). That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

The nearest patch of suitable habitat for the koala is approximately 3 km to the east of the Project Area within the Mount Archer National Park or 27 km to the west within the Morinish State Forest. Habitat within the Project Area is a small portion of a largely fragmented patch of habitat. Habitat is not considered to be refuge habitat for the species due to the fragmented nature of the habitat and distance between other patches of habitat. During the February 2019 survey (AECOM, 2020d), no koalas were observed in the Project Area and there are no records within the last 10 years within 10 km of the Project Area.

Figure 6-11: Potential grey-headed flying-fox (Pteropus poliocephalus) habitat within the Project Area and broader area



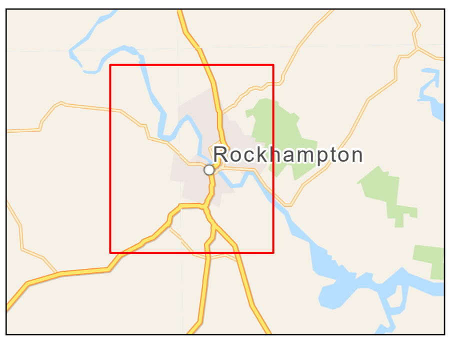
Legend

Field-verified habitat for species within the Project Area

- Brigalow woodland
- Eucalyptus woodland on alluvial plains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on metamophics or granitic
- Fringing riparian woodland with Eucalyptus raveretiana
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping

- Mangroves and saltmarsh
- Eucalyptus populnea woodland on alluvial floodplains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Eucalyptus woodland on metamorphics or granitic
- Fringing riparian woodland
- Brigalow woodland
- Project Footprint
- Project Area



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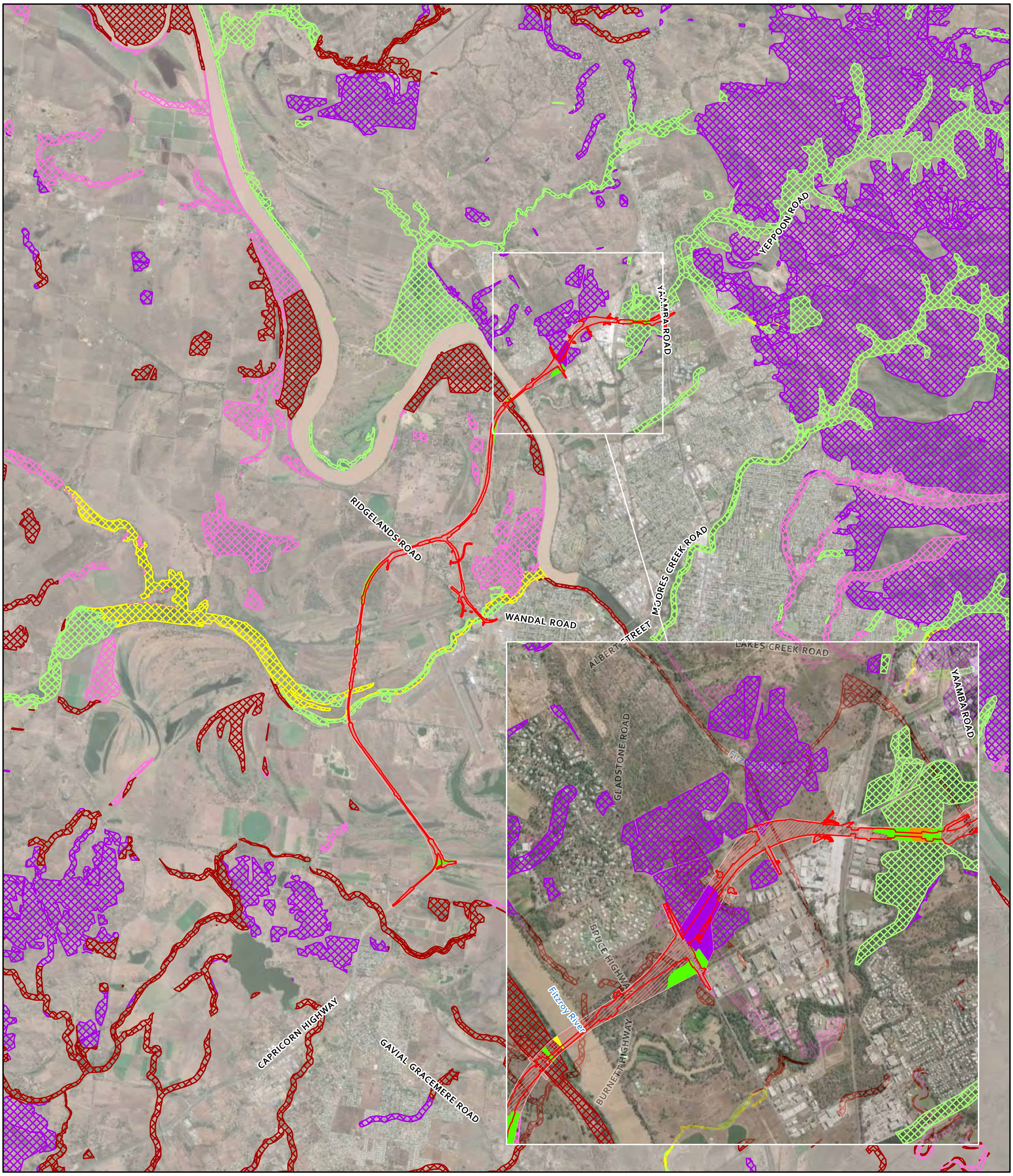
Rockhampton Ring Road

Source: Queensland Department of Resources: RE (2020);AECOM: Habitat (2021); Metromap: Imagery (2020)

Figure 6-12: Potential koala (Phascolarctos cinereus) (combined populations of Qld, NSW and the ACT) habitat within the Project Area and broader area

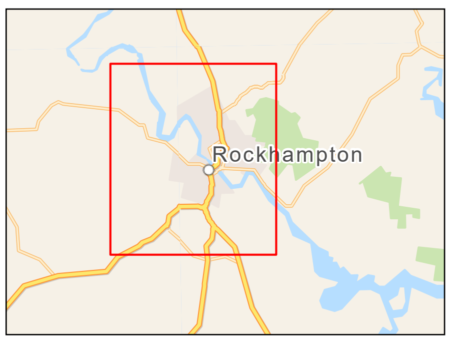


Legend

Field-verified habitat for species within the Project Area
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Eucalyptus woodland on metamophics or granitic
- Fringing riparian woodland with Eucalyptus raveretiana
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping
- Eucalyptus populnea woodland on alluvial floodplains
- Fringing riparian woodland
- Eucalyptus woodland on metamorphics or granitic
- Eucalyptus woodland on alluvial floodplains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis

- Project Footprint
- Project Area



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Jacobs SMEC
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Rockhampton Ring Road

Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

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The koala EPBC referral guidelines do not identify important populations of koala. Therefore, any population potentially occurring within the Project Area has been assessed against the definition in the EPBC Act Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013). Koalas are expected to occur in low density in this region. The limited vegetation within the Project Area and the existing barriers to movement (high fragmentation and the existing Capricorn Highway) mean that the Project Area is unlikely to support an important population (AECOM, 2020d).

An assessment against the EPBC Act Referral Guidelines for the Vulnerable Koala (Australian Government Department of the Environment, 2014b) was undertaken to determine if the habitat within the Project Area is critical to the survival of the koala (AECOM, 2020d). The assessment determined that the Project Area does not contain habitat critical to the survival of the koala as a score of four was obtained and is discussed further in the Significant Impact Assessment for the koala (Section 7.5.4.2.1).

6.3.5 Ornamental Snake (*Denisonia maculata*) – Vulnerable

The ornamental snake is known only from the Brigalow Belt north and parts of the Brigalow Belt south biogeographical regions, with core distribution occurring within the Fitzroy and Dawson sub-basins. Essential habitat is mapped throughout the Project Area in association with open eucalyptus alluvial woodlands. This species is known to prefer woodlands and open forests associated with moist areas, particularly gilgai mounds and depressions in Queensland regional ecosystem (RE) land zone 4 (Tertiary-early Quaternary clay plains), but also lake margins and wetlands. Habitat is likely to be found in *Acacia harpophylla*, *Acacia cambagei*, *Acacia argyrodendron* or *Eucalyptus coolabah*-dominated vegetation communities, or pure grassland associated with gilgais. At night, the species forages near water, almost exclusively on native frogs. This species gives birth to live young (Australian Government Department of Agriculture, Water and the Environment, 2021e).

No gilgai was present in the Project Area, however there are historic records at nearby Berserker, approximately 2 km to the east (dated 1974) (Atlas of Living Australia, 2021) and potential habitat occurs in some wetland (primarily Pink Lily Lagoon and Lotus Lagoons) and riparian communities where there was cracking clays, ranging from shallow to deep, together with fallen timber in the vegetated margins (particularly at Pink Lily Lagoon), which could provide breeding, foraging and dispersal habitat for the species. Likelihood of occurrence was however considered low due to the high level of habitat disturbance from cattle use, the lack of native frogs (the primary prey for the species) and prolific cane toads. Ornamental snake was not recorded during the field surveys in February 2019 (AECOM, 2020d), which may have been related to the dry conditions, noting that surveys were undertaken in accordance with guidelines..

The Commonwealth Government considers that an occurrence of important habitat for the ornamental snake is a surrogate for an important population of the species (Australian Government Department of Agriculture, Water and the Environment, 2021e), with gilgai depressions and mounds and habitat connectivity between gilgais and other suitable habitats defined as important habitat in Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles. Gilgai was not present within the Project Area and other areas of potential habitat were degraded due to cattle intrusion, low abundance of native prey species and the presence of invasive exotic species (cane toad), hence habitat within the Project Area is not considered critical to the survival of this species. The habitat available within the Project Area does not meet the criteria to be considered important habitat (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011a).

There is no species-specific guideline for determining habitat critical to the survival of the ornamental snake, however, alteration of water quality or quantity affecting 4 ha or more hectares of important gilgai or riparian habitat is considered a high risk of significant impacts; clearing 1 - 2 ha of important habitat is considered uncertain with regards to significant impacts; and clearing 1 ha or less of important habitat (providing that important habitat connectivity is not compromised) is considered low risk of significant impacts in the Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011a).

Approximately 35.6 ha of potential breeding, foraging and dispersal habitat for this species is present within the Project Area, including Brigalow woodland, eucalyptus woodlands, lacustrine or palustrine wetlands and fringing riparian woodlands with approximately 12,046.6 ha available in the broader area (Figure 6 13). Of these potential habitat areas, approximately 25.4 ha is used for cattle grazing in the Project Area (71% of potential habtitat) and approximately 8,932.9 ha is used for cattle grazing in the broader area (74% of potential habitat). That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area, with most of this potential habitat in the Project area used for cattle grazing. The Project is unlikely to impact the local community.

There is no information available regarding the breeding habitat of the ornamental snake hence it is not possible to map breeding habitat.

6.3.6 Squatter Pigeon (*Geophaps scripta scripta*) – Vulnerable

The squatter pigeon (southern) is a ground-dwelling bird that inhabits dry grassy woodland and open forest, mostly in sandy areas close to permanent water. The species is known to persist in areas of active grazing and substantial habitat degradation. It forages for seeds among sparse and low grass, in improved pastures and disturbed habitats such as road reserves. Suitable waterbodies are accessed daily to drink, and as such vegetation patches adjacent to waterbodies may be considered suitable habitat for this species (Australian Government Department of Agriculture, Water and the Environment, 2021h).

Breeding habitat for the squatter pigeon (southern) occurs on stony rises occurring on sandy or gravelly soils, within 1 km of a suitable, permanent waterbody. Given that the subspecies nests in shallow depressions in the ground, it requires well-draining soils. Therefore, landscapes are good indicators of where natural breeding habitats for the squatter pigeon (southern) occur. Well-draining, gravelly, sandy or loamy soils support the open-forest to woodland communities with patchy, tussock-grassy understories that support the subspecies' breeding requirements (Australian Government Department of Agriculture, Water and the Environment, 2021h).

The squatter pigeon (southern) was recorded on several occasions during the survey program and there are 18 records between 2000-2021 in the wider Rockhampton region and Fitzroy River Floodplain (Birdlife Australia, 2021). There are suitable habitat features in various parts of the Project Area and in the immediate surrounding area, including wetlands and creeks, as well as open woodland with an understory of native grasses and modified agricultural areas with scattered trees. The ephemeral nature of wetlands within the Project Area and wider region are likely to influence the presence of the species, due to the requirement of water. In years where wetlands are inundated and water is available throughout the landscape, the species is likely to be widespread through the region. During periods when most wetlands are dry, the species is expected to seek available water in landscape and concentrate around reliable water sources such as the Fitzroy River and other waterways and larger, more permanent wetlands.

Dispersal habitat is defined as areas of forest or woodland occurring between patches of foraging and breeding habitat and suitable waterbodies (Australian Government Department of Agriculture, Water and the Environment, 2021h). Any open woodland and grassland surrounding the lagoons of the Project Area (excluding Dunganweate and Nelsons Lagoons which lack riparian vegetation) may be used for foraging, roosting and dispersal. Approximately 194.3 ha of potentially suitable breeding, foraging, roosting and dispersal habitat occurs within the Project Area including modified grasslands, eucalyptus woodlands, riparian woodlands and lacustrine or palustrine wetlands. Approximately 34,589.6 ha of potential habitat occurs in the broader area (Figure 6-14). That is, there is a very large area of potential habitat outside of the Project Area compared to the small area to be potentially impacted in the Project Area and Project is unlikely to impact the local community.

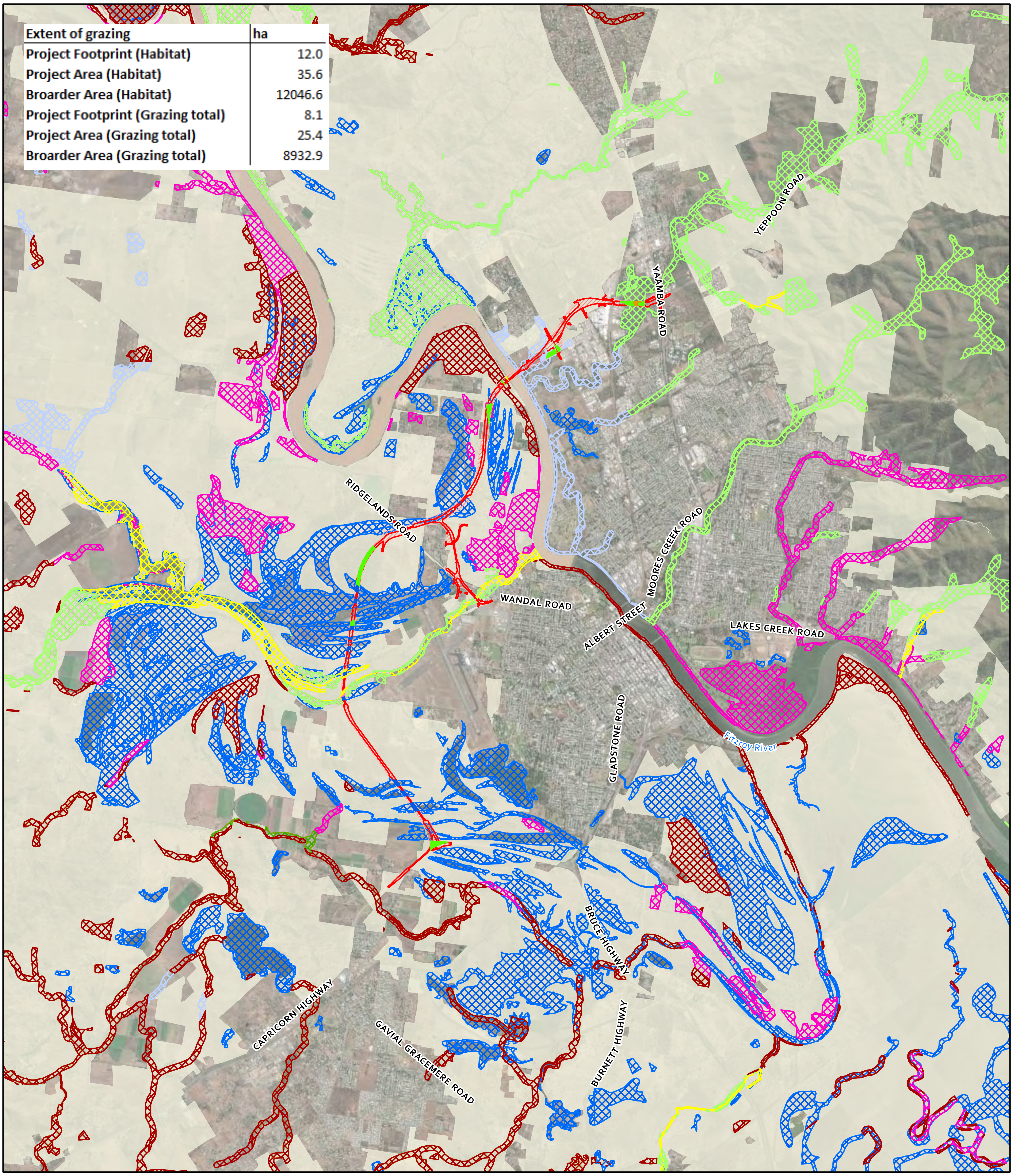
The potential breeding habitat within the broader area (Figure 6-15, Figure 6-16) was identified using the breeding habitat requirements described in the squatter pigeon (southern) SPRAT Profile (Australian Government Department of Agriculture, Water and the Environment, 2021h). Within the broader area, a 1 km radius of permanent water bodies was delineated and potential habitat types within that radius were identified as potential breeding habitat and overlaid with contours given the preference for breeding on stony rises on sandy or gravely soil. Three specific areas have been identified based on their elevation as key potential habitat features, these areas include:

- The bend in the Fitzroy River in the northern extent of the broader area
- The ridges between Pink Lily Lagoon and the Fitzroy River
- The grassy knoll between Crescent Lagoon and Murray Lagoon.

On this basis, breeding habitat was not identified in the Project Area.

Figure 6-13: Potential ornamental snake (Denisonia maculata) habitat within the Project Area and broader area

Extent of grazing	ha
Project Footprint (Habitat)	12.0
Project Area (Habitat)	35.6
Broarder Area (Habitat)	12046.6
Project Footprint (Grazing total)	8.1
Project Area (Grazing total)	25.4
Broarder Area (Grazing total)	8932.9



Legend

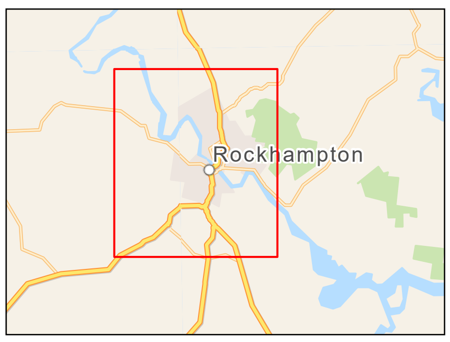
- Project Footprint
- Project Area
- Grazing native vegetation land use

Field-verified habitat for species within the Project Area

- Brigalow woodland
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Fringing riparian woodland with Eucalyptus raveretiana
- Lacustrine or palustrine wetland
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping

- Eucalyptus populnea woodland on alluvial floodplains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Fringing riparian woodland
- Brigalow woodland
- Lacustrine or palustrine wetland
- Semi evergreen vine thicket



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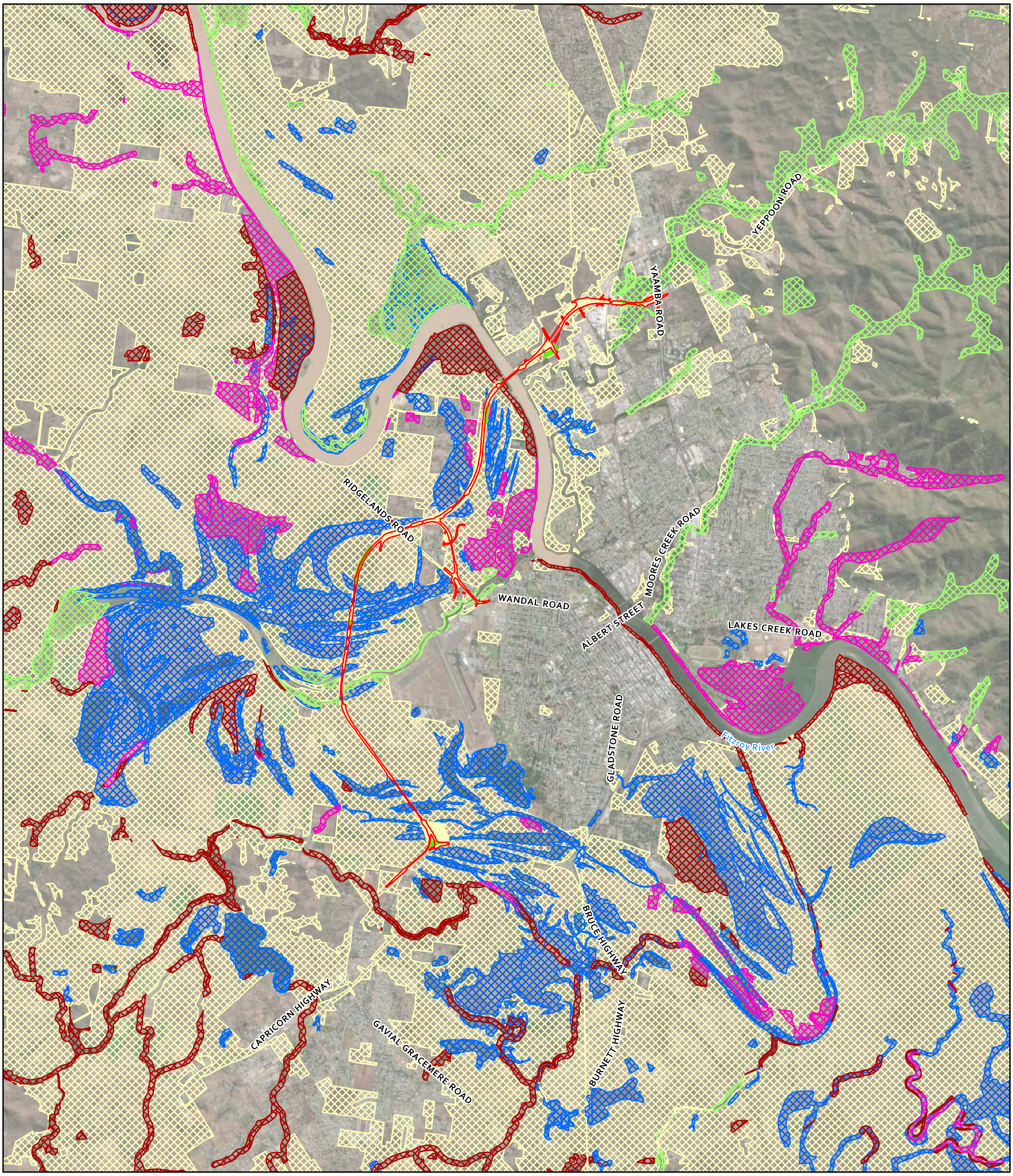
Source: Queensland Department of Resources: RE (2020), Land Use (2019); AECOM: Habitat (2021); Metromap: Imagery (2020)

Figure 6-14: Potential squatter pigeon (Geophaps scripta scripta) habitat within the Project Area and broader area



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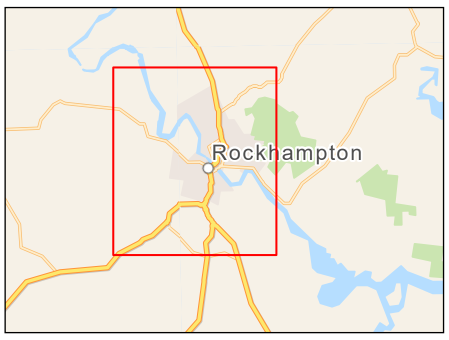
Field-verified habitat for species within the Project Area
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Lacustrine or palustrine wetland
- Modified grasslands

Potential habitat based on Regional Ecosystem mapping
- Eucalyptus populnea woodland on alluvial floodplains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Lacustrine or palustrine wetland
- Modified Grasslands

- Project Footprint
- Project Area



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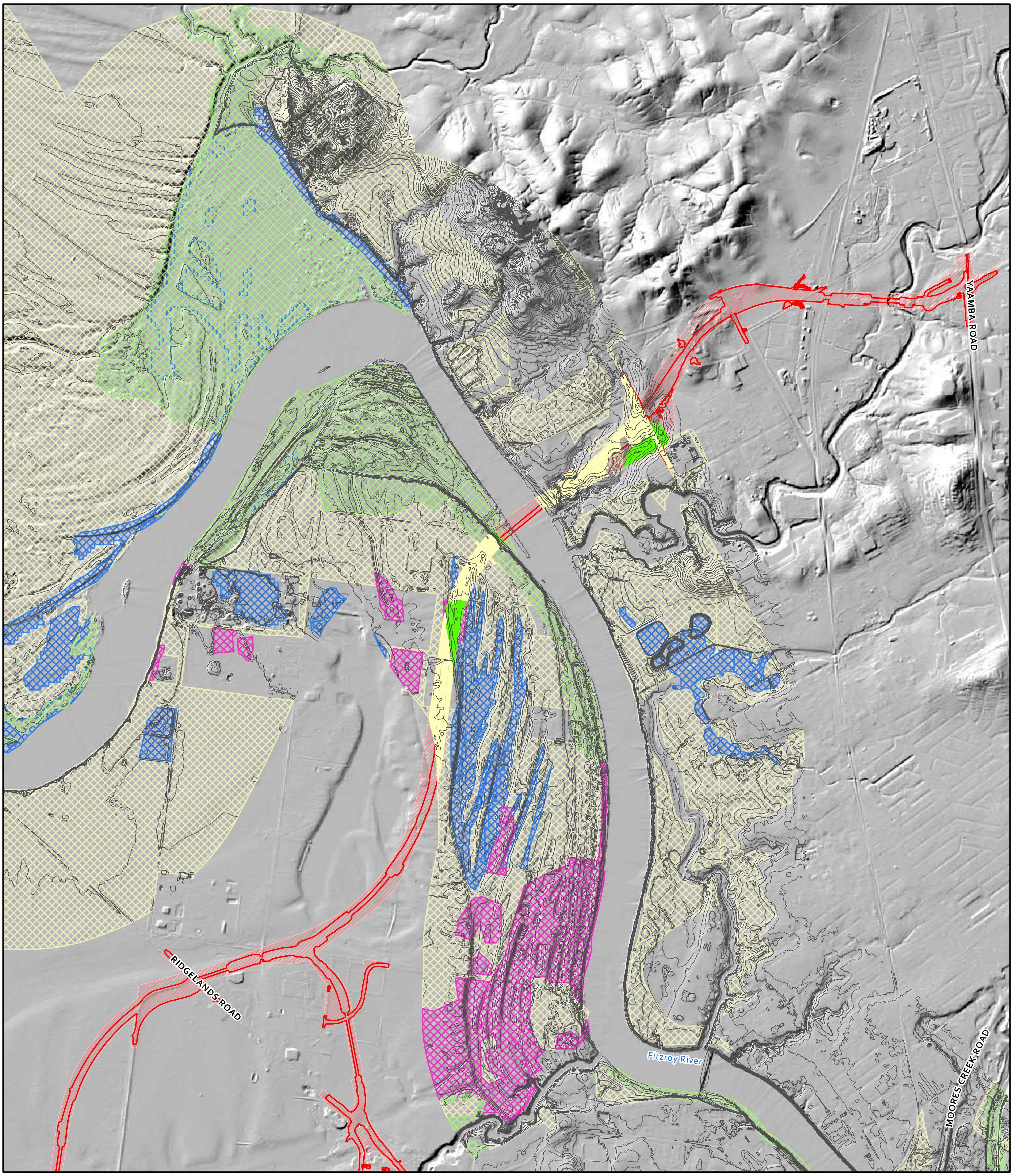
Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

Figure 6-15: Squatter pigeon potential breeding habitat



Legend

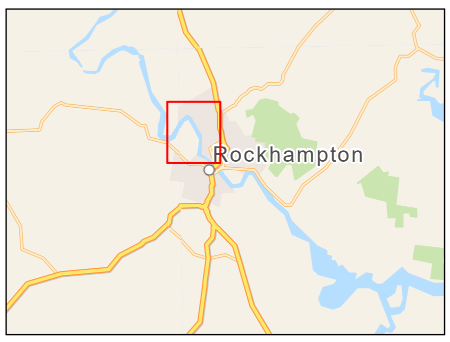
1m Contours

Field-verified habitat for species within the Project Area

- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Modified grasslands

Potential habitat based on Regional Ecosystem mapping

- Eucalyptus populnea woodland on alluvial floodplains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Lacustrine or palustrine wetland
- Modified grasslands
- Project Area
- Project Footprint



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Source: Queensland Department of Resources: Roads, RE, Hillshade (2020); AECOM: Habitat (2021)

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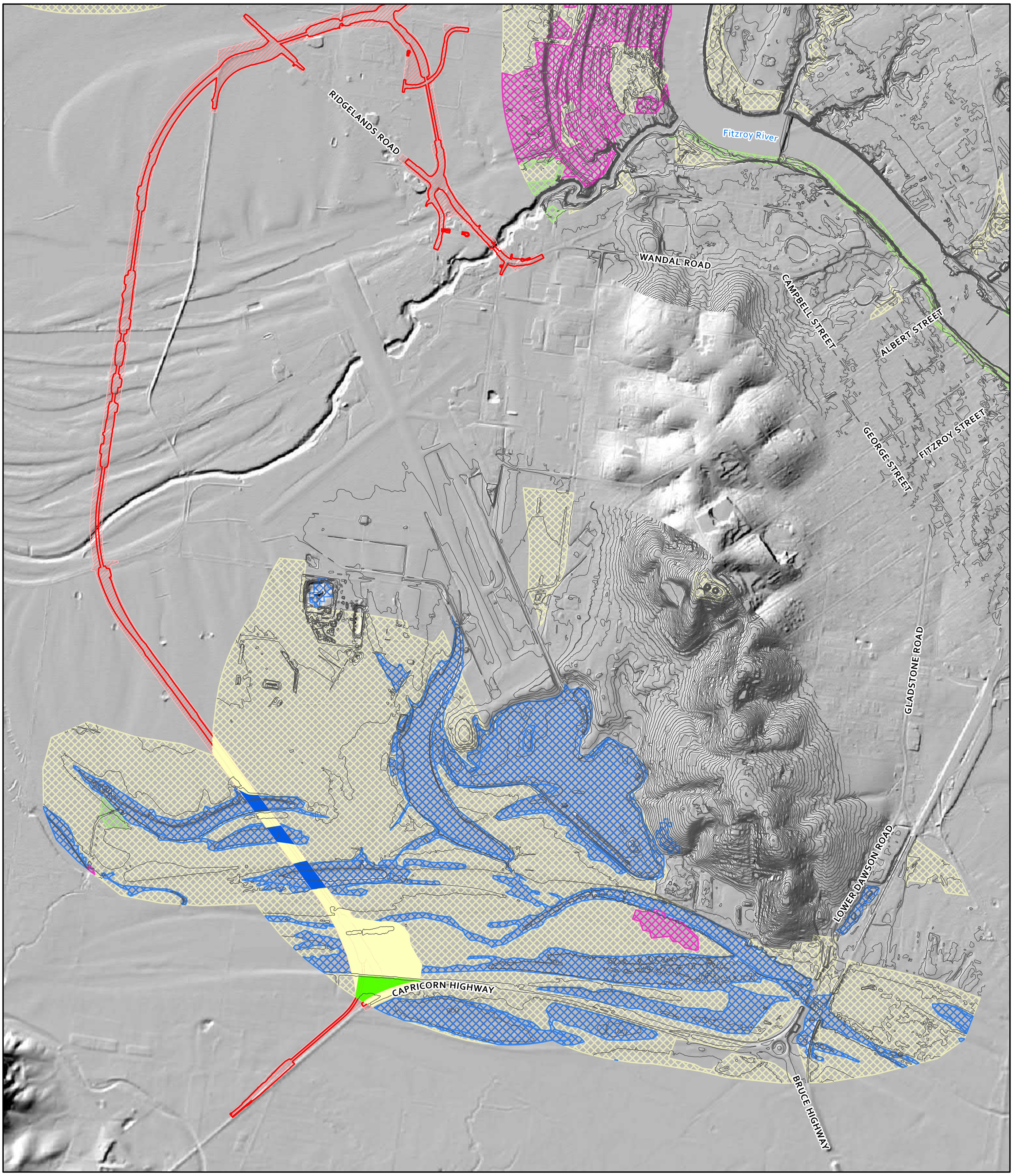
Figure 6-16: Squatter pigeon potential breeding habitat



Legend

1m Contours

Field-verified habitat for species within the Project Area

Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis

Lacustrine or palustrine wetland

Modified grasslands

Potential habitat based on Regional Ecosystem mapping

Eucalyptus populnea woodland on alluvial floodplains

Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis

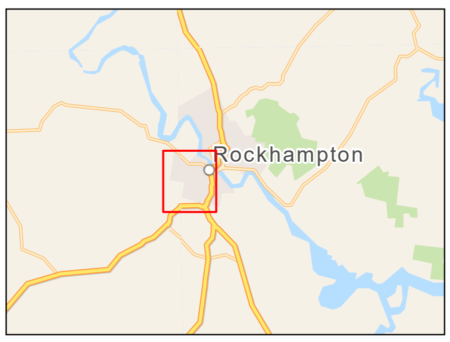
Eucalyptus woodland on alluvial floodplains

Lacustrine or palustrine wetland

Modified grasslands

Project Area

Project Footprint



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Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: Roads, RE, Hillshade (2020); AECOM: Habitat (2021)

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Habitat critical to the survival of the squatter pigeon (southern) is not defined, however is considered to be limited to breeding habitat only. Breeding habitat is found on land zones 5 (Tertiary-early Quaternary loamy and sandy plains and plateaus) and 7 (Cainozoic duricrusts) within 1 km of permanent or semi-permanent water. Land zones within and surrounding the Project Area are land zone 3 (Cainzoic alluvial plains and piedmont fans) and land zone 11 (Mesozoic/Proterozoic metamorphosed sediments and interbedded volcanics). Breeding habitat is not available within the Project Area and as such no habitat critical to the survival of the species is present. However, the squatter pigeon (southern) is known to access suitable waterbodies to drink on a daily basis and as such water resources within the Project Area may be important for the species.

In 2019 the species was recorded during a survey near Gracemere Lagoon approximately 2 km south west of the Project Area (AECOM, 2020d), and during the additional targeted migratory bird surveys undertaken in 2021 (Jacobs SMEC Design Joint Venture, 2021a). Important populations of squatter pigeon (southern) have been defined as per those listed in the SPRAT database (Australian Government Department of Agriculture, Water and the Environment, 2021h):

- Populations occurring in the Condamine River catchment and Darling Downs of southern Queensland
- The populations known to occur in the Warwick-Inglewood-Texas region of southern Queensland
- Any populations potentially occurring in northern New South Wales.

None of the important populations occur within or in proximity to the Project Area. This species remains common north of the Carnarvon Ranges in Central Queensland and is considered to be distributed as a single, continuous (i.e. inter-breeding) sub-population. Any population of squatter pigeon (southern) in the Project Area does not meet the definition of an important population.

6.4 Migratory Birds

Wetlands within the Project Area are all part of the Fitzroy River Floodplain and Delta Important Bird Area or Key Biodiversity Area. The majority of these wetlands are highly variable in terms of their size, depth, bank profile, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer when most migratory shorebird populations are in Australia. This is particularly evident by reviewing wetland conditions and resultative bird diversity and abundances observed over the course of the migratory bird survey program (February 2019 – one survey, March 2020 – one survey, March 2021 – two surveys) (AECOM 2020d; 2020b; Jacobs SMEC Design Joint Venture 2021).

Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to migratory birds is also highly variable between years and within seasons. In a local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain collectively comprise important habitat for a number of migratory birds.

Under the EPBC Act, important habitat is a key concept for migratory species, as identified in EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance (Australian Government Department of the Environment, 2013). Important habitat in Australia for migratory shorebirds under the Act include those recognised as internationally or nationally important. The widely accepted and applied approach to identifying internationally important shorebird habitat throughout the world has been through use of criteria adopted under the Ramsar Convention. The Wildlife Conservation Plan for Migratory Shorebirds and EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of Environment and Energy, 2017) both stipulate that criteria to be used to identify a site of international importance for migratory shorebirds are that the site regularly supports:

- 1% of the individuals in the flyway population of one species or subspecies of migratory shorebird or
- A total abundance of at least 20,000 waterbirds.

Habitat critical to the survival of the squatter pigeon (southern) is not defined, however is considered to be limited to breeding habitat only. Breeding habitat is found on land zones 5 (Tertiary-early Quaternary loamy and sandy plains and plateaus) and 7 (Cainozoic duricrusts) within 1 km of permanent or semi-permanent water. Land zones within and surrounding the Project Area are land zone 3 (Cainzoic alluvial plains and piedmont fans) and land zone 11 (Mesozoic/Proterozoic metamorphosed sediments and interbedded volcanics). Breeding habitat is not available within the Project Area and as such no habitat critical to the survival of the species is present. However, the squatter pigeon (southern) is known to access suitable waterbodies to drink on a daily basis and as such water resources within the Project Area may be important for the species.

In 2019 the species was recorded during a survey near Gracemere Lagoon approximately 2 km south west of the Project Area (AECOM, 2020d), and during the additional targeted migratory bird surveys undertaken in 2021 (Jacobs SMEC Design Joint Venture, 2021a). Important populations of squatter pigeon (southern) have been defined as per those listed in the SPRAT database (Australian Government Department of Agriculture, Water and the Environment, 2021h):

- Populations occurring in the Condamine River catchment and Darling Downs of southern Queensland
- The populations known to occur in the Warwick-Inglewood-Texas region of southern Queensland
- Any populations potentially occurring in northern New South Wales.

None of the important populations occur within or in proximity to the Project Area. This species remains common north of the Carnarvon Ranges in Central Queensland and is considered to be distributed as a single, continuous (i.e. inter-breeding) sub-population. Any population of squatter pigeon (southern) in the Project Area does not meet the definition of an important population.

6.4 Migratory Birds

Wetlands within the Project Area are all part of the Fitzroy River Floodplain and Delta Important Bird Area or Key Biodiversity Area. The majority of these wetlands are highly variable in terms of their size, depth, bank profile, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer when most migratory shorebird populations are in Australia. This is particularly evident by reviewing wetland conditions and resultative bird diversity and abundances observed over the course of the migratory bird survey program (February 2019 – one survey, March 2020 – one survey, March 2021 – two surveys) (AECOM 2020d; 2020b; Jacobs SMEC Design Joint Venture 2021).

Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to migratory birds is also highly variable between years and within seasons. In a local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain collectively comprise important habitat for a number of migratory birds.

Under the EPBC Act, important habitat is a key concept for migratory species, as identified in EPBC Act Policy Statement 1.1 Significant Impact Guidelines – Matters of National Environmental Significance (Australian Government Department of the Environment, 2013). Important habitat in Australia for migratory shorebirds under the Act include those recognised as internationally or nationally important. The widely accepted and applied approach to identifying internationally important shorebird habitat throughout the world has been through use of criteria adopted under the Ramsar Convention. The Wildlife Conservation Plan for Migratory Shorebirds and EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of Environment and Energy, 2017) both stipulate that criteria to be used to identify a site of international importance for migratory shorebirds are that the site regularly supports:

- 1% of the individuals in the flyway population of one species or subspecies of migratory shorebird or
- A total abundance of at least 20,000 waterbirds.

Nationally important habitat for migratory shorebirds has been defined in these same documents, using a similar approach to the international criteria, i.e. if the site regularly supports:

- 0.1% of the flyway population of a single species of migratory shorebird or
- 2000 migratory shorebirds or
- 15 migratory shorebird species.

'Support' is defined differently depending on whether the habitat is considered permanent or ephemeral.

For permanent wetlands, 'support' is defined as: migratory shorebirds are recorded during surveys and/or known to have occurred within the area during the previous five years. For ephemeral wetlands, 'support' is defined as: habitat that migratory shorebirds have ever been recorded in, and where that habitat has not been lost permanently due to previous actions.

The National Directory of Important Migratory Shorebird Habitat (Weller, et al., 2020) identifies all sites in Australia that, based on the best available knowledge, meet one or more of the international or national criteria using significance thresholds that correspond with the revised population estimates (Hansen, et al., 2016). Previous assessments (Watkins, 1993) of Australian sites of importance focused only on international importance and the most recent identified 118 sites (Bamford, Watkins, Bancroft, Tischler, & Wahl, 2008). The substantial increase in the number of monitoring sites included in BirdLife Australia's Shorebirds 2020 program over the past decade, and subsequent increases in quantity of contemporary count data, have provided the information needed to undertake Action 2b of the Wildlife Conservation Plan for Migratory Shorebirds.

6.4.1 Black-tailed Godwit (*Limosa limosa*) – Migratory, Marine

The black-tailed godwit can be found in a variety of coastal and inland wetlands throughout Australia. During the Austral spring/summer period, this species is widespread in northern Australia. The species is also widespread in coastal Queensland, and inland parts of Queensland in response to large-scale flood events and resultative available wetland habitats. These species live in 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 (Australian Government Department of Agriculture, Water and the Environment, 2021j). The black-tailed godwit forages on wide intertidal mudflats or sandflats, in soft mud or shallow water and occasionally in shallow estuaries. They use similar habitats on shores of inland lakes and other wetlands. They are found in muddy areas that are often open and unvegetated, but commonly use drying marshy wetlands preferred by pectoral sandpipers (*Calidris melanotus*) and long-toed stints (*Calidris subminuta*) (Higgins & Davies, 1996).

Black-tailed godwits first arrive in north-west Australia from late August each year with numbers falling through September to mid-November (Blakers, Davies, & Reilly, 1984). They arrive in the Gulf of Carpentaria from September to December (Garnett, Wading Bird Abundance and Distribution - South-eastern Coast of the Gulf of Carpentaria., 1989). Most individuals stay in north Australia, especially coastal Arnhem Land and the south-east Gulf of Carpentaria, but some disperse further south southern and south eastern Australia. When migrating northwards to their breeding grounds, they move up the east coast of Queensland during March to April and depart Australia from Arnhem Land and the Gulf of Carpentaria after mid-April each year (Higgins & Davies, 1996).

A total of 40 black-tailed godwits were recorded during the first of the March 2021 surveys between two wetlands (Padygole Lagoon, Lower Gracemere Lagoon) (Jacobs SMEC Design Joint Venture, 2021a). The second survey in March 2021 found 20 individuals present at the same two wetlands. Padygole, Murray and Lower Gracemere Lagoons provided ideal conditions for this species. Pink Lily and Lotus Lagoons, when inundated are also expected to provide habitat for black-tailed godwit. Approximately 9.5 ha of potentially suitable foraging, roosting and dispersal habitat for this species is present within the Project Area, including the shallow muddy margins around lacustrine or palustrine wetlands when water is present, with approximately 4,041.5 ha of potential habitat in the broader area (Figure 6-9).

Black-tailed godwit breed in the northern hemisphere and there is no breeding habitat in the Project Area.

Based on available database records, the species is routinely recorded at Murray Lagoon with a high count of 82 birds in 2018 (Birdlife Australia, 2021). The species is likely to occur in the Fitzroy River floodplain in suitable wetland habitats in numbers exceeding important habitat or national significance threshold (160 birds).

6.4.2 Caspian Tern (*Hydroprogne caspia*) – Migratory, Marine

The Caspian tern is mostly found in sheltered coastal embayments such as harbours, lagoons, inlets, bays, estuaries and river deltas, and those with sandy or muddy margins are preferred. They also occur on near-coastal and inland wetlands and large river systems that are either fresh or saline, especially lakes (including ephemeral lakes), waterholes, reservoirs, rivers and creeks, and use artificial wetlands such as reservoirs, sewage ponds and saltworks (Australian Government Department of Agriculture, Water and the Environment, 2021g).

They forage on the wing by plunge-diving in open waterbodies, such as lakes and rivers, to capture a variety of fish species which make up the majority of their diet, often preferring sheltered shallow water near the margins.

During the survey program (AECOM, 2020d; 2020b; Jacobs SMEC Design Joint Venture 2021), Caspian tern were recorded at Pink Lily Lagoon (approximately 15 individuals roosting in shallow waters), Dunganweate Lagoons (multiple individuals foraging), Nelson Lagoon (single individual flying overhead) and Murray Lagoon (large communal roost and multiple individuals foraging) and Crescent Lagoon (multiple individuals foraging). Of these, Pink Lily Lagoon and Nelson Lagoon are within the Project Area. Eight individuals were observed overflying two wetlands and 14 individuals were observed over seven wetlands during the March 2021 surveys.

Approximately 12.9 ha of potentially suitable foraging, roosting and dispersal habitat for the Caspian tern occurs within the Project Area, associated with lacustrine or palustrine wetlands such as Pink Lily Lagoon and Nelson Lagoon subject to water levels, and riverine waterbodies (Figure 6-17). Nelson Lagoon is situated within a disturbed and heavily grazed landscape. The waterbody is too deep for roosting by migratory shorebird species but provides foraging habitat for Caspian tern.

There is approximately 4,041.5 ha of potential habitat for Caspian Terns in the local area, including lacustrine, palustrine, riverine and estuarine wetlands/waterbodies.

Caspian terns breed in the northern hemisphere and there is no breeding habitat in the Project Area.

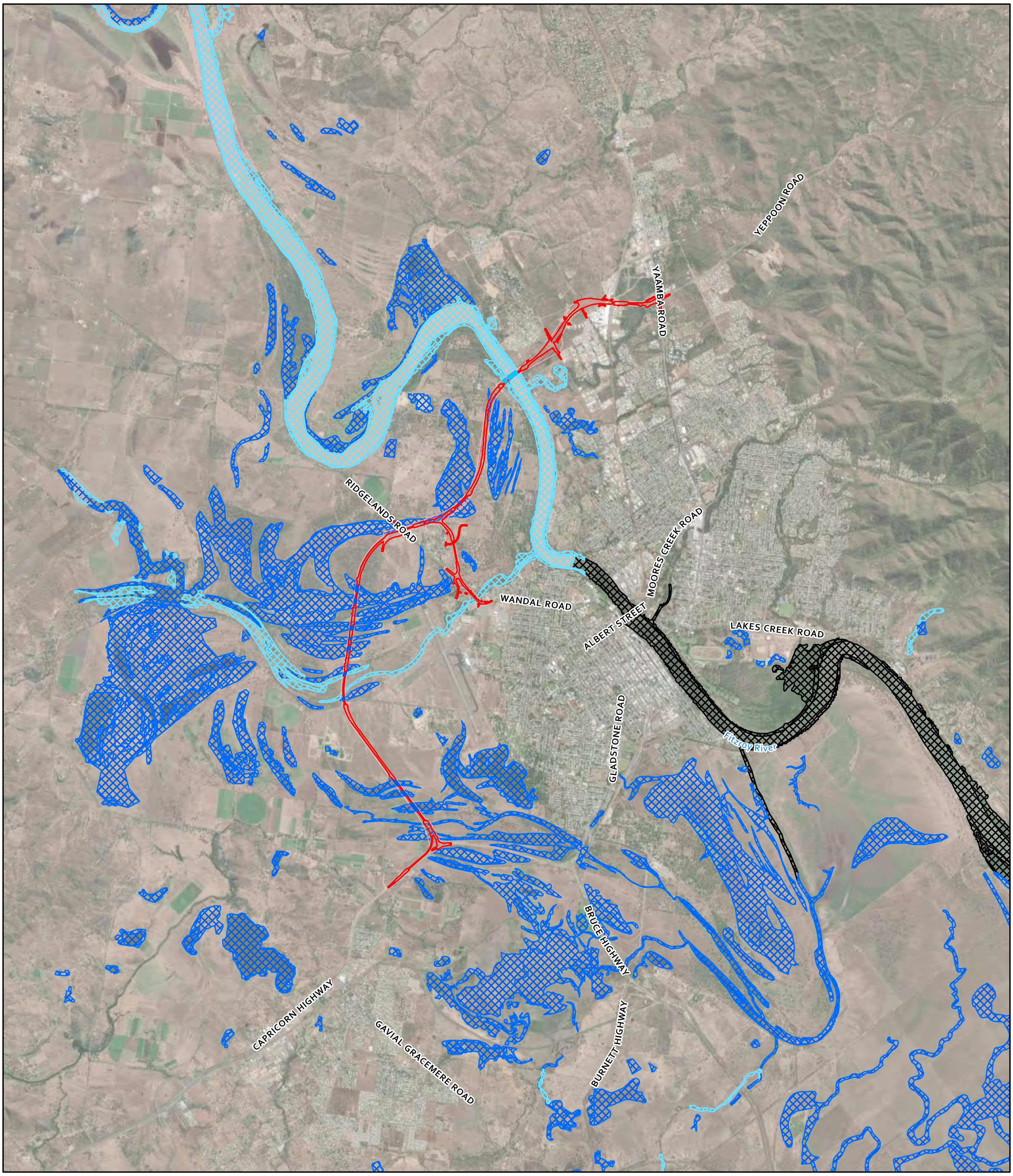
6.4.3 Common Greenshank (*Tringa nebularia*) – Migratory, Marine

In Queensland, this species is widespread in the Gulf country and eastern Gulf of Carpentaria. 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 Mount Guide, and sparsely scattered records elsewhere (Birdlife Australia, 2021). The common greenshank is found in a wide variety of inland wetlands and sheltered coastal habitats of varying salinity. It occurs in sheltered coastal habitats, typically with large mudflats and saltmarsh, mangroves or seagrass. Habitats include embayments, harbours, river estuaries, deltas and lagoons and are recorded less often in round tidal pools, rock-flats and rock platforms (Australian Government Department of the Environment, Water and the Environment, 2021r).

Habitat across the Project Area is well suited to this species and it is known from the Rockhampton region in recent years, including records at Murray Lagoon in 2016 (Birdlife Australia, 2021). Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters and muddy margins when water is present (Figure 6-9).There is approximately 4,041.5 ha of potential habitat in the broader area.

Common greenshank breed in the northern hemisphere and there is no breeding habitat in the Project Area.

Figure 6-17: Potential caspian tern (Hydroprogne caspia) habitat within the Project Area and broader area

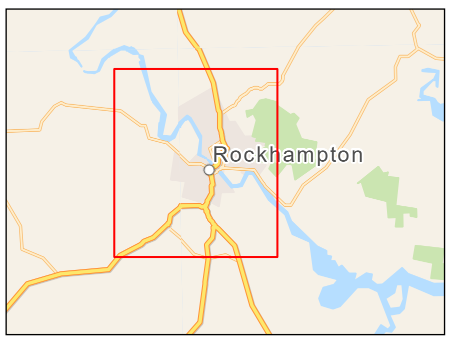


Legend

Field-verified habitat for species within the Project Area
- Lacustrine or palustrine wetland
- Riverine waterbody

Potential habitat based on Regional Ecosystem mapping
- Riverine waterbody
- Lacustrine or palustrine wetland
- Estuarine waterbody

- Project Footprint
- Project Area



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6.4.4 Common Sandpiper (*Actitis hypoleucos*) – Migratory, Marine

Found along all coastlines of Australia and in inland areas, the common sandpiper is widespread in small numbers, preferring to forage in isolation rather than aggregate in large flocks like most other migratory shorebirds. The population when in Australia is concentrated in northern and western parts of the country. The common sandpiper is known to occur in a range of wetland environments, both coastal and inland. Their primary habitat is rocky shorelines and narrow muddy margins of billabongs, lakes, estuaries and mangroves. The muddy margins utilised by the species are often narrow and may be steep. The species is often associated with mangroves, and sometimes found in areas of mud littered with rocks or snags (Australian Government Department of the Environment, Water and the Environment, 2021s).

Suitable habitat for this species is found within the Project Area, however the closest record in available databases is at the Port Alma saltworks, approximately 20 km south east of the Project Area. The species is highly unlikely to occur in numbers exceeding its national significance or important habitat threshold within the Project Area.

Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters and muddy margins (Figure 6-9). There is approximately 4,041.5 ha of potential habitat in the broader area.

Common Sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

6.4.5 Curlew Sandpiper (*Calidris ferruginea*) – Critically Endangered, Migratory, Marine

Curlew sandpiper were not recorded during the survey program; The species has been previously recorded approximately 2 km east of the Project at Murray Lagoon in 2002 and 4 km south west of the Project at Padygole Lagoon in 2009 (Birdlife Australia, 2021), and consistently recorded at coastal roosts within the Fitzroy River delta and the southern parts of Keppel Bay.

Within the Project Area, sub-optimal foraging and roosting habitat for curlew sandpiper occurs at Pink Lily Lagoon, Lotus Lagoon, Crescent Lagoon, Dunganweate Lagoon, Nelson Lagoon and Black Duck Lagoon. These wetlands are considered suboptimal given curlew sandpiper mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, but also around non-tidal swamps, lakes and lagoons near the coast (Higgins & Davies 1996). They are recorded inland, though less often, including around ephemeral waterbodies, usually with bare edges of mud or sand, and in non-tidal wetlands, they usually wade, mostly in water 15‑30 mm, but up to 60 mm, deep (Higgins & Davies 1996). Curlew sandpipers generally roost on bare dry shingle, shell or sand beaches, sandspits and islets in or around coastal or near-coastal lagoons and other wetlands (Higgins & Davies 1996). That is, these wetlands in Project Area are not intertidal mudlfats and do not provide mudflats nearby water due to the steep bank profile and lack of water for much of the year and sometimes for several years (as illustrated by the hydrographs in Section 3.2.5), and do not provide roosting habitat (i.e. bare dry shingle, shell or sand). In addition, approximately 5.4 ha of the wetlands that provide potential habitat in the Project Area (9.5 ha) are subject to livestock damage (Figure 6-9).

Although Pink Lily Lagoon is also disturbed by cattle pugging, vegetation thinning and weed incursion, it may provide a relatively large area of shallow wetland habitat, wide muddy margins for foraging and fringing vegetation suitable for refuge when it is holding water. Similarly, Lotus Lagoon is also expected to provide habitat for curlew sandpiper when inundated.

Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands (Figure 6-9) with approximately 4,041.5 ha of potential habitat in the broader area.

Curlew sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

Habitat critical to the survival of the curlew sandpiper is not formally defined, and there is currently no recovery plan for this species given it was listed individually under the EPBC Act in 2015. Conservation Advice for the curlew sandpiper details that 22 internationally important sites for south-ward migration occur within Australia (Australian Government Department of the Environment, 2015b). None of these sites are within the Project Area.

6.4.6 Eastern Osprey (*Pandion haliaetus*) – Migratory, Marine

Eastern ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia. They are mostly found in coastal areas but occasionally travel inland along major rivers, particularly in northern Australia. They require extensive areas of open fresh, brackish or saline water for foraging (Australian Government Department of Agriculture, Water and the Environment, 2021m).

Nests are constructed in a variety of natural features and manmade structures including dead or partly dead trees, on cliffs, rocks, lighthouses and telecommunication towers.

The species was recorded during field surveys at Yeppen Lagoon, located approximately 2 km east of the southern extent of Project Area and over Shalom Lagoon, approximately 2.5 km south of the northern extent of the Project Area. There are eight records of this species in available databases in the local area, including at Woolwash Lagoon (2017) and Murray Lagoon (2012) (Birdlife Australia, 2021). Osprey nests are large and conspicuous - none were observed during the field survey program.

All freshwater lagoons, when inundated, and the Fitzroy River provide suitable foraging habitat for eastern osprey with large open areas and a variety of suitable fish prey species known to exist in the catchment. Large trees and stags in the riparian zone of the Fitzroy River and areas surrounding Pink Lily Lagoon, Lotus Lagoon and Black Duck Lagoon provide potential nesting opportunities and may be used for perches when foraging when these waterbodies are inundated. When wetlands within the Project Area are dry the species is expected to be restricted to the Fitzroy River corridor. The species is highly mobile and may traverse the Project Area across all habitat types when dispersing between inundated wetland foraging locations. However, they are known to travel inland along major rivers, as such the Fitzroy River, which is likely the primary dispersal pathway.

The species exhibits a preference for coastal areas however they do frequent a variety of habitats including inland wetlands and rivers such as those in the Project Area. As such it is likely that the eastern osprey utilises habitat within the Project Area on an intermittent or opportunistic basis for breeding/nesting, foraging, roosting and dispersal. Approximately 15.9 ha of potentially suitable habitat occurs within the Project Area in lacustrine, palustrine and riverine waterbodies and fringing riparian woodlands, with approximately 5,251.2 ha of potential habitat in the broader area (Figure 6-18).

Important habitat for the eastern osprey has been identified as (Australian Government Department of Environment, 2015a):

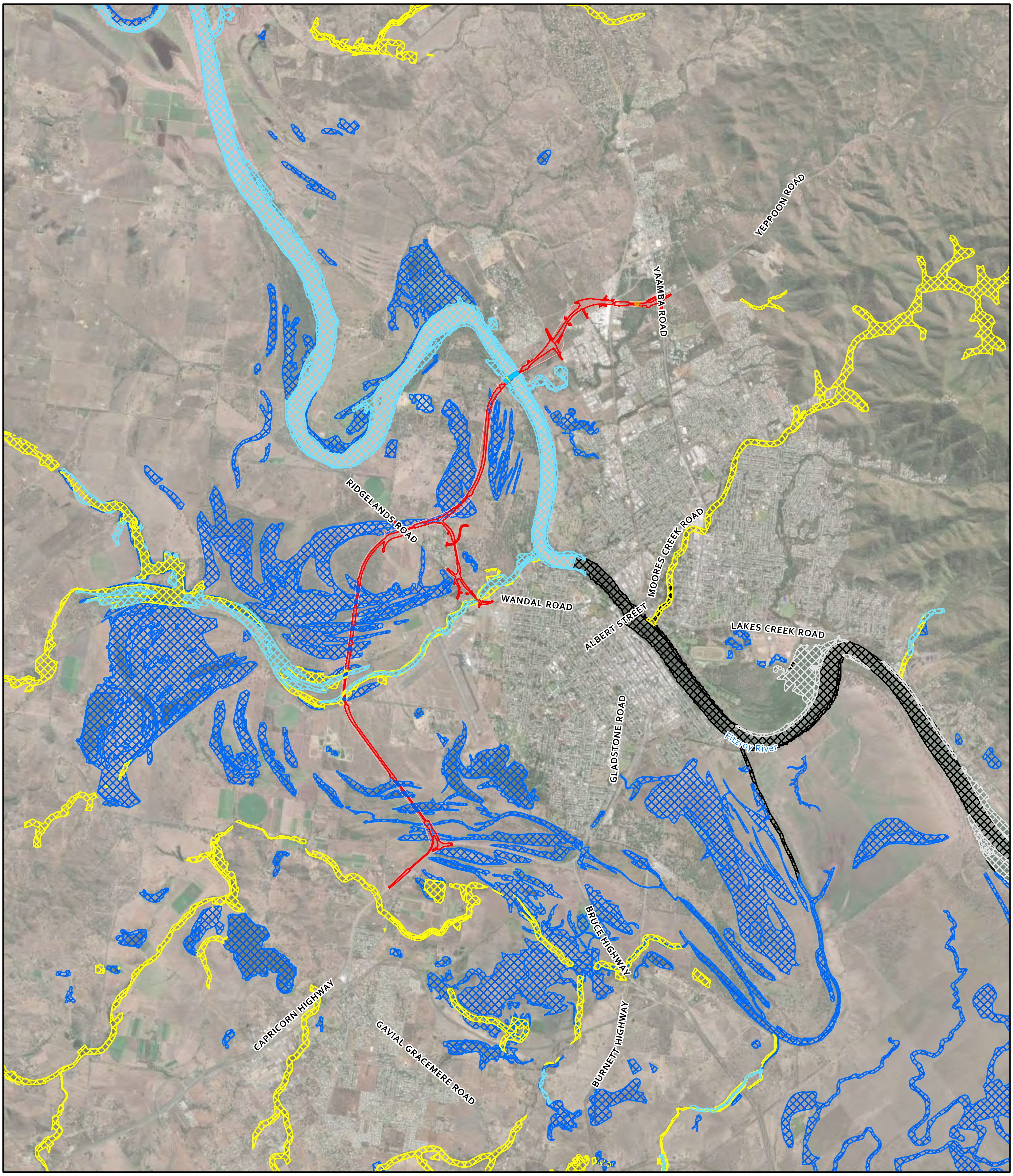
- Bays, estuaries, along tidal stretches of large coastal rivers, mangrove swamps, coral and rock reefs, terrestrial wetlands and coastal lands of tropical and temperate Australia and offshore islands
- Nesting habitat in trees (often dead or with dead tops), rocky coastlines and on artificial structures such as telecommunications towers
- Foraging habitat is primarily in the sea or nearby estuarine waters.

The area threshold for important habitat for this species has been identified as 840 km of coastline (1%) and 84 km of coastline (0.1%). An ecologically significant proportion of the eastern osprey population is estimated at 24 individuals (0.1%).

Based on this definition and field-verification of habitat during field surveys, terrestrial wetlands within and adjacent to the Project Area may comprise important habitat for the species, although an ecologically significant proportion of the population was not present during the survey program, and is highly unlikely to be present based on the overall extent of the Project Area.

Eastern osprey breed in the tallest features in the landscape (trees, constructed towers and other man-made infrastructure) adjacent to permanent water such as the Fitzroy River, or wetlands such as Murray and Crescent Lagoon. No breeding or nesting sites were recorded during the survey program, and there are no breeding records noted in available databases (Birdlife Australia 2021).

Figure 6-18: Potential eastern osprey habitat within the Project Area and broader area

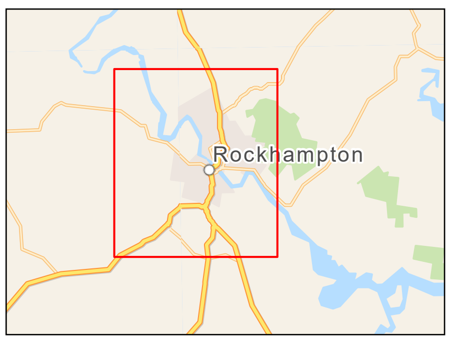


Legend

Field-verified habitat for species within the Project Area
- Fringing riparian woodland with Eucalyptus raveretiana
- Lacustrine or palustrine wetland
- Riverine waterbody
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping
- Riverine waterbody
- Mangroves and saltmarsh
- Fringing riparian woodland
- Lacustrine or palustrine wetland
- Estuarine waterbody

- Project Footprint
- Project Area



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Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

6.4.7 Glossy Ibis (*Plegadis falcinellus*) – Migratory, Marine

Preferred foraging and breeding habitat for the glossy ibis comprises freshwater marshes at the edges of lakes and rivers, lagoons, floodplains, wet meadows, swamps, reservoirs, sewage ponds, rice-fields and cultivated areas under irrigation. The species is occasionally found in coastal locations such as estuaries, deltas, saltmarshes and near-coastal lagoons (Australian Government Department of Agriculture, Water and the Environment, 2021n). Within Australia, this species moves in response to good rainfall, expanding its range, however the core breeding areas used are within the Murray-Darling Basin region of New South Wales and Victoria, the Macquarie Marshes in New South Wales, and in southern Queensland. The glossy ibis often moves north in autumn, then returns south to the main breeding areas in spring and summer.

The glossy ibis was recorded during the field survey program (AECOM, 2020b; 2020d; Jacobs SMEC Design Joint Venture, 2021a) at Pink Lily Lagoon (three individuals), Lotus Lagoon (single individual) and Nelson Lagoon (single individual) actively foraging in the shallow wetted areas where aquatic vegetation was abundant. Although Pink Lily and Lotus Lagoons are suitable habitat, Nelson Lagoon is too deep for foraging for the Glossy Ibis. A total of 57 individuals were observed at seven wetlands (Murray Lagoon, Padygole Lagoon, Little Lion Lagoon, Dunganweate Lagoons, Capricorn Lagoon, Woolwash Lagoon and Sullivan Road Wetlands) during the March 2021 surveys.

Approximately 179.7 ha of potentially suitable foraging, roosting and dispersal habitat for this species is present within the Project Area, in association with modified grasslands, fringing riparian woodlands, lacustrine or palustrine wetlands subject to water levels, and riverine waterbodies, with approximately 30,091.9 ha of potential habitat in the broader area (Figure 6-19).

No evidence of Glossy Ibis breeding or nesting sites were recorded during the survey program, and there are no breeding records (courtship, nesting behavior, dependent chicks or fledglings) noted in available databases (Birdlife Australia 2021).

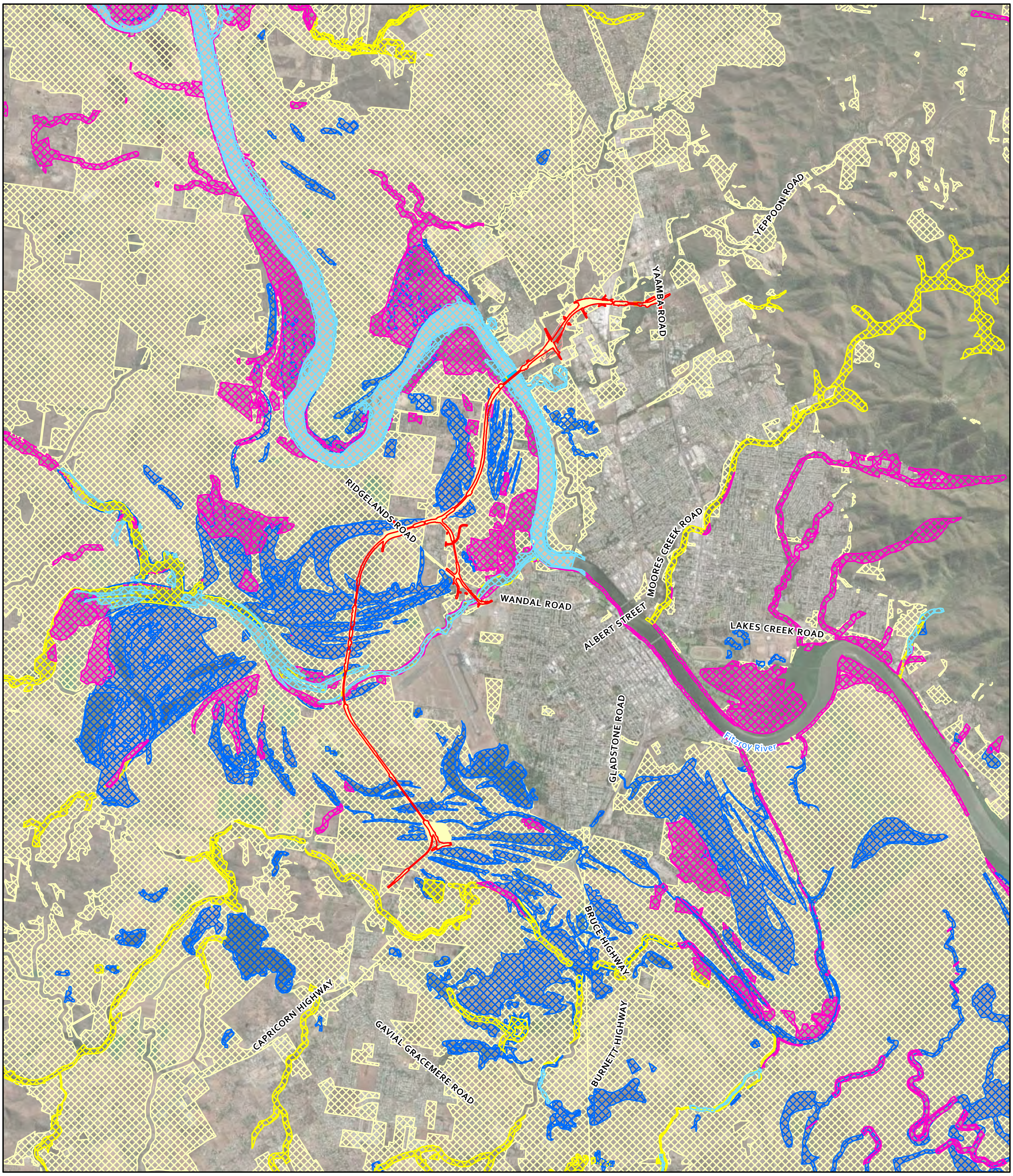
6.4.8 Latham's Snipe (*Gallinago hardwickii*) – Migratory, Marine

Latham's snipe is a non-breeding visitor to eastern Australia and a passage migrant through northern Australia. In Queensland, its range extends along the east coast from Cape York Peninsula, south and inland over the eastern tablelands to south-eastern Queensland. In Australia, Latham's snipe inhabit both permanent and ephemeral wetlands ranging up to 2000 m above sea-level (Chapman, 1969; Naarding, 1982). These wetlands range from open freshwater wetlands with low, dense vegetation to saline or brackish water in modified or artificial habitats including those occurring near human activity (Frith, Crome, & Brown, 1977; Naarding, 1983).

Latham's snipe forage in areas of mud, typically with some form of low, dense vegetation cover and typically roost on the ground near their foraging areas in sites that provide some form of shelter e.g. clumps of vegetation, drainage ditches, boulders or shallow water (Todd, 2000; Frith, Crome, & Brown, 1977; Naarding 1982; 1983). They are also tolerant of disturbance and can be found in human-modified landscapes and in habitats located close to humans or human activity. They roost in grass around the margins of wetlands during the day, and forage for a range of invertebrates in soft mud around the margins of wetlands and in damp soil of grasslands at night, when the species is more comfortable foraging in more exposed locations away from vegetative cover.

Important habitat for Latham's snipe 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 (Australian Government Department of Environment, 2015a). Consideration of habitat usage at both the local and regional scale is important for migratory bird species that frequent dynamic inland wetland areas as they are particularly responsive to changes in habitat conditions. A key defining feature of the National Migratory Shorebird Program (formerly Shorebirds 2020) run by BirdLife Australia is the notion of a 'Shorebird Area'. Following Clemens, Weston, Haslem, Silcocks, & Ferris (2010) a shorebird area is defined as: the geographic area that has been used by the same group of shorebirds over the main non-breeding period (Austral summer), which is effectively the home range of the local shorebird population when present. Shorebird areas may include multiple roosting and feeding habitats. While most migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of the same area where there is evidence of regular bird movement between them. Migratory shorebird areas therefore often extend beyond the boundaries of a property or Project Area and may also extend beyond Ramsar boundaries for internationally important areas.

Figure 6-19: Potential glossy ibis (Plegadis falcinellus) habitat within the Project Area and broader area

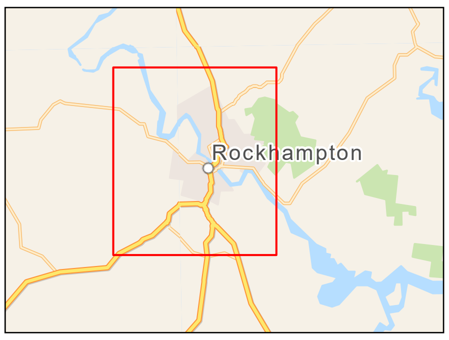


Legend

Field-verified habitat for species within the Project Area
- Fringing riparian woodland with Eucalyptus raveretiana
- Lacustrine or palustrine wetland
- Modified grasslands
- Riverine waterbody
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping
- Riverine waterbody
- Eucalyptus woodland on alluvial floodplains
- Fringing riparian woodland
- Lacustrine or palustrine wetland
- Modified Grasslands

- Project Footprint
- Project Area



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Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2019); Metromap: Imagery (2020)

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In order to assess the relative importance of wetlands present within the Project Area, migratory bird surveys were conducted at all suitable wetland areas within a 6 km radius of the Project Area, which we consider to be the Shorebird Area within which the local Latham's snipe population is expected to utilise suitable habitat and respond to annual and seasonal variation in local wetland conditions.

Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to Latham's snipe, is also highly variable between years and within seasons. As a result, identified important habitat areas defined by the presence of 18 birds or more Latham's snipe at any given wetland, may only constitute important habitat once in a series of consecutive years, and may not be considered important habitat on a consistent or predictable annual basis (e.g. when dry). In a local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain collectively comprise important habitat for Latham's snipe.

Four separate targeted migratory bird surveys have been undertaken (AECOM 2020b; 2020d; Jacobs SMEC Design Joint Venture, 2021a). Fourteen Latham's snipe were observed foraging at Pink Lily Lagoon on 11 February 2019 (AECOM, 2020d). At Lotus Lagoon and Nelson Lagoon in March 2020 a total of seven individuals were observed (AECOM, 2020b). No Latham's snipe were observed within any of the wetlands within the Project Area during the March 2021 surveys (Jacobs SMEC Design Joint Venture, 2021a) due to many of the wetlands being largely dry and therefore unsuitable for migratory shorebirds. A total of 45 Latham's snipe were recorded in several other wetlands in the vicinity of the Project Area during the March 2021 surveys, with a notable decline in the observed population following the second March 2021 survey indicating a mass departure from the region, and likely commencement of northward migration to the species' breeding areas in Japan and South eastern Russia. Wetlands in which Latham's snipe were recorded included Murray Lagoon, Crescent Lagoon, Woolwash Lagoon and Little Lion Lagoon, all located within 6 km of the Project Area, and highlighting the broader floodplain and all associated wetlands as important habitat for the species.

Approximately 9.5 ha of lacustrine or palustrine wetland habitat within the Project Area may be used for foraging, roosting and dispersal, (Figure 6-9). However, the extent of wetland mapping does not accurately reflect the extent of suitable habitat for Latham's snipe as this species is known to avoid areas of woodland vegetation along the high banks of wetlands, and will forage outside of typical wetland habitat in adjacent or nearby irrigated farmland during the night. There is approximately 4,041.5 ha of potential habitat in the broader area.

Given the size of the lagoon, and the amount of potential representative habitat when inundated, there is a potential for Pink Lily lagoon to support at least 18 Latham's snipe. Pink Lily Lagoon is a naturally occurring wetland with riparian cover surrounding much of the littoral zone which provides foraging habitat for Latham's snipe. This includes 1 – 2 m tall *Urochloa mutica* (para grass) and *Persicaria orientalis* (princes feathers). Lotus Lagoon also provides suitable foraging and roosting habitat for the species when inundated. Although the majority of this wetland was dry or had significantly receded during the site investigations (AECOM, 2020b; 2020d; Jacobs SMEC Design Joint Venture 2021), when periodically inundated, this wetland is expected to provide extensive, shallow, wetted habitat that may be utilised by Latham's snipe. The Project Area also traverses the two Dunganweate Lagoons and Nelson Lagoon and is situated in proximity to several other wetlands such as Black Duck Lagoon, Capricorn Highway Lagoons and Crescent Lagoon. Each of these wetlands varies significantly in habitat suitability for Latham's snipe and other migratory shorebirds, again in response to water levels. Dunganweate, Nelsons and Capricorn Highway Lagoons have similar profiles, being elongated, narrow and having relatively steep bank profiles. They are also subject to livestock grazing pressures which degrades the habitat suitability for shorebirds foraging around the verges of these sites. These wetlands would provide suitable habitat only when at or beyond capacity, at which point water held in these sites spills over adjacent shallow verges and margins. Dunganweate Lagoons did not present suitable foraging habitat for Latham's snipe at the time of the 2019 (AECOM, 2020b; 2020d) and 2021 (Jacobs SMEC Design Joint Venture, 2021a) shorebird surveys due to absence of dense riparian vegetation, water levels being too deep or too low to be suitable for foraging, and severe bank and shoreline degradation caused by livestock. Fauna habitat values at Capricorn Highway Lagoon could not be accurately determined due to access restrictions during the 2019 survey (AECOM, 2020b; 2020d), but the site was accessed and surveyed as part of the 2021 survey (Jacobs SMEC Design Joint Venture, 2021a). During this survey, water levels were significantly reduced. There was a notable absence of emergent and fringing vegetation and therefore limited refugia available for Latham's snipe around the margins of the wetland. Livestock access and resultative degradation was also prevalent at this location.

Based on available data in the Rockhampton region, Latham's snipe has also been previously recorded at Dunganweate Lagoons, Capricorn Highway Lagoon, O'Shanesy Park wetland, Woolwash Lagoons, Rockhampton Lakes Creek Reserve, Kershaw Gardens, Shalom Lagoon, Limestone Creek Wetlands, Duckpond Lagoon, Yeppen Lagoon and Sullivan Road Wetlands (Birdlife Australia, 2021). The local population of Latham's snipe that are expected to visit each year are likely to move between each of these wetlands, and others further afield, in response to habitat suitability – water levels, foraging resources and availability of secure roosting sites. Numbers of birds at any one wetland are expected to vary significantly between years and over the course of an austral spring and summer period when migratory birds are present, but the overall number of birds in the region is likely to be similar between years.

6.4.9 Little Curlew (*Numenius minutus*) – Migratory, Marine

Little curlews generally spend the non-breeding season in northern Australia from Port Hedland in Western Australia to the Queensland coast. There are many records of the species from inland Australia, and widespread but scattered records on the east coast.

The little curlew is most often found feeding in short, dry grassland and sedgeland, including dry floodplains and blacksoil plains, which have scattered, shallow freshwater pools or areas that are seasonally inundated. Open woodlands with a grassy or burnt understorey, dry saltmarshes, coastal swamps, mudflats or sandflats of estuaries or beaches on sheltered coasts, mown lawns, gardens, recreational areas, ovals, racecourses and verges of roads and airstrips are also used (Australian Government Department of Agriculture, Water and the Environment, 2021k).

The species was not recorded during the survey program, but there are records of the species from north east of Rockhampton at Kinka Beach (33 km from the Project Area) and Corio Bay (55 km from the Project Area) (Queensland Government Department of Environment and Science, 2021e) and on the northern end of Curtis Island (54 km from the Project Area) (eBird, 2021). Given the presence of floodplain habitat within the Project Area that may be suitable for this species pending wetland inundation, this species may occur on an occasional or opportunistic basis, although it may on rare occasions occur in numbers exceeding its important habitat or national significance threshold (110).

Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area at palustrine and lacustrine wetlands subject to water levels with approximately 4,041.5 ha of potential habitat in the broader area (Figure 6-9). This species can also feed in adjacent grasslands if conditions are suitable.

Little curlew breed in the northern hemisphere, therefore there is no breeding habitat in the Project Area.

6.4.10 Little Tern (*Sternula albifrons*) – Migratory, Marine

The little tern was not recorded in during the survey program (AECOM 2020d; 2020b; Jacobs SMEC Design Joint Venture, 2021a) and is unlikely to utilise wetlands within the Project Area given the distance from coastal marine intertidal areas in which it prefers to forage. In Australia, little terns inhabit sheltered coastal environments, including lagoons, estuaries, river mouths and deltas, lakes, bays, harbours and inlets, especially those with exposed sandbanks or sand-spits.

There are two records of little tern in the Rockhampton region, at Murray Lagoon from 2017 and 2020 and another from Lakes Creek Reserve in 2019 (eBird, 2021), although upon reviewing these records, which have images attached to them, they have been misidentified and are non-breeding whiskered terns (*Chlidonias hybrida*). These records have been shared with other database platforms (e.g. Atlas of Living Australia, WildNet). Upon identifying this error, these records have now been amended in both Birdata and eBird database platforms. Based on the wetland habitat within the Project Area consisting of lacustrine or palustrine waterbodies, and the distance from coastal environs, little tern are not expected to occur.

6.4.11 Marsh Sandpiper (*Tringa stagnatilis*) – Migratory, Marine

The marsh sandpiper is a medium sized shorebird which can occur singly or in small to large flocks. They often associate with other waders and are often seen with greenshanks, especially in saltfields. They may feed in tight co-ordinated groups, and sometimes with other shorebird species (Higgins & Davies 1996).

The marsh sandpiper is found on coastal and inland wetlands throughout Australia. The species is widespread in coastal Queensland, but few records exist north of Cooktown.

The marsh sandpiper lives in 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. In the south-east Gulf of Carpentaria they have been recorded in both saline and fresh waters (Garnett, Wading Bird Abundance and Distribution - South-eastern Coast of the Gulf of Carpentaria., 1989). Elsewhere they tend to avoid, or rarely occur in, tidal habitats, and rarely occur on beaches.

A single individual marsh sandpiper was recorded during field surveys (AECOM, 2020b) at Pink Lily Lagoon. Four individuals were recorded at Padygole Lagoon (outside of the Project Area) during the March 2021 surveys (Jacobs SMEC Design Joint Venture, 2021a). There are multiple records of this species in available databases (Birdlife Australia, 2021) (Queensland Department of Environment and Science, 2021b), demonstrating annual occurrence in wetlands across the Fitzroy River floodplain, with some observer bias evident at heavily surveyed areas close to Rockhampton such as Murray Lagoon. Padygole, Murray and Lower Gracemere Lagoons provide ideal conditions for this and many other migratory shorebird species due to their profile, shallow gradually sloping banks, exposed mud and shallow waters. Pink Lily and Lotus Lagoons are also expected to provide habitat for this species when they are inundated.

Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands subject to water levels (Figure 6-9), with approximately 4,041.5 ha of potential habitat in the broader area.

Marsh sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

The highest reported observation of marsh sandpiper in the Rockhampton region in available databases is 80 birds at Fitzroyvale Oxbow, approximately 20 km east of the Project Area. Based on available data and the variability of habitat across the Fitzroy River floodplain, marsh sandpiper may occur in numbers exceeding their important habitat or national significance threshold (130), particularly at Padygole, Murray and Lower Gracemere Lagoons.

6.4.12 Pectoral Sandpiper (*Calidris melanotos*) – Migratory, Marine

Pectoral sandpipers have one of the largest flyway populations of any of the 37 regular migrant shorebird species which routinely visit Australia. When in Australia, they are usually recorded as single birds or in very low numbers, usually associated with larger groups of sharp-tailed sandpipers. There are no nationally or internationally significant sites in Australia for this species based on available database records and over 50 years of shorebird population monitoring observations (Birdlife Australia, 2021; Weller et al. 2020).

In Queensland, most records for the pectoral sandpiper occur around Cairns. There are scattered records elsewhere, mainly from east of the Great Divide between Townsville and Yeppoon. Records also exist in the south-east of the state as well as a few inland records at Mount Isa, Longreach and Oakley.

This species is usually found in coastal or near coastal habitat but very occasionally found further inland. It prefers wetlands that have open fringing mudflats and low, emergent or fringing vegetation, such as grass or samphire (Australian Government Department of Agriculture, Water and the Environment, 2021c).

The species was not recorded during the survey program. A single record exists at Kinka Beach from 1987, 31 km north east of the Project Area (Atlas of Living Australia, 2021). Suitable habitat for this species is found within the Project Area and given the prevalence of sharp-tailed sandpiper records in the region, it is highly likely that pectoral sandpiper would also occur. Within the Rockhampton region, the species is not expected to ever exceed its national significance or important habitat threshold (1,220 birds).

Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters, emergent aquatic vegetation and muddy margins (Figure 6-9) with approximately 4,041.5 ha of potential habitat in the broader area.

Pectoral sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

6.4.13 Red-necked Stint (*Calidris ruficollis*) – Migratory, Marine

The red-necked stint is the smallest migratory shorebird that visits Australia. Red-necked stints breed in Siberia and Alaska and are a common passage migrant through Japan, the Korean Peninsula, China, Vietnam, Malaysia, the Philippines and west Micronesia. Over 80 per cent of the Flyway population of red-necked stints spend the non-breeding season in Australia, with small numbers overwintering in New Zealand and Papua New Guinea. When in Australia, red-necked stints are most common in the south eastern part of the country but occur across all states.

In Australasia, the red-necked stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. Occasionally they have been recorded on exposed or ocean beaches, and sometimes on stony or rocky shores, reefs or shoals. They also occur in saltworks and sewage farms; saltmarsh; ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks and pools in saltflats. They sometimes use flooded paddocks or damp grasslands (Australian Government Department of Agriculture, Water and the Environment, 2021b). The red-necked stint mostly forages on bare wet mud on intertidal mudflats or sandflats, or in very shallow water, mostly in areas with a film of surface water and mostly close to edge of water. During high tides they sometimes forage in non-tidal wetlands. Like sharp-tailed sandpiper and curlew sandpiper, red-necked stints will readily take advantage of flooded inland wetlands and inundated floodplains and are therefore considered to be a habitat generalist.

The species was not recorded during the survey program but there are two records from Murray Lagoon, just east of the Project Area, most recently in 2018 (Birdlife Australia, 2021). Given the presence of other migratory shorebird species, the habitat conditions at Padygole, Murray and Lower Gracemere Lagoons and the highly adaptive and opportunistic nature of red-necked stints, it is likely that the species would occur in numbers exceeding its important habitat or national significance threshold (475 birds) in the region.

Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters and muddy margins (Figure 6-9) with approximately 4,041.5 ha of potential habitat in the broader area.

Red-necked stint breed in the northern hemisphere and there is no breeding habitat in the Project Area.

Given the large size of the potential breeding habitat in the broader area, it is presumed that the removal of a small portion of potential breeding habitat for the project will have a minimal effect on the red-necked stint.

6.4.14 Sharp-tailed Sandpiper (*Calidris acuminata*) – Migratory, Marine

Sharp-tailed sandpiper are a small-medium sized shorebird that migrate from northern Siberia to Australia annually. The species can often be observed in small groups in areas of suitable habitat, but often occur in large flocks of up to 30,000 individuals in optimal conditions.

Sharp-tailed sandpiper begin to depart from Tasmania between January and February and begin leaving southern mainland Australia during mid-February, most departing in March, with a few remaining through to early May in the south-east. Many, apparently, cross inland with records from the arid inland region between February to April. At least some move north from south-east Australia via the coast of Queensland, during March and April. Birds are not capable of flying non-stop out of Australia. Instead, most birds from south-east Australia are thought to fly to seasonal swamps on the coast of the Gulf of Carpentaria, occurring at least as far north as Edward River and possibly Watson River, where they build up fat reserves before moving north. Most (91%) of the sharp-tailed sandpiper population migrate to Australia during the non-breeding season with small numbers visiting New Zealand (Australian Government Department of Agriculture, Water and Environment, 2021t). Following the breeding season, the sharp-tailed Sandpiper departs the breeding areas from late June, with most leaving during July. Adult males leave before females which, in turn, depart before juveniles (Higgins & Davies, 1996). Small numbers arrive in north-west Australia during mid-August, with large numbers in early September. Small numbers pass through the Torres Strait, and can occur on the coast of the Gulf of Carpentaria during September and December and on the coast of north-east Queensland from late August. After arriving in Australia, most birds move slowly south across the continent to south-east Australia (Higgins & Davies, 1996).

Within Australia, sharp-tailed sandpipers have been recorded within all states and territories typically migrating to the south-east and can be observed in both inland and coastal locations, albeit many inland records are of bird in passage (Higgins & Davies, 1996; Australian Government Department of Agriculture, Water and Environment, 2021a).

Bamford et al. (2008) identified 39 internationally important sites within Australia, with nine of these sites located within Victoria, including the Bellarine Peninsula. Sharp-tailed sandpipers are considered widespread throughout Victoria, especially coastal areas but sparse in north-east and north-central Victoria (Higgins & Davies 1996) and are one of the most common, widespread and frequently observed migratory shorebirds in Australia. Since the commencement of BirdLife Australia's Shorebirds 2020 Program in 2007, revision of the Flyway Population Estimates (Hansen, et al., 2016) and creation of the Australian National Directory of Important Migratory Shorebird Habitat (Weller et al. 202), 12 additional sites of international importance have been identified across the country, and 134 sites of national importance, including Fitzroyvale Oxbow, approximately 20 km from the Project Area.

In Australasia, sharp-tailed sandpiper is considered a habitat generalist and prefer muddy edges of shallow or brackish wetlands with inundated saltmarsh or low-lying vegetation. These habitats include lagoons, swamps, dams, lakes, estuaries, mangrove-lined creeks, saltworks and sewage farms. When inundated, they have been recorded using paddocks, sedgelands and other ephemeral wetlands, but leave these areas when then begin to dry (Australian Government Department of Agriculture, Water and Environment, 2021t). Sharp-tailed sandpiper forage in inundated areas with their diet typically consisting of seeds, worms, crustaceans, molluscs and insects (Higgins & Davies 1996). They forage at the edge of the water of wetlands or intertidal mudflats, either on bare wet mud or sand, or in shallow water. They also forage among inundated vegetation of saltmarsh, grass or sedges. They forage in sewage ponds, and often in hypersaline environments. After rain, they may forage in paddocks of short grass, well away from water. They may forage on coastal mudflats at low tide and move to freshwater wetlands near the coast to feed at high tide. Occasionally they forage on wet or dry mats of algae and among rotting beachcast seagrass or seaweed, and sometimes they are recorded foraging around the edges of stony wetlands or among rocks in water, and rarely on exposed reef (Higgins & Davies 1996). They will use freshwater, estuarine, brackish and coastal or marine habitats depending on food resource availability.

Roosting for sharp-tailed sandpiper typically occurs at the edges of wetlands, on wet open mud or sand, shallow water or short sparse vegetation in small to large groups (Australian Government Department of Agriculture, Water and Environment, 2021t). They have also been recorded roosting on sandy beaches, stony shores or on protruding rocks in water (Higgins & Davies 1996). Sharp-tailed Sandpipers are early responders to artificial habitat creation, and also favourable habitat conditions across the landscape.

The Australia national Migratory Shorebird Program (formerly Shorebirds 2020) has recorded significant population fluctuations at known coastal sites as a result of suitable habitat conditions elsewhere in the country. Following extensive rainfall and wetland inundation in inland parts of Australia, sharp-tailed sandpiper appears to demonstrate a preference for these habitat areas when suitable, and only move on to coastal areas when conditions deteriorate inland.

Twenty-two sharp-tailed sandpipers were recorded during the first of the March 2021 surveys at Crescent Lagoon, Sullivan Road Wetlands and Lower Gracemere Lagoon, all outside of the Project Area (Jacobs SMEC Design Joint Venture, 2021a). Two individuals were recorded during the second March 2021 survey, at Sullivan Road Wetlands. Approximately 9.5 ha of potential foraging, roosting and dispersal habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters and muddy margins (Figure 6-9), with approximately 4,041.5 ha of potential habitat in the broader area.

Sharp-tailed sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

Given the large size of the potential breeding habitat in the broader area, it is presumed that the removal of a small portion of potential breeding habitat for the project will have a minimal effect on the sharp-tailed sandpiper.

6.4.15 White-throated Needletail (*Hirundapus caudacutus*) – Vulnerable, Marine, Migratory

There are two recognised subspecies of white-throated needletail (Threatened Species Scientific Committee, 2019):

- subspecies *caudacutus* which breeds in central and eastern Siberia, northern Mongolia, northern China and the Korean Peninsula, Sakhalin and Japan, and is migratory, spending the non-breeding season in Australasia.
- subspecies *nudipes*, which breeds in the Himalayas from northern Pakistan and south-western China, and is largely resident (does not migrate) and does not occur in Australasia (Chantler 1999; Higgins 1999).

The nominate subspecies *caudacutus* of the white-throated needletail is a trans-equatorial migrant, breeding in the northern hemisphere before flying south for the boreal winter. The white-throated needletail is found across a range of habitats across eastern and south-eastern Australia, more often over wooded areas, where it is almost exclusively aerial.

Departure from the breeding grounds in eastern Siberia, Japan and north-eastern China occurs between late August and October. Southward migration to Australia can be extremely rapid and can be poorly detected, although birds generally arrive between September through to December (Australian Government Department Agriculture, Water and the Environment, 2021i). During the non-breeding season, the species is widespread in eastern and south-eastern Australia, and can be considered a passage migrant in northern parts of the country. Northward migration back to the breeding grounds occurs from around February each year, with a recorded increase in sightings and abundance in northern New South Wales and Queensland through late February and early March. Most of the over-wintering population depart from mid-March through April, flying northwards across the Torres Strait (Australian Government Department Agriculture, Water and the Environment, 2021i).

The white-throated needletail is a highly mobile species and often tracks low pressure systems across the landscape to forage on the wing in updraughts and the convergence of opposing wind currents. It forages anywhere between ‘cloud level’ up to 1000 m, and ‘ground level’ and readily forms mixed feeding flocks with other aerial insectivores (Australian Government Department Agriculture, Water and the Environment, 2021i).

There is no roosting habitat in the project area. There is approximately 2,955.9 ha of potential roosting area in the broader area in association with vegetation that has dense foliage in the canopy (i.e. brigalow, eucalyptus and riparian regional ecosystems) on Mount Archer (Figure 6-20).

On very rare occasions, white-throated needletail have been observed to roost in hollows or the dense canopies of large trees in extensive heavily wooded or forested areas on elevated ridgelines and ranges, usually in response to extreme weather conditions. References to the species roosting in trees and hollows while over-wintering in Australia is noted to potentially over-emphasize such occurrences (Higgins, 1999).

Relatively recent conservation advice for white-throated needletail identifies evidence of collision with wind turbines (Hull, 2013), overhead wires (Cameron & Hinchey, 1981; Campbell, 1930), windows (Slater, 1964) and lighthouses (Draffan, et al. 1983; Stokes, 1983) while the birds are in Australia, but the scale of the impact of such occurrences has not been quantified (Threatened Species Scientific Committee, 2019). Broad scale use of insecticides has also been identified as another possible cause of decline of white-throated needletails, either through a decrease in the abundance of invertebrates or from cumulative secondary poisoning via accumulation resulting from the consumption of insect prey that individually carry sublethal quantities. The loss of potential roosting sites in Australia may also be contributing to the decline of the species (Tarburton, 2014).

White-throated needletail breed in the northern hemisphere and there is no breeding habitat in Australia. The white-throated needletail was not recorded during the multi-year survey program, which included the key period during which the species is in Australia in 2019, 2020 and 2021. Multiple recent records exist within 10 km of the Project Area in available bird observation databases (Birdata, 2021, (eBird, 2021),) as well as across most eastern parts of Queensland every year. This species is likely to aerially forage above the Project Area on a transient and opportunistic basis, with approximately 210.5 ha of potential aerial foraging habitat available in the Project Area (Figure 6-20) and approximately 46,193.2 ha of potential habitat in the broader area. Habitat within and adjacent to the Project Area has been subject to extensive modification through historical land clearing and agricultural practices and there are no extensive patches of tall forest or woodland. The Project Area is also situated on the Fitzroy River floodplain, there are no ranges or ridgeline habitats with woodland or forest vegetation to provided areas suitable for roosting.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population. Similar to migratory shorebirds, an ecologically significant proportion of the population is determined by the presence of a percentage of the overall species population. There are no species-specific guidelines for determining habitat critical to the survival of the white-throated needletail, although Important Habitat is described as large continuous tracts of native vegetation, particularly dense woodland and tall forest along the extent of the Great Dividing Range (Australian Government Department of Environment, 2015a). There is no habitat within the Project Area that constitutes Important habitat for the species or habitat critical to the survival of the species.

The white-throated needletail SPRAT profile (Australian Government Department Agriculture, Water and the Environment, 2021i), Threatened Species Scientific Committee listing advice (Threatened Species Scientific Committee, 2019), and the Draft referral guideline for 14 birds listed migratory under the EPBC Act (Australian Government Department of Environment, 2015a) do not identify any ‘important populations’ for the species. As records are distributed widely within the broader region, the species is predominantly aerial and does not breed in Australia, and the Project Area is not near the limit of the species range, no ‘important populations’ of white-throated needletail are expected to occur within the Project Area.

No impacts to this species are expected to occur as a result of the delivery of the Project, and therefore a significant impact assessment has not been undertaken.

6.4.16 White-winged Black Tern (*Chlidonias leucopterus*) – Migratory, Marine

White-winged black terns are non-breeding migrants to Australia, where they are widespread and common along south-western, northern and central-eastern coasts, with only scattered records of small numbers along the coasts elsewhere in southern Australia. In Queensland, the species is widespread through the Gulf of Carpentaria and along western Cape York Peninsula, but most records are from the south-east. On the eastern Queensland coast, it is recorded at scattered sites, particularly around Cairns, Innisfail and adjacent hinterlands (Australian Government Department of Agriculture, Water and the Environment, 2021d).

White-winged black terns are migratory, leaving their Eurasian breeding grounds from late July to late August to spend the boreal winter in the Southern Hemisphere (Department of the Environment, 2019), arriving in northern Australia on a broad front, mainly from October–November each year. Birds leave Australia between March and May, though some remain during the austral winter (Australian Government Department of Agriculture, Water and the Environment, 2021d).

In Australia, and elsewhere in their non-breeding range, the species mostly inhabits fresh, brackish or saline, and coastal or subcoastal wetlands. White-winged black terns frequent tidal wetlands, such as harbours, bays, estuaries and lagoons, and their associated tidal sandflats and mudflats. Terrestrial wetlands, including swamps, lakes, billabongs, rivers, floodplains, reservoirs, saltworks, sewage ponds and outfalls are also inhabited. Wetlands may be open, or with floating emergent or marginal vegetation (Australian Government Department of Agriculture, Water and the Environment, 2021d).

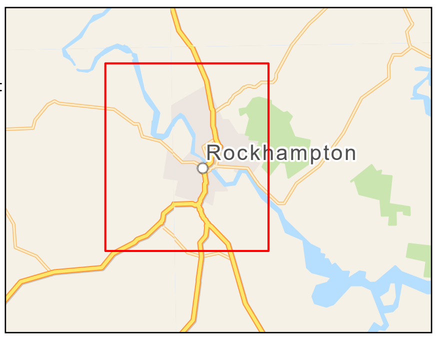
Figure 6-20: Potential habitat for the white-throated needletail (Hirundapus caudacutus) within the Project Area and broader area

Legend

Field-verified habitat for species within the Project Area
- Brigalow woodland
- Eucalyptus woodland on alluvial floodplains +/- Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Eucalyptus woodland on metamophics or granitic
- Fringing riparian woodland with Eucalyptus raveretiana
- Lacustrine or palustrine wetland
- Modified grasslands
- Riverine waterbody
- Fringing riparian woodland

Potential habitat based on Regional Ecosystem mapping
- Riverine waterbody
- Mangrove and saltmarsh
- Eucalyptus populnea woodland on alluvial floodplains
- Eucalyptus woodland on alluvial floodplains with Eucalyptus tereticornis
- Eucalyptus woodland on alluvial floodplains
- Eucalyptus woodland on metamorphics or granitic
- Fringing riparian woodland
- Brigalow woodland
- Lacustrine or palustrine wetland
- Semi evergreen vine thicket
- Estuarine waterbody
- Modified Grasslands

- Project Area
- Project Footprint



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Queensland Department of Resources: RE (2020); AECOM: Habitat (2021); Metromap: Imagery (2020)

The white-winged black tern mainly forages aerially, over water or over muddy or sandy edges of wetlands; and also forages over land adjacent to wetlands, especially if inundated, including rice paddies and dry paddocks and grassland (Australian Government Department of Agriculture, Water and the Environment, 2021d). The species often roosts or loafs on ground at the edges of wetlands, including sandflats, mudflats, beaches, spits, banks, islets and rocks (Higgins & Davies, 1996) (Lindgren, 1956) but also often on emergent branches of submerged trees or piles and posts (Gochfeld & Burger, 1996) (Australian Government Department of Agriculture, Water and the Environment, 2021d).

White-winged black terns were recorded at Padygole Lagoon and Sullivan Road Wetlands, both outside of the Project Area (Jacobs SMEC Design Joint Venture, 2021a). There are limited previous records of the species in central Queensland, with most records being associated with the areas of greater Brisbane, Townsville and Cairns. Given the habitat requirements of this species, any inundated wetland or floodplain would be expected to support its foraging requirements and there is approximately 9.5 ha of potential habitat in the Project Area subject to water levels (Figure 6-9) with approximately 4,041.5 ha of potential habitat in the broader area.

White-winged black terns breed in the northern hemisphere and there is no breeding habitat in the Project Area.

6.4.17 Wood Sandpiper (*Tringa glareola*) – Migratory, Marine

Similar to common sandpiper, wood sandpipers are largely solitary, preferentially foraging on their own rather than aggregating in large flocks. Several individuals can often be found foraging in association with one another, but they are more frequently observed on their own or with other mixed species migratory shorebird flocks. The wood sandpiper uses well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes (Australian Government Department of Agriculture, Water and the Environment, 2021q). They are typically associated with emergent, aquatic plants or grass, and dominated by taller fringing vegetation and often with fallen timber. They also frequent inundated grasslands, short herbage or wooded floodplains, where floodwaters are temporary or receding, and irrigated crops. This species uses artificial wetlands, including open sewage ponds, reservoirs, large farm dams, and bore drains (Australian Government Department of Agriculture, Water and the Environment, 2021q).

In central coastal regions of Queensland, there are a distinct lack of records of wood sandpiper. Most Queensland records are from the Cairns or Brisbane regions (Birdlife Australia, 2021).

Most wetlands in the Project Area lack tall vegetation in fringes, however tall *Persicaria orientalis* was recorded fringing Pink Lily Lagoon and this wetland is likely to provide habitat for this species subject to water levels. No nearby records exist, with the closest records being located approximately 30 km to the north east around Kinka Beach (BirdLife Australia, 2021). Within the Rockhampton region, the species is not expected to ever exceed its national significance or important habitat threshold (130 birds).

Approximately 9.5 ha of potential foraging habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters and muddy margins (Figure 6-9). with approximately 4,041.5 ha of potential habitat in the broader area.

Wood sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

6.5 Summary of MNES Present or with an Elevated Likelihood of Occurrence in Project Area

Table 6-1 provides a summary of the MNES confirmed present during the field surveys and anticipated to be relevant to the Project. Table 6-2 provides details on the condition of each of the habitat types in the Project Area, for each of the MNES.

The white-winged black tern mainly forages aerially, over water or over muddy or sandy edges of wetlands; and also forages over land adjacent to wetlands, especially if inundated, including rice paddies and dry paddocks and grassland (Australian Government Department of Agriculture, Water and the Environment, 2021d). The species often roosts or loafs on ground at the edges of wetlands, including sandflats, mudflats, beaches, spits, banks, islets and rocks (Higgins & Davies, 1996) (Lindgren, 1956) but also often on emergent branches of submerged trees or piles and posts (Gochfeld & Burger, 1996) (Australian Government Department of Agriculture, Water and the Environment, 2021d).

White-winged black terns were recorded at Padygole Lagoon and Sullivan Road Wetlands, both outside of the Project Area (Jacobs SMEC Design Joint Venture, 2021a). There are limited previous records of the species in central Queensland, with most records being associated with the areas of greater Brisbane, Townsville and Cairns. Given the habitat requirements of this species, any inundated wetland or floodplain would be expected to support its foraging requirements and there is approximately 9.5 ha of potential habitat in the Project Area subject to water levels (Figure 6-9) with approximately 4,041.5 ha of potential habitat in the broader area.

White-winged black terns breed in the northern hemisphere and there is no breeding habitat in the Project Area.

6.4.17 Wood Sandpiper (*Tringa glareola*) – Migratory, Marine

Similar to common sandpiper, wood sandpipers are largely solitary, preferentially foraging on their own rather than aggregating in large flocks. Several individuals can often be found foraging in association with one another, but they are more frequently observed on their own or with other mixed species migratory shorebird flocks. The wood sandpiper uses well-vegetated, shallow, freshwater wetlands, such as swamps, billabongs, lakes, pools and waterholes (Australian Government Department of Agriculture, Water and the Environment, 2021q). They are typically associated with emergent, aquatic plants or grass, and dominated by taller fringing vegetation and often with fallen timber. They also frequent inundated grasslands, short herbage or wooded floodplains, where floodwaters are temporary or receding, and irrigated crops. This species uses artificial wetlands, including open sewage ponds, reservoirs, large farm dams, and bore drains (Australian Government Department of Agriculture, Water and the Environment, 2021q).

In central coastal regions of Queensland, there are a distinct lack of records of wood sandpiper. Most Queensland records are from the Cairns or Brisbane regions (Birdlife Australia, 2021).

Most wetlands in the Project Area lack tall vegetation in fringes, however tall *Persicaria orientalis* was recorded fringing Pink Lily Lagoon and this wetland is likely to provide habitat for this species subject to water levels. No nearby records exist, with the closest records being located approximately 30 km to the north east around Kinka Beach (BirdLife Australia, 2021). Within the Rockhampton region, the species is not expected to ever exceed its national significance or important habitat threshold (130 birds).

Approximately 9.5 ha of potential foraging habitat for this species is present within the Project Area, including palustrine and lacustrine wetlands with shallow waters and muddy margins (Figure 6-9). with approximately 4,041.5 ha of potential habitat in the broader area.

Wood sandpiper breed in the northern hemisphere and there is no breeding habitat in the Project Area.

6.5 Summary of MNES Present or with an Elevated Likelihood of Occurrence in Project Area

Table 6-1 provides a summary of the MNES confirmed present during the field surveys and anticipated to be relevant to the Project. Table 6-2 provides details on the condition of each of the habitat types in the Project Area, for each of the MNES.

Table 6-1 Approximate extent of potential habitat in the Project Area for listed species with the potential to occur

Species	Habitat Utilisation	Habitat Type/s	Approximate Area of Habitat (ha) in the Project Area
Flora			
Black ironbox (*Eucalyptus raveretiana*)	Suitable habitat along Limestone Creek in association with the field verified RE 11.3.25a.	Fringing riparian woodland along Limestone Creek	1.0
Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC	The Project Footprint has been refined and most of the TEC in the Project Area is outside the Project Footprint.	Brigalow woodland	1.9
Coolibah – black box woodlands of the Darling Riverine Plains and the Brigalow Belt south bioregions TEC	This patch of regrowth was mapped outside the Brigalow Belt South Bioregion, north of the Fitzroy River, and therefore does not meet the criteria of the TEC.	NA	NA
Marlborough blue (*Cycas ophiolitica*)	Not recorded during any of the field surveys however potential habitat may be available based on RE mapping	Eucalyptus woodland on metamorphics or granitic Fringing riparian woodland Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis*	30.6
Weeping Myall woodland TEC	Not recorded during any of the field surveys however potential habitat	*Eucalyptus populnea* woodland on alluvial floodplains	2.0

Species	Habitat Utilisation	Habitat Type/s	Approximate Area of Habitat (ha) in the Project Area
	may be available based on RE mapping		
Aquatic fauna			
Estuarine crocodile	Breeding/nesting, foraging and dispersal	Lacustrine or palustrine wetlands Riverine waterbodies	12.9
Fitzroy River turtle	Foraging and dispersal	Riverine waterways including 50 m buffer	10.8
White-throated snapping turtle	Foraging and dispersal	Riverine waterways including 50 m buffer	10.8
Terrestrial fauna			
Australasian bittern	Highly unlikely to occur in the Project Area	NA	NA
Australian painted snipe	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Grey-headed flying-fox	Foraging, opportunistic roosting and dispersal	Eucalyptus woodland on metamorphics or granitic Brigalow woodland *Eucalyptus populnea* woodland on alluvial floodplains Fringing riparian woodland Fringing riparian woodland with *Eucalyptus raveretiana* Eucalyptus woodland on alluvial floodplains	33.9

Species	Habitat Utilisation	Habitat Type/s	Approximate Area of Habitat (ha) in the Project Area
		Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis*	
Koala	Breeding, foraging and dispersal	Eucalyptus woodland on metamorphics or granitic Fringing riparian woodland Fringing riparian woodland with *Eucalyptus raveretiana* Eucalyptus woodland on alluvial floodplains Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis*	31.9
Ornamental snake	Breeding, foraging and dispersal	Lacustrine or palustrine wetlands Brigalow woodland Fringing riparian woodland Fringing riparian woodland with *Eucalyptus raveretiana* Riverine waterbody Eucalyptus woodland on alluvial floodplains Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis*	35.6
Squatter pigeon (southern)	Breeding, foraging, roosting and dispersal	Lacustrine or palustrine wetlands Eucalyptus woodland on alluvial floodplains Eucalyptus woodland on alluvial floodplains with *Eucalyptus tereticornis*	194.3

Species	Habitat Utilisation	Habitat Type/s	Approximate Area of Habitat (ha) in the Project Area
		Modified grasslands	
Migratory birds			
Black-tailed godwit	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Caspian tern	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands Riverine waterbodies	12.9
Common greenshank	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Common sandpiper	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Curlew sandpiper	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Eastern osprey	Breeding/nesting, foraging, roosting and dispersal	Lacustrine or palustrine wetlands Fringing riparian woodland Fringing riparian woodland with *Eucalyptus raveretiana* Riverine waterbodies	15.9
Glossy ibis	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands Fringing riparian woodland Fringing riparian woodland with *Eucalyptus raveretiana* Riverine waterbodies Modified grasslands	179.7

Species	Habitat Utilisation	Habitat Type/s	Approximate Area of Habitat (ha) in the Project Area
Latham's snipe	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Little curlew	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Little tern	Highly unlikely to occur in the Project Area	NA	NA
Marsh sandpiper	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Pectoral sandpiper	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Red-necked stint	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Sharp-tailed sandpiper	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
White-throated needletail	Aerial foraging and dispersal	All habitat types	210.5
White-winged black tern	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5
Wood sandpiper	Foraging, roosting and dispersal	Lacustrine or palustrine wetlands	9.5

Table 6-2 Summary of the condition of potential habitat in the Project Area for listed species with the potential to occur

Habitat types	Condition description	Relevant MNES
Lacustrine or palustrine wetland	The majority of the lacustrine and palustrine wetlands in the Project Area are highly variable in terms of their size, depth, bank profile, vegetative characteristics and surrounding land use, and as a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold. During the surveys (AECOM, 2020f; AECOM, 2020d; AECOM, 2020e), condition in the Project Area was poor due to the extent of clearing, grazing, weeds, drought conditions and water quality. At the time of the February 2019 survey (AECOM, 2020d), habitat values recorded in this community include cracking clays (although generally rare), as well as occasional hollow logs and woody debris especially in the adjacent fringing vegetation. In the fringing vegetation, large eucalypt canopy trees were also present with some bearing small hollows and providing nesting opportunities. Due to the historic thinning in riparian zones, weeds, ongoing cattle grazing and drought conditions this habitat was considered heavily impacted. At the time of the June 2019 survey (AECOM, 2020e), Pink Lily Lagoon was characterised by two pools up to 1.6 m with shallow sloping, black cracking clay banks. Riparian vegetation was limited to vegetated margins dominated by *Persicaria orientalis* and exotic *Urochloa mutica* (paragrass). No aquatic macrophytes were recorded. Snags and woody debris were limited to occasional inundated stags and fence posts. Periphyton (i.e. a complex mixture of algae, cyanobacteria, heterotrophic microbes, and detritus that is attached to submerged substrate) was observed in the water column. At the time of the June 2019 survey (AECOM, 2020e), Dunganweate Lagoon was characterised by a crescent shaped pool up to of 2.8 m with moderately sloping banks dominated by clay soils with occasional rocks or sand patches. Dense patches of the floating *Nelumbo nucifera* (lotus) covering < 10% of the lagoon and small amounts of ribbonweed (*Vallisneria* sp.) in shallow margins. Occasional woody debris primarily associated with a disused timber ramp. Algae and detritus were observed on and surrounding the woody debris and dense stands of macrophytes. At the time of the June 2019 survey (AECOM, 2020e), Nelson Lagoon was characterised by a small pool up to 1 m deep, with black cracking clays in shallow sloping banks and clay substrate. Heavily disturbed grazing habitat with vegetation dominated by open *Eucalyptus tereticornis* woodland. No aquatic macrophytes. Some woody debris is present in the form of narrow, inundated stags. At the time of the April 2019 survey (AECOM, 2020d), Lotus Lagoon was mostly dry with soil cracking uncommon but present in the fringes of some of the waterbodies. Adjacent riparian zones were heavily impacted, especially in the northern-most section with exotic grass prevalent. Grazing activity was ongoing in the west of this wetland.	Estuarine crocodile Australian painted snipe Ornamental snake Squatter pigeon Black-tailed godwit Caspian tern Common greenshank Common sandpiper Curlew sandpiper Eastern osprey Glossy ibis Latham's snipe Little curlew Marsh sandpiper Pectoral sandpiper Red-necked stint Sharp-tailed sandpiper White-throated needletail Wood sandpiper

Habitat types	Condition description	Relevant MNES
	At the time of the June 2019 survey (AECOM, 2020e), water quality was poor with elevated electrical conductivity values at all wetlands and elevated turbidity at Pink Lily Lagoon, with respect to the water quality objectives. At the time of the September 2019 survey (C&R Consulting, 2020), the guideline values were exceeded at Pink Lily, Nelson and Dunganweate Lagoons for electrical conductivity, at Pink Lily and Dunganweate Lagoons for pH and at both Pink Lily and Lotus Lagoons for suspended solids and turbidity.	
Riverine waterbody	During the June 2019 survey (AECOM, 2020e), the Fitzroy River was relatively saline, with dissolved oxygen % saturation and turbidity values outside of guidelines values. During the September 2019 survey (C&R Consulting, 2020), turbidity was also above guideline values. The Fitzroy River provides for connectivity within the Fitzroy River Barrage pool only. Condition in the Project Area (i.e. the crossing of the Fitzroy River) was moderate given the permanent availability of water and extensive riparian and overhanging vegetation but poor water quality and fragmentation due to the impoundment of the river by the Fitzroy River Barrage (noting is does have a fishway installed).	Estuarine crocodile Fitzroy River turtle White-throated snapping turtle Ornamental snake Caspian tern Eastern osprey Glossy ibis White-throated needletail
Brigalow woodland	Occurs as a fragmented patch in a significantly modified landscape with little connectivity with adjacent vegetation, and relatively low value within the context of the broader landscape. *Acacia harpophylla* was dominant in the tree layer with tree height 5 – 9 m with 74% crown cover. Exotic perennial plants comprise < 1% of the total vegetation cover and are mainly concentrated on the edges. A mature canopy layer was absent, and due to the age of trees present no hollows or deep crevices in the bark were present. Leaf litter was abundant however groundcovers were relatively low, with areas of bare ground common and microhabitat features such as coarse woody debris and decorticating bark absent. Condition in the Project Area is poor due to the fragmented and immature nature of the patch.	Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC Grey-headed flying-fox White-throated needletail
Fringing riparian woodland	At the time of the June 2019 survey (AECOM, 2020e), the Fitzroy River riparian woodland had well developed riparian areas on both banks, dominated by large native trees including *Eucalyptus tereticornis* (river red gum) and *Melaleuca leucadendra* (analogous with RE 11.11.25). On the southern bank the macrophyte community was dominated by the exotic species *Eichhornia crassipes, Hymenachne amplexicaulis* and *Salvinia molesta*. On the northern bank, macrophyte communities	Marlborough blue Grey-headed flying fox Koala Ornamental snake

Habitat types	Condition description	Relevant MNES
	were dominated by exotic species *Pistia stratiotes* and *Eichhornia crassipes.* The Fitzroy River is a permanently flowing waterway with connectivity within the Fitzroy River Barrage pool. At the time of the June 2019 survey (AECOM, 2020e), Limestone Creek was characterised by a series of large shallow pools separated in the dry season by dry cobbled reaches of varying width. The riparian has been historically cleared or thinned of native vegetation and subject to agricultural and land development practices, however, much of the riparian vegetation within the Project Area meets remnant status. The riparian vegetation was primarily open forest of *Melaleuca fluviatilis* (river tea tree) over *Casuarina cunninghamiana* (river she-oak) and exotic *Leucaena leucocephala* (leucaena). The riparian weed Ruellia simplex (Mexican petunia) was common in the ground layer. Condition in the Project Area is moderate due to the well developed riparian vegetation but dominance of exotic species is some parts.	Eastern osprey Glossy ibis White-throated needletail
Fringing riparian woodland with *Eucalyptus raveretiana*	Total of 63 black ironbox individuals and approximately 8.8 ha of suitable habitat. Black ironbox was the dominant canopy species in a narrow fringing riparian open forest along Limestone Creek. Other associated species in the canopy include *Melaleuca fluviatilis, Casuarina cunninghamiana* and *Corymbia clarksoniana.* The understorey was dominated by the weed species *Leucaena leucocephala* (leucaena), while the sparse to mid-dense groundcover was dominated by weedy grasses. Habitat values included fine litter in the ground cover, occasional fallen logs and hollows in trees. This community is analogous with RE 11.11.25a. Condition in the Project Area is poor due to abundant cover of leucaena, which may be limiting the recruitment potential of black ironbox.	Black ironbox (*Eucalyptus raveretiana*) Grey-headed flying fox Koala Ornamental snake Eastern osprey Glossy ibis White-throated needletail
Eucalyptus woodland on alluvial floodplains	Open woodland to low open woodland on alluvium and dominated by *Eucalyptus coolabah* in the canopy. RE 11.3.3 can also include a secondary tree or shrub layer may occur and can include *Eucalyptus. populnea, Melaleuca bracteata, Acacia stenophylla, Alectryon oleifolius, Terminalia oblongata, Acacia pendula, Acacia cambagei and Duma florulenta*. RE 11.3.3c can also include a sedge or grass understorey in back swamps and old channels, with ground layer dominated by a range of sedge or grass species depending on hydrological regime, soil and management conditions. Characteristic ground layer species include *Eleocharis* spp. or *Marsilea* spp. in more frequently inundated sites tending toward a grassy ground layer in less frequently flooded sites. During the April 2019 survey (AECOM, 2020d), scattered patches of this habitat occur across the Project Area on alluvial floodplains and included areas of high value regrowth RE 11.3.3. The shrub layer was generally sparse and predominately comprised of the weeds *Leucaena leucocephala* and *Cryptostegia grandiflora* (rubbervine). The ground layer was dense,	Grey-headed flying-fox Koala Ornamental snake Squatter pigeon (southern) White-throated needletail

Habitat types	Condition description	Relevant MNES
	largely dominated by introduced grasses, especially *Megathyrsus maximus* (Guinea grass). Disturbance across the habitat area was substantial, with historic clearing and thinning events as well as ongoing grazing evident. Key habitat values recorded in this community include fine litter in the ground cover, fallen logs and decorticating bark. Condition in the Project Area was poor due to the clearing, grazing and weeds.	
Eucalyptus woodland on alluvial floodplains *with Eucalyptus tereticornis*	Open woodland to low open woodland dominated by *Eucalyptus tereticornis* and/or Eucalyptus spp. in the canopy. RE 11.3.4 can also include *Eucalyptus camaldulensis, Corymbia tessellaris, Corymbia clarksoniana, Eucalyptus melanophloia, Eucalyptus platyphylla* or *Angophora floribunda.* A shrub layer is usually absent, and a grassy ground layer is prominent, and may include any of *Bothriochloa bladhii subsp. bladhii, Aristida spp., Heteropogon contortus, Dichanthium* spp. and *Themeda triandra*. During the April 2019 survey (AECOM, 2020d), scattered patches of this habitat occur across the Project Area on alluvial floodplains and included areas of high value regrowth and remnant RE 11.3.4. This habitat was described in combination with RE 11.3.3 (Eucalyptus woodland on alluvial floodplains) with the description provided above. Condition in the Project Area was poor due to the clearing, grazing and weeds.	Marlborough blue Grey-headed flying-fox Koala Ornamental snake Squatter pigeon (southern) White-throated needletail
Eucalyptus woodland on metamorphics or granitic	Woodland dominated by *Eucalyptus crebra* (narrow-leaved ironbark) and *Corymbia dallachiana* (Dallachy's gum) in the canopy layer (approximately 14 m height), located on deformed and metamorphosed sediments (analogous with RE 11.11.15). During the April 2019 survey (AECOM, 2020d), this habitat occurred in two areas adjacent to an industrial precinct north of the Fitzroy River. The shrub layer was relatively sparse and included *Acacia decora* (Western silver wattle), *Alphitonia excelsa* (soap tree) and *Vachellia bidwillii.* The ground layer was generally dense, dominated by native grasses such as *Themeda triandra* (kangaroo grass) and exotic species. Historical clearing has occurred in this habitat type, with trees in the T1 layer relatively young and unlikely to bear hollows in the immediate or near future. Habitat values included fallen logs, occasional course litter, decorticating bark and stones in the ground layer, mistletoe, small gullies and abundant cover of grass (> 70%). As it is connected to a larger tract of vegetation in a northward direction, this habitat may also provide dispersal opportunities for a variety of fauna species. Condition in the Project Area was good due to habitat availability, connectivity and limited weeds.	Marlborough blue Grey-headed flying fox Koala White-throated needletail
Modified grasslands	Non-remnant vegetation as a result of historical clearing and cattle grazing, which dominates the Project Area. During the April 2019 survey (AECOM, 2020d), vegetation within this habitat type varied and included isolated paddock trees and some riparian vegetation between lagoons and along drainage lines. The introduced pasture species *Cenchrus ciliaris* (buffel grass) dominates much of this community, although patches of native grass still exist in places. Habitat values	Squatter pigeon (southern) Glossy ibis

Habitat types	Condition description	Relevant MNES
	in this community were limited but included occasional tree hollows in riparian zones and high abundance of grass in the ground layer where grazing was restricted. Condition in the Project Area was poor due to the extensive clearing, grazing and weeds.	White-throated needletail

7. Potential Impacts, Risk Assessment and Mitigation

7.1 Mitigation and Management Approach

This section details the mitigation and management approach to minimise the potential negative direct and indirect impacts of the Project on the identified matters of national environmental significance (MNES) species and their habitat. The approach firstly avoids impacts through the design process, and secondly, where impacts are unavoidable, minimises the potential impacts through management actions.

7.1.1 Avoidance

Due to limitations associated with the proposed alignment in respect to other infrastructure (including airports and linking roads) and the extent of wetlands and fauna habitat in the landscape, completely avoiding all wetlands and all fauna habitats was not able to be achieved.

However, through alterations to the road design and limitations on construction, the Project has been able to avoid the mapped extent of Black Duck Lagoon (which provides habitat value for MNES fauna and migratory birds) and most of the brigalow (*Acacia harpophylla* dominant and co-dominant) TEC.

The Project is anticipated to result in the loss of approximately 0.3 ha of brigalow (*Acacia harpophylla* dominant and co-dominant) TEC within the Project Footprint. A no-go zone will be declared along the remaining extent of the brigalow TEC in the Project Area (approximately 1.6 ha) to protect the habitat during construction.

The Project is anticipated to impact eight *Eucalyptus raveretiana* (black ironbox) individuals within the Project Area. In the Project Area, the area to the south of the bridge over Limestone Creek is declared a no-go-zone, the area to the north of the bridge is to be actively rehabilitated.

To avoid impacts to the black ironbox and brigalow TECs during construction, no-go zones will be established, a suitably qualified botanist will survey, identify and mark (via high visibility flagging tape or similar) all black ironbox within the no-go zone and temporary exclusion fencing will be erected in accordance with AS4970-2009.

Dewatering may be undertaken in association with bridge construction if there is heavy rainfall during installation, or if groundwater or surface water is encountered in the area of excavation. Dewatering will be required for the Fitzroy River bridge and may be required for the near-permanent wetlands (i.e. northern Dunganweate Lagoon and Nelson Lagoon) and mitigation measures to minimise impacts are discussed in Section 7.1.2.3.

Where impacts to MNES fauna and fauna habitat such as wetlands are unavoidable, the mitigation measures focus on minimising impacts to fauna habitats to the greatest extent possible.

7.1.2 Minimising Impacts

The primary potential impact to MNES fauna and fauna habitat values is anticipated to be due to altered hydrology and water quality and vegetation clearing.

To minimise impacts to terrestrial fauna habitat, the road corridor width in fauna habitats and vegetation clearing requirements has been minimised to the greatest extent possible. This has been achieved by minimising the road width, steepening batter slopes and minimising construction widths at key locations.

The area (ha) of temporary (construction) and permanent (operation) impacts to the fauna habitat types as a result of the Project are detailed in Changes to Public Utility Plant to accommodate the Project, such as electricity and telecommunications infrastructure, are unlikely to impact MNES as works do not require clearing of or substantial excavation within MNES fauna habitat such as wetlands or vegetation (remnant regional ecosystems (REs) or high value regrowth). Works are mostly within the Project Area or within road reserves where they are outside of the Project Area.

Table 7-1 and Table 7-2. The temporary and permanent impact areas of each fauna habitat type are discussed in Section 6 and summarised in Table 6-1.

Where impacts to wetlands are unavoidable, bridges (rather than culverts) have been incorporated into the design at the wetlands. Bridges are considered to have the least impact to wetlands as they allow the local hydrology to be maintained, provide fauna passage under the bridge, and the footprint of the structure is limited to the piers, thereby minimising the total loss of wetland habitat. Bridges have been incorporated into the alignment at the following wetlands:

- Pink Lily
- Lotus Lagoon
- Dunganweate Lagoons
- Nelson Lagoon
- Black Duck Lagoon.

Changes to Public Utility Plant to accommodate the Project, such as electricity and telecommunications infrastructure, are unlikely to impact MNES as works do not require clearing of or substantial excavation within MNES fauna habitat such as wetlands or vegetation (remnant regional ecosystems (REs) or high value regrowth). Works are mostly within the Project Area or within road reserves where they are outside of the Project Area.

Table 7-1 Temporary impact area of each fauna habitat type in the Project Area

Habitat Type	Impact Area (ha)
Eucalyptus woodland on alluvial floodplains	0.3
Eucalyptus woodland on alluvial floodplains *with Eucalyptus tereticornis*	20.7
Lacustrine wetland or palustrine wetland	9.5
Riverine waterbody	3.3
Fringing riparian woodland	2.0
Fringing riparian woodland with *Eucalyptus raveretiana*	1.0
Eucalyptus woodland on metamorphics or granitic	7.9
Brigalow woodland	1.9
Modified grasslands	163.8
Total	**210.5**

Table 7-2 Permanent impact area of each fauna habitat type in the Project Footprint

Habitat Type	Impact Area (ha)
Eucalyptus woodland on alluvial floodplains	0.1
Eucalyptus woodland on alluvial floodplains *with Eucalyptus tereticornis*	9.0
Lacustrine wetland or palustrine wetland	2.4
Riverine waterbody	0.9

Habitat Type	Impact Area (ha)
Fringing riparian woodland	0.5
Fringing riparian woodland with *Eucalyptus raveretiana*	0.3
Eucalyptus woodland on metamorphics or granitic	3.5
Brigalow woodland	0.3
Modified grasslands	90.2
Total	**107.2**

7.1.2.1 Hydraulics and Hydrology

7.1.2.1.1 Wetlands

The construction and operation of the Project has the potential to modify the hydraulic function of the wetlands within and adjacent to the Project Area, therefore it is important that changes to the hydrological characteristics of the landscape do not negatively impact the wetland connectivity and undermine ecosystem health.

A hydraulic model has been developed to assess wetland connectivity and modification of the hydrologic regime of the wetlands/lagoons during the operation of the Project, the result of which are further detailed in the Technical Note – Hydraulics of Wetland Connectivity (Jacobs SMEC Design Joint Venture, 2021b) and summarised below.

The model results present the end of flood afflux, which is defined as the drained water surface or ponded extent left across the floodplain in the Design Case (i.e. with the Project) less that in the Base Case (i.e. with no Project) post-flood. Positive values indicate locations where the Project has modified minor flow paths to terminal lagoons (terminal lagoons are lagoons at the end of flow paths). Negative values indicate locations where water is diverted away from lagoons.

The end of flood afflux maps represents the final results of an iterative process between the road designers and the environment team that has required the inclusion of additional targeted flood mitigation structures and design alterations to maintain the hydraulic connectivity of the wetlands to maintain ecosystem function.

The initial model results demonstrated that without the targeted flood mitigation structures, several hundred millimetres of afflux would be expected in Murray Lagoon, Crescent Lagoon, Pink Lily Lagoon and disruption to connectivity in Lotus Lagoon. Most notably, initial model results demonstrated approximately 1.4 m of additional afflux in Crescent Lagoon during the 86.5% annual exceedance probability (AEP) event (which is a fairly minor event), when flows are not sufficient to spill into (the terminal) Murray Lagoon.

Several mitigation measures were incorporated in the design including:

- Three new banks of culverts under the embankment of the highway south of the bridge over Nelson Lagoon and Dunganweate Lagoons, including 9/1050 mm diametre reinforced concrete pipes, 9/1200mm x 900mm slab link box culverts and 9/1500mm x 900mm slab link box culverts
- 900 mm diameter reinforced concrete pipe culvert at Lotus Lagoon
- Steepening of the north embankment slope where Lotus Lagoon overflows into Pink Lilly Lagoon to allow for increased water flow and drainage
- In total, 18 bridges spanning approximately 7 km have been incorporated into the design to mitigate potential impacts associated with altered hydrology, along with cross-drainage culverts
- The Rockhampton Airport Channel is located outside of the Project Area and will also mitigate impacts by facilitating flows to Murray Lagoon thereby reducing any potential changes to hydrology associated with the road impeded flow in that area.

The results of the hydraulic modelling demonstrate that the flood mitigation measures incorporated into the design has generally maintained the hydraulic connectivity of the wetlands in the Project Area.

Although there remain a few areas of minor afflux to some locations, these areas result in less than 100 mm of flood level change, with most locations being much less than this, and this is considered to be a minor change which will have negligible effect on the overall function of wetlands. Further equalisation of flood waters in these areas (to achieve a 0 mm flood water change) are considered to be impractical and the flood level differences are very minor.

Whilst the hydraulic model developed is validated to ensure it is an appropriate tool for its purpose, being the detailed design of the Rockhampton Ring Road in accordance with the Functional Specification (Queensland Government Department of Transport and Main Roads, 2020c), there are limitations to any model, which are detailed in the Technical Note – Hydraulics of Wetland Connectivity (Jacobs SMEC Design Joint Venture, 2021d). The main limitation relevant to wetland connectivity is that not all elements of the hydrological (water) cycle are accounted for in a surface water model, particularly evaporation and groundwater interactions/recharge.

Evaporation is likely to have the largest influence on water level once the water has stopped flowing as this is when the water is more likely to be warmed by the sun to a point where it starts to evaporate. Groundwater recharge is likely to be higher once the water has stopped flowing as the process involves water slowly percolating downwards through microscopic spaces in the underlying soil and rock under gravitational pressure, where the soil is saturated with some porosity.

In summary, the afflux values presented by the model are a conservative approximation of post flood wetland conditions while the water is flowing (i.e. at the peak of the flood event and until flow substantially reduces or stops), as processes such as evaporation and groundwater recharge are likely to have more of an influence on water level once flow has substantially reduced or stopped (provided there is heating by the sun and soil porosity respectively).

During construction, some temporary changes to wetland hydrology may be experienced due to construction access tracks and crossings. Potential impacts will be temporary in nature are mitigated by the low flood immunity of the temporary roads and tracks (i.e. overtopping on low flow events) and the inclusion of cross-culverts in low flow channels. Following completion of construction, temporary access tracks and crossings will be removed and the area will be rehabilitated.

7.1.2.1.2 Waterways

The Project is not predicted to alter hydrology in waterways that may provide foraging habitat for MNES (Jacobs SMEC Design Joint Venture, 2021d), that is the Fitzroy River and marginal habitat in Limestone Creek subject to water levels.

The crossing of the Fitzroy River is a multi-span bridge over a large permanent waterway within the Fitzroy Barrage inundation pool, and no changes to hydrology are predicted.

The crossing of Limestone Creek is a bridge over an ephemeral waterway with cobbled sections that may provide pool and riffle habitat following rain. The modelling predicts increased water levels at the peak of a 10% AEP flood on the eastern bank upstream of the bridge, however for the end-of-flood hydrology (after a 10% AEP Limestone Creek flood passes down Limestone Creek) there are pools left in the creek bed under the bridge and the level and extent of the pool remains unchanged from the base case (i.e. without the road development), that is the Project is not predicted to change the water levels or likely extent of riffles in this waterway.

During construction, some temporary changes to wetland hydrology may be experienced due to construction access tracks and crossings. Potential impacts will be temporary in nature are mitigated by the low flood immunity of the temporary roads and tracks (i.e. overtopping on low flow events) and the inclusion of cross-culverts in low flow channels. Following completion of construction, temporary access tracks and crossings will be removed and the area will be rehabilitated.

7.1.2.1.3 Scour and the Potential for Erosion and Sedimentation

The Project Area is a floodplain environment with bridges incorporated to maintain existing flow conditions thereby reducing afflux, and reducing velocities and the potential for scour, erosion and sedimentation.

The hydraulic model assessed 13 locations across the Project Area to determine if floods of particular sizes are expected to bring about scouring and the potential for erosion and sedimentation. The modelled velocity at 10 of the 13 sites was 0 m/s even in the large flood events, and at the absolute peak localised velocities were all <0.6 m/s. A velocity of 0.6 m/s is unlikely to cause substantial erosion of most soil types, with maximum mean velocities of up to 3 m/s considered safe against erosion for average alluvial soil and up to 5 m/s considered safe against erosion for stiff clays (Etcheverry, 1915). That is, these particles are bound together and of the velocity is not high enough to initiative the scour so erosion will not eventuate.

There are areas of dispersive soils in the Project Area, which are defined as being subject to a process by which clay particles are repelled by electrostatic forces and mechanical forces and separate from each other forming a suspension of clay particles in water. Dispersive soils are prone to gully erosion and tunneling (i.e. air voids occur where not compacted during construction and water can easily enter these voids causing dispersion of the surrounding soil and small ‘pipes’ can form which quickly develop into ‘tunnels’). Like most soils, erosion is more likely where soils are bare (i.e. not covered with vegetation) and sloping. Dispersive clays in the Project Area are on a relatively flat floodplain and mostly vegetated with relatively dense grasses, and while these soils do have the potential for erosion, erosion is unlikely to be substantial given the dense vegetative cover and flat landscape and that all bare surfaces will be rehabilitated as soon as possible. Gully or tunnel erosion is currently not evident across the floodplain.

Smaller, more frequent, flood events are likely to have localised erosion values at the bridges far less than the long duration 1% AEP Fitzroy River breakout events (greater than 9 days floodplain inundation) tabled in the hydraulic assessment report. In areas of the floodplain with stiff clays (the lagoon areas), particles are bound together (cohesive) and frequent flood velocities are not high enough and flood depths are not deep enough to initiate scour of the bed. Erosion will not eventuate.

7.1.2.1.4 Flooding

As discussed in Section 7.1.2.1.1, the initial hydraulic model results demonstrated that without the targeted flood mitigation structures, several hundred millimetres of afflux would be expected in floodplain wetlands. Several mitigation measures were incorporated in the design including 18 bridges, numerous culverts, steepening of the north embankment slope where Lotus Lagoon overflows into Pink Lilly Lagoon to allow for increased water flow and drainage, and the Rockhampton Airport Channel.

The results of the hydraulic modelling demonstrate that the flood mitigation measures incorporated into the design has generally prevented flooding in the Project Area to a 1% AEP event. There are a few areas of minor afflux to some locations, these areas result in less than 100 mm of flood level change, with most locations being much less than this. Further equalisation of flood waters in these areas (to achieve a 0mm flood water change) are considered to be impractical and the flood level differences are very minor.

As discussed in Section 4.2.1 the hydraulic assessment also shows that the Rockhampton Ring Road and Rockhampton Connector Road have an immunity of no less than a 1% AEP flood event. Local road connections have lower flood immunity. The Project is unlikely to substantially impact the flood immunity or flooding of roads in the vicinity of the Project.

7.1.2.1.5 Changes to Water Table Levels

Changes to water table levels are not expected in association with altered surface hydrology, given hydraulic modelling does not predict substantial changes to surface hydrology.

There may be minor and reversible changes to groundwater levels associated with dewatering during construction, as discussed in Section 7.1.2.3.1. In the unlikely event that there are changes to groundwater levels, changes are likely to be localised given the relatively shallow depth, small lateral extent and the short duration of excavation. The floodplain wetland mosaic is essentially sustained by surface flows and surface-related flows infiltrating the shallow subsurface zones of the alluvial sediments (C&R Consulting, 2020), and recharged by rainfall. The groundwater systems of the Project Area are therefore likely to recover relatively quickly compared to activities that are extracting large volumes of water for long durations from confined aquifers (i.e. underground water that is overlain by a low permeability layer, so it does not receive direct vertical recharge and is less responsive to surface conditions), Water in the Great Artesian Basin for example can takes thousands of years to flow from the intake beds along the Great Dividing Range and eastern Carpentaria (Queensland Government Department of Environment and Science, 2020c)

In summary, water table levels are unlikely to be substantially changed by altered surface or groundwater hydrology associated with the Project.

7.1.2.2 Water Quality

During the construction phase, vegetation clearing, construction of haul routes and access tracks, and bulk earthworks have the potential to negatively impact the water quality of wetlands and waterways including:

- Reduced water quality from point and non-point sources such as concentrated potential contaminants from impervious surfaces including nutrients, hydrocarbons and metals, sediment from exposed soils and stockpiles, and increases in erosion and sedimentation
- Stratification of temperature, dissolved oxygen and nutrients in the water column
- Changes to soil chemistry including exposure of acid sulfate soils
- Increased aquatic weeds, which can reduce oxygen levels in the water column overnight
- Potential salinization of wetlands and waterways as a result of rising water tables from vegetation clearing.

Localised impacts to water quality may occur during periods of high rainfall, particularly during works on creek and wetland crossings, bridges and associated temporary structures.

Sediment and suspended solids can have substantial ecological impacts. Water with a high level of sediment restricts plant respiration and can influence feed behaviour of animals (negatively and positively). Nutrients can lead to increased risk of eutrophication and algal blooms, which can in turn reduce oxygen levels. Freshwater turtles are likely to be sensitive to water quality, particularly oxygen levels.

Fuel and/or chemical spills may arise from construction vehicles carrying fuels and/or chemicals. These contaminants have the potential to directly enter waters of the Project Area and negatively impact habitat and aquatic fauna.

Groundwater quantity and quality can be impacted by reduced recharge and introduction of contaminants. Hardening of the Project Footprint has the potential to reduce groundwater recharge along the alignment. Contaminants may be introduced through contamination of surface waters. The impacts to MNES from the alteration of groundwater quality are equivalent to the impacts associated with the alteration to surface water quality discussed above.

Impacts to water quality have been minimised by:

- reducing the extent of clearing
- rehabilitating all cleared areas within the Project Area (but outside of the Project Footprint)
- capturing runoff in sediment basins for treatment prior to release.

The surface water and groundwater sampling program involves baseline monitoring to establish existing water quality conditions, by recording and analysing parameters associated with potential impacts to MNES. The Environmental Management Plan (Appendix A) provides sub plans for Erosion and Sediment Control, Groundwater and Surface Water, Weed and Pest, and Landscape and Revegetation, which provide objectives, performance criteria, management strategies, training, monitoring, reporting, responsibilities, timing and corrective action. Potential impacts to each MNES associated with water quality are discussed in section 7.2.

7.1.2.2.1 Pavement Runoff

During the operational phase, the main risk to the receiving waters intersected by the Project, that provide habitat for MNES, is increased pavement runoff associated with the new road surface area. There may be adverse environmental impacts caused by introduction and concentration of pollutants from the new road surface.

Contaminants created or deposited by vehicles may become suspended in runoff and drainage waters. Typical road contaminants include sediment, heavy metals, hydrocarbons, pesticides, and biological material such as faecal matter and seed (from the transportation of livestock). Deposition of contaminated runoff can affect wetland communities and waterways.

When dissolved in the water, heavy metals and nutrients can lead to increased risk of eutrophication and algal blooms. Floating oil residues are also a common road pollutant and can impact the oxygenation of the water column needed for the respiration of aquatic fauna including freshwater turtles. Reduced biodiversity in wetland systems can result in trophic cascades which impacts the overall ability of ecosystems to function.

Fuel and/or chemical spills may arise from vehicles carrying fuels and/or chemicals. These contaminants have the potential to directly enter the receiving environment and negatively impact the surrounding habitat and individual fauna.

The water sampling program involved baseline monitoring to establish existing water quality conditions, by recording and analysing parameters associated with potential impacts to MNES.

The Project has developed a Water Quality Strategy (Jacobs SMEC Design Joint Venture, 2021e) which requires varying approaches due to the sensitivity of the receiving environment and the constraints associated with each zone. The strategy adopted for each zone aims to mitigate adverse environmental impacts caused by introduction and concentration of pollutants from the new road surface.

In locations where bridges pass over waterways and wetlands, the intent is for runoff to be collected in scuppers (i.e. an outlet on a bridge to drain water from the bridge surface) and along longitudinal drainage pipes connected to the bridge deck and discharged outside of waterways and wetlands. Where possible, these pipes will outlet directly to bioretention basins. Where this is not feasible due to the extents of flood inundation along the road corridor, or constraints associated with the bridge length and grade, the pipes will outlet outside of the wetlands. For lengths of bridges that do not cross a wetland or road, runoff will be captured by scuppers and outlet directly to the ground.

A range of water quality control devices have been incorporated into the design to minimise the potential impact of the Project on the receiving waters and include the following:

- Inlet sediment basin are provided at all bioretention basins. An inlet pond to bioretention basin system is designed to remove coarse sediment, allow for high flow to bypass the bioretention filter media, provide appropriate storage for coarse sediment, regulate flows entering filter media and also capture any spill on road. Low flows from the sediment basin discharge through to the bioretention basin.
- Bioretention basins have been provided at the bridge drainage outlet locations at wetlands and waterways. Bioretention basins are effective at removing litter, fine sediment, phosphorus, nitrogen, metal and hydrocarbons from stormwater. Bioretention basins also help in managing urban hydrology, particularly frequent stormwater flow. Bioretention basins have the advantage of additional storage capacity and therefore are less likely to be exposed to high velocities that can occur in a bioretention swale. Lining the filter area encourages additional storage in the filtration zone and further aids the filtration process.
- Bioretention swales are a type of bioretention system that both treats and convey stormwater and require less width compared to the bioretention basins. A bioretention swale is comprised of all the main components of a bioretention system co-located within the base of a swale.
- Grassed-lined swales are provided at roundabouts to convey longitudinal flow along the road where sufficient grade is available. Swales provides both a flow conveyance function and water quality treatment through sedimentation and contact of flowing with swale vegetation.
- Buffer strips along embankments.

A summary of the results for each wetland and waterway is presented below with further information regarding the water quality modelling is contained in the Water Quality Modelling Report (Jacobs SMEC Design Joint Venture, 2021g) contained in Appendix B.

The load-based pollutant reduction targets water quality objectives adopted on this project are from the State Planning Policy 2017. These treatment objectives for stormwater are expressed in mean annual reductions of pollutant loads from typical urban areas with no urban stormwater treatments installed. Where the targets are stated as 'marginally achieved', these are within 10% for total suspended solids, 10% for total phosphorus, 15% for total nitrogen and 10% for gross pollutant. Results within this margin would demonstrate that the infrastructure in place is providing the desired benefit to the downstream receiving environment and within the margin of accuracy for the MUSIC model results.

Pink Lily Lagoon

Table 7-3 summarises the results of the MUSIC (Model for Urban Stormwater Improvement Conceptualisation) modelling and compliance with the water quality objective targets for Pink Lily Lagoon. Results indicate that total phosphorus and gross pollutants load reductions have achieved the load reduction target values. However, total suspended solids and total nitrogen load reduction targets are marginally achieved as they are 96% and 88% of the target value, respectively. A significant length of road is located in close proximity to Pink Lily Lagoon where it is not possible to provide any grassed swale or water treatment for stormwater flow from the road batters due to availability of space within the corridor (i.e. at the Rockhampton connector roundabout). In addition, the flat topography also poses a constraint to diverting flow from these areas to basins for treatment. This area also has flood immunity constraints which limit the provision of any treatment device. Buffer strips are provided to treat sheet flow, which is not effective in treating total nitrogen. This constraint was the main reason of marginally achieving total nitrogen target.

Table 7-3 Treatment Effectiveness – Pink Lily Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets Water Quality Objectives	% Load Reduction	Compliance with Water Quality Objectives Target
Total suspended solid	9200	1650	85	82	Load reduction target marginally achieved
Total phosphorus	15.7	5.83	60	63	Load reduction target achieved
Total nitrogen	60.3	36.5	45	40	Load reduction target marginally achieved
Gross pollutant	466	19.1	90	96	Load reduction target achieved

Lotus Lagoon

Table 7-4 summarises the results of MUSIC modelling and compliance with the water quality objective targets for Lotus Lagoon area. Results indicate that total suspended solids and total phosphorus load reductions are fully achieved. However, total nitrogen load reduction targets are marginally achieved, and gross pollutant targets are not achieved. Although eight bioretention basins/bioretention swales are provided for the water quality treatment for the stormwater from the bridges, Lotus Lagoon has significant extents on either side of the proposed road between bridges which is not suitable for grassed swales or other treatment devices due to flat gradients. These constraints precluded the design from not fully complying with the total nitrogen and gross pollutant water quality objective targets.

Table 7-4 Treatment Effectiveness – Lotus Lagoon

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets Water Quality Objectives	% Load Reduction	Compliance with Water Quality Objectives Target
Total suspended solid	6530	974	85	85	Load reduction target achieved
Total phosphorus	12.6	4.48	60	62	Load reduction target achieved
Total nitrogen	58.3	36.2	45	38	Load reduction target marginally achieved
Gross pollutant	564	296	90	48	Load reduction target not achieved

Dunganweate Lagoon

Table 7-5 summarises the results of the MUSIC modelling and compliance with the water quality objective targets for Dunganweate Lagoons. Results indicate that total suspended solids, total phosphorus, total nitrogen and gross pollutant load reductions exceed the water quality objective targets. A bio-basin is provided for treatment of stormwater from the bridge area, which will drain into high ecological significance areas of Nelson Lagoon. However, the middle section of the bridge will drain away from the high ecological significance area and therefore was excluded from the modelling.

Table 7-5 Treatment Effectiveness – Dunganweate Lagoons

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets Water Quality Objectives	% Load Reduction	Compliance with Water Quality Objectives Target
Total suspended solid	1770	217	85	88	Load reduction target achieved
Total phosphorus	2.99	0.909	60	70	Load reduction target achieved
Total nitrogen	10.8	5.53	45	49	Load reduction target achieved
Gross pollutant	92.3	0	90	100	Load reduction target achieved

Nelson Lagoon

Table 7-6 summarises the results of MUSIC modelling and compliance with the water quality objective targets for Nelson Lagoon. Results indicate that total suspended solids, total phosphorus, total nitrogen and gross pollutant load reductions are above the load reduction target values and therefore comply with the water quality objective targets

Table 7-6 Treatment Effectiveness – Nelson Lagoons

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets Water Quality Objectives	% Load Reduction	Compliance with Water Quality Objectives Target
Total suspended solid	1380	96	85	93	Load reduction target achieved
Total phosphorus	2.25	0.512	60	77	Load reduction target achieved
Total nitrogen	7.53	3.59	45	52	Load reduction target achieved
Gross pollutant	81.8	0	90	100	Load reduction target achieved

Fitzroy River

Table 7-7 summarises the results of MUSIC modelling and compliance to the water quality objective targets. Two bioretention basins are provided for treatment of stormwater from the bridge area. Results indicate that total suspended solids, total phosphorus, total nitrogen and gross pollutant load reductions are above the required load reduction target values. This means the stormwater treatment complied with the water quality objective targets.

Table 7-7 Treatment Effectiveness – Fitzroy River

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets Water Quality Objectives	% Load Reduction	Compliance with Water Quality Objectives Target
Total suspended solid	5450	776	85	86	Load reduction target achieved
Total phosphorus	8.62	2.62	60	70	Load reduction target achieved
Total nitrogen	30.3	15.8	45	48	Load reduction target achieved
Gross pollutant	293	0	90	100	Load reduction target achieved

Limestone Creek

Table 7-8 summarises the results of MUSIC modelling and compliance to the water quality objective targets for Limestone Creek. Results indicate that total suspended solids, total phosphorus and total nitrogen load reductions have achieved the load reduction target values. However, gross pollutant load reduction targets are above 90% of the target value, which can be considered marginally achieved. Some part of the road has only buffer strips for the treatment of stormwater sheet flow due to the terrain constraint which is not effective in treating gross pollutant.

Table 7-8 Treatment Effectiveness – Limestone Creek

Parameter	Load Sources (kg/yr)	Residual Load (kg/yr)	% Load Reduction Targets Water Quality Objectives	% Load Reduction	Compliance with Water Quality Objectives Target
Total suspended solid	2360	225	85	90	Load reduction target achieved
Total phosphorus	3.77	1.0	60	73	Load reduction target achieved
Total nitrogen	12.3	5.85	45	52	Load reduction target achieved
Gross pollutant	135	24.3	90	82	Load reduction target marginally achieved

7.1.2.3 Dewatering

Groundwater is water that is underground and saturates soil and fills spaces in rock. Groundwater may flow underground and naturally re-surface at different locations, such as springs, wetlands or waterways. It supports important ecological components and processes, including:

- groundwater dependent ecosystems such as plants with roots that access groundwater,
- intermittent waterways where groundwater flow can reduce the duration of non-flowing periods, preserve pools of water at the surface, and maintain carbon and nutrient recycling in the bed sediment, and
- support biodiversity and ecological processes under waterways (Australian Government Department of Environment and Energy, 2018).

Any activity that extracts groundwater may cause groundwater drawdown (i.e. change in groundwater level due to an applied stress), which can have important ecological consequences.

The Construction Groundwater and Surface Water Sub Plan and MNES Flora and Fauna Sub Plan outlines performance criteria and management measures for dewatering (Appendix A). A groundwater conceptual model is being developed and groundwater baseline monitoring is underway, both of which will be used to refine dewatering requirements and further minimise impacts during construction.

7.1.2.3.1 Hydrology

Dewatering will be avoided wherever possible however as discussed in Section 4.3.4:

- Surface water will be abstracted for the construction of the Fitzroy River bridge and may be abstracted for the more permanent wetlands (i.e. north Dunganweate Lagoon and Nelson Lagoon) or following heavy rainfall.
- Dewatering to 2 m is unlikely to encounter groundwater at most locations at most times of the year based on Project data (current baseline sampling and sampling by C & R Consulting in September 2019), long term groundwater data available for the southern floodplain (data collected by Fulton Hogan from 2019 to 2021), and a regional assessment (Pearce & Hansen, 2006). Groundwater levels typically sit at least 5 m below the ground surface.

If required, dewatering is anticipated to be limited to an excavation depth of up to 2 m below ground level and a lateral extent ranging from approximately 15 x 23 m to approximately 20 x 8 m (depending on the containment method) over a duration of approximately 6 weeks per pier and a total estimated construction duration of approximately three years.

In the unlikely event that there are changes to groundwater levels, changes are likely to be localised given the relatively shallow depth, small lateral extent and the short duration of excavation. The floodplain wetland mosaic is essentially sustained by surface flows and surface-related flows infiltrating the shallow subsurface zones of the alluvial sediments (C&R Consulting, 2020), and recharged by rainfall. The groundwater systems of the Project Area are therefore likely to recover relatively quickly compared to activities that are extracting large volumes of water for long durations from confined aquifers (i.e. underground water that is overlain by a low permeability layer, so it does not receive direct vertical recharge and is less responsive to surface conditions) that can take tens to hundreds of years to replenish (e.g. the Great Artesian Basin). Dewatering is unlikely to substantially impact surface water, groundwater or wetland hydrology.

7.1.2.3.2 Water Quality

Dewatering of surface water will be required for installation of the pile caps for the Fitzroy River bridge and groundwater and/or surface water is more likely to be encountered in association with near-permanent wetlands (i.e. northern Dunganweate Lagoon and Nelson Lagoon). Dewatering may also be required where smaller ephemeral waterways or wetlands are holding water or following heavy rainfall. Where dewatering of surface water is required, impacts will be minimised by the relatively shallow depth (<2 m) and small area (15 x 17 m or 20 x 8 m depending on the containment method) to be excavated, and the short duration of dewatering (<6 weeks). Dewatering could impact water quality where suspended sediments and/or other potential contaminants are introduced to receiving waters.

Where dewatering is required, impacts to MNES will be minimised by capturing water in sediment basins for treatment prior to releasing to the receiving environment where within nominated Surface Water Quality Investigation Criteria identified in the Environmental Management Plan, or where practical for use as dust suppression or construction water.

Construction of the Fitzroy River bridge will require dewatering to install the piles and pile caps. Dewatering for the Fitzroy River bridge will be undertaken using a floating platform and water will be released back to the Fitzroy River. Dewatering from this relatively small area of the Fitzroy River into the large and permanently flowing Fitzroy River for a relatively short period of time (approximately 6 weeks per pier) is unlikely to impact water quality given the source water is the same as the receiving water and the water is relatively turbid compared to the Environmental Protection (Water) Policy 2009 water quality objective value of 50 NTU. Turbidity was 173.3 NTU during the June 2019 survey (AECOM, 2020e) and 75.86 NTU-field, 80.4 NTU-lab during the September 2019 survey (C&R Consulting, 2020).

Dewatering for construction of the floodplain bridges will be avoided, however may be required following heavy rainfall or where groundwater of surface water is encountered. Dewatering to 2 m is unlikely to encounter groundwater and surface water is unlikely to be encountered where works are undertaken outside of the wet season given the ephemeral nature of the waterways and most wetlands. Watering will be captured in a sediment pond for treatment.

Bridges in the north are unlikely to require dewatering as the pile caps sit above the groundwater level and dewatering would only be required following a heavy rainfall.

Further details including management measure, monitoring and reporting are provided in the Construction Groundwater and Surface Water Sub Plan in the Environmental Management Plan (Appendix A).

7.1.2.4 Acid Sulfate Soils

Disturbance of acid sulfate soils can generate sulfuric acid, iron, aluminium and sometimes heavy metals, which can cause impacts to the environment.

Acidic water can kill plants together with fish and other aquatic fauna if they are unable to move away from the acidity. Lower levels of acidity can weaken aquatic plants and fauna and make them more vulnerable to disease and interfere with maturation and over time sensitive species may be replaced by stronger and acid-tolerant invaders, e.g. mosquitoes (Queensland Government, 2019).

Iron is not toxic, however iron precipitates out of acid-sulfate-affected surface water forming an orange scum that smothers vegetation and can move downstream and bring about toxic algal blooms. Aluminium is a very common element and safe when bound in rocks and soil, however it can be environmentally harmful when released into water due to the disturbance of acid sulfate soils. Aluminium hydroxide compounds are toxic to fish as they affect gills and their ability to absorb oxygen and aluminium ions can reduce plant growth and damage root systems. Acid interacting with soil can also release any other metals and many elements that are stable at neutral pH become mobile under acidic conditions, and can be toxic to plants and/or animals, e.g. arsenic, zinc, lead and manganese (Queensland Government, 2019).

The Construction Acid Sulfate Soil Sub Plan within the Environmental Management Plan (Appendix A), outlines management measures should acid sulfate soil be present within the Project Area, including:

- The potential for ASS to be present within the Project Area should be determined by utilising the Atlas of Australian Acid Sulfate Soils mapping, accessed via the Australian Soil Resource Information System
- If the Australian Acid Sulfate Soils mapping identifies the potential for ASS to be present within the Project Area, the presence of ASS should be field-verified. Field testing and sampling shall be undertaken in accordance with the Queensland Acid Sulfate Soil Technical Manual (QASST Manual) (Ahern, et al., 2014)
- If the field-verification confirms the presence of ASS within the Project Area, the Contractor is to prepare an ASS Management Plan in accordance with QASST Manual (Ahern, et al., 2014) that, as a minimum, addresses the following:
    - Liming rates for treatment of ASS
    - The location of treatment of ASS
    - Measures to contain material stockpiled for treatment
    - Measures to collect and treat acidic runoff from stockpiled material
    - Verification testing requirements
    - Location of disposal of treated material
- If ASS or Potential Acid Sulfate Soils (PASS) are observed during construction, and an ASS Management Plan has not been developed, the Contractor is to develop an ASS Management Plan
- The Contractor's Environmental Management Plan (Construction) shall address the requirements of MRTS04 General Earthworks including the requirements concerning the management of ASS and PASS
- All material used in the works must be free of ASS/PASS
- ASS/PASS material must not be used in the construction of bunds and other diversion devices
- ASS/PASS treatment and management must be undertaken by a suitably qualified professional
- Stockpiled areas for ASS/PASS treatment must be clearly marked on drawings and signed to avoid dumping in incorrect areas
- Any treatment undertaken will be carried out on prepared pads, not in situ and interactions with groundwater and surface waters avoided
- All stockpiled areas for ASS treatment are to be bunded and drained to collection ponds
- Runoff from stockpiled material will only be discharged upon meeting acceptable water quality criteria (as per Construction Groundwater and Surface Water Sub Plan of the Environmental Management Plan).

7.1.3 Management Plans

An Environmental Management Plan (Appendix A) has been developed to minimise and manage impacts to MNES confirmed present during the field surveys or which have been assessed as having an elevated likelihood of occurrence within the Project Area. The following sub plans have been developed:

- MNES Flora and Fauna
- Erosion and Sediment Control
- Groundwater and Surface Water
- Acid Sulfate Soils
- Weed and Pest
- Landscape and Revegetation.

7.2 Potential Impacts and Mitigation

7.2.1 Flora

This section includes potential impacts to MNES flora associated with construction and operational phase activities and key mitigation measures. The Environmental Management Plan (Appendix A) provides a full list of mitigation measures together with performance criteria and information regarding training, monitoring, reporting, responsibility, timing and corrective actions for each sub plan listed in Section 7.1.3, and is designed to inform the Environmental Management Plan (Construction) to be developed by the construction Contractor.

7.2.1.1 Construction Phase

7.2.1.1.1 Direct Temporary Loss of Habitat from Vegetation Clearing, Bulk Earthworks and Habitat Fragmentation

A small area of suitable black ironbox (*Eucalyptus raveretiana)* habitat, including several mature trees, will be temporarily lost along the northern side of the bridge across Limestone Creek, however it will be actively rehabilitated following completion of construction. The Project is likely to physically fragment the existing black ironbox population in Limestone Creek, particularly during the construction phase (due to the potential construction of access tracks and other supporting infrastructure), however the area will be rehabilitated and given this species disperses seeds through the waterway there will be no long term impacts to genetic connectivity. The area of black ironbox to the south of the bridge across Limestone Creek will also be declared a no-go zone and will not be cleared and will contribute to recovery of the cleared area north of the bridge.

The Project will result in the loss of a small patch of the brigalow (*Acacia harpophylla* dominant and co-dominant) TEC within the Project Footprint, however most of this TEC with the Project Area is outside of the Project Footprint and will be protected by a no-go zone. The Project is not likely to fragment the brigalow TEC as the relatively small area to be lost is on the northern margin of the community and the community will be connected to the tributary to the south and to the Fitzroy River and into several tributaries. *Acacia harpophylla* is also known to naturally rehabilitate following disturbance as the primary reproduction mode is shooting profusely from lateral roots (suckering) (Peeters & Butler, 2014).

Key mitigation measures include clear demarcation of no-go zones and active rehabilitation of black ironbox (and rehabilitation of all flora) outside of the Project Footprint (Figure 4-4, Figure 4-5).

7.2.1.1.2 Indirect and Facilitated Degradation of Habitat via the Introduction and/or Spread of Invasive Weeds or Pathogens

The movement and transport of machinery, vehicles and equipment that are contaminated with weed seed is a source of spreading invasive weeds from infested areas to weed free locations or areas with minimal infestations. This form of spread has the potential to move pest plant's reproductive material over long distances from the original source or a core infestation area. Without treatment, new weed infestations can quickly spread beyond controllable methods.

Construction activities may introduce new weed species to black ironbox habitat at Limestone Creek however the quality of habitat within and adjacent to the Project Area is degraded due to an infestation of *Leucaena leucocephala* (leucaena) in the mid storey. The main identified threat to black ironbox is habitat disturbance and smothering by rubber vine (*Cryptostegia grandiflora*). It is unlikely that rubber vine, or invasive species other than leucaena, would become established in the species' habitat due to the current infestation of Leucaena.

The brigalow TEC identified within the Project Area is a small, fragmented patch of high value regrowth occurring within a significantly modified landscape. The brigalow TEC is in good condition with little weeds present within the patch, however weeds were observed on the edges (*Bryophyllum delagoense, Harrisia martenii, Cyptostegia grandiflora, Parkinsonia aculeata* and *Lantana camara*) (AECOM, 2020f).

Construction will occur immediately adjacent to the brigalow TEC, which may provide a conduit for new weed species to be introduced. Weeds can alter the structure and function of brigalow ecosystems, with introduced grasses such as buffel grass, Rhodes grass and green panic grass posing the greatest threat by drawing fires into the brigalow TEC and increasing fire severity (Australian Government Department of Agriculture Water and Environment, 2021a). Particularly vulnerable are fragmented remnants, patchy regrowth and patches in low rainfall areas. Therefore, construction of the Project may potentially cause a reduction in the quality or integrity of the brigalow TEC if treatment of new weed infestations does not occur.

Phytophthora cinnamomi is a plant pathogen that can spread easily, causing disease and death in susceptible plants and associated loss of potential habitat for fauna. *Phytophthora cinnamomi* can remain dormant during dry weather and is generally impossible to eradicate from infested areas, so it is critical to prevent spread. Any activity that moves soil, water or plant material can spread Phytophthora and to minimise spread of the disease all vehicles and machinery need to be clean on arrival and departure, and to source pathogen-free material and plant stock. Phytophthora dieback is a key threatening process under the EPBC Act due to its actual and potential impacts on threatened species and ecological communities (Australian Government Department of Agriculture, Water and Environment, 2018)

Key mitigation measures include pre-clearing surveys to locate declared plants in the Project Area and inform removal and treatment, wash down of all vehicles and machinery, weed control and monitoring in the Project Area, pathogen management and spoil management, and covering of all putrescible waste (i.e. liable to decay or purification) generated during construction.

7.2.1.1.3 Indirect Degradation via Altered Surface or Groundwater Hydrology

Dewatering has the potential to alter surface or groundwater hydrology. Dewatering is expected to be required during bridge pile and pile cap installation at Fitzroy River and may be required during bridge pile cap installation at Limestone Creek, which are in the vicinity of the brigalow TEC and black ironbox habitats respectively. Dewatering will be temporary only and limited to up to approximately 6 weeks for each pier.

Vegetation of the brigalow TEC occurs over shallow alluvial aquifers and vegetation is likely to be groundwater dependent, particularly larger trees. The TEC is unlikely to be impacted by dewatering given water abstracted from the Fitzroy River is surface water proposed for return to the river where within nominated Surface Water Quality Investigation Criteria identified in the Environmental Management Plan. On this basis, the level of groundwater or surface water are unlikely to be altered.

Black ironbox is typically found in riparian zones and is likely to be groundwater dependent. Dewatering is unlikely to be required for the installation of the Limestone Creek bridge given the ephemeral nature of the waterway, the depth of the groundwater (recorded at > 3.85 m below the surface during July 2021 and >12 m below the surface during the September 2021 baseline survey), and the geology (predominated clay over siltstone), however it may be required following heavy rain. The surface water or groundwater level is unlikely to be unaltered by dewatering given the relatively small area to be dewatered, the shallow depth to be dewatered (up to 2 m below ground level), and the short duration of dewatering (approximately 6 weeks per pier), hence black ironbox is unlikely to be impacted by altered groundwater levels. Given surface waters are unlikely to be altered by dewatering, water flow and seed dispersal is also unlikely to be altered, particularly given the small area of works within Limestone Creek.

Key mitigation measures include:

- Stormwater management to avoid significant local changes in the volume and velocity of surface runoff into the wetland systems, and the inclusion of transverse culverts and pipes or the use of porous material (i.e. rock fill) to minimise impacts to surface water
- Avoiding or limiting dewatering associated with bridge construction.

7.2.1.1.4 Indirect Degradation via Vegetation Clearing and Salinity

Vegetation clearing can contribute to salinity, however it is generally in association with increased surface water availability as discussed for the floodplain of the Project Area in Section 7.2.4.1.3. In Queensland, areas with aquifers less than 6 m below ground surface with remnant vegetation, particularly tea tree (*Melaleuca* spp.), have the greatest potential to develop water table salinity following clearing (Queensland Government Department of Environment and Resource Management, 2011a).

The areas that support black ironbox and the brigalow TEC tend to have aquifers below 6 m, however they can rise to above 6 m (e.g. recorded at 3.58 m below the surface at the Fitzroy River bridge during June 2021 surveys and 3.85 m below the surface at the Limestone Creek bridge during July 2021 surveys by the Project). The black ironbox in the Project Area was also associated with *Melaleuca fluviatilis*, together with other species, which can be an indicator of the potential water table salinity.

Black ironbox is salt tolerant (Australia Government Department of Agriculture, Water and the Environment, 2021) and the vegetation types that make up the brigalow TEC grow on both acidic and salty clay soils (Australian Government Department of Agriculture Water and Environment, 2021a).

Brigalow can also tolerate high salt levels, although growth under these conditions is typically reduced (Peeters & Butler, 2014), and brigalow seeds can germinate in very high salinity levels. Germination of greater than 90% occurred at an electrical conductivity of 20 dS/m (Reichman, Bellairs, & Mulligan, 2006), noting conductivity values for a soil saturation extract are reported to vary from 0.1 dS/m (low salinity hazard) to 9.0 dS/m (very high) (Queensland Government, 2020a).

Salinity is unlikely to be a major issue in these northern parts of the Project Area. However it could occur when aquifers persist above 6 m and remnant vegetation is cleared. Much of the area to be cleared in the northern parts of the Project Area is non-remnant modified grasslands or urban development. Relatively small areas of remnant vegetation or high value regrowth are proposed for clearing:

- approximately 0.3 ha of brigalow TEC will be cleared, with a no-go zone declared along the remaining extent of the brigalow TEC in the Project Area (approximately 1.6 ha) to protect the vegetation during construction
- approximately 1.0 ha of black ironbox will be cleared, with the area to the south of the Limestone Creek bridge in the Project Area declared a no-go-zone and the area to the north of the bridge actively rehabilitated
- approximately 0.1 ha of eucalyptus woodland on alluvial floodplains +/- *Eucalyptus tereticornis* will be cleared in the Project Footprint with up to an additional 0.2 ha cleared in Project Area depending on constructions infrastructure (e.g. access tracks).

In summary, small areas of salinity could occur due to clearing where shallow aquifers persist but both black ironbox and the vegetation types that make up the brigalow TEC are salt tolerant and are unlikely to be impacted.

7.2.1.2 Operational Phase

7.2.1.2.1 Direct Permanent Loss of Habitat from Vegetation Clearing, Bulk Earthworks and Indirect Habitat Fragmentation

The Project will result in the permanent loss of black ironbox. Given the dominance of this species in the canopy layer, additional black ironbox individuals and suitable habitat are anticipated to be present beyond the surveyed extent of Limestone Creek and have been recorded across the Fitzroy Floodplain (Atlas of Living Australia, 2021). The direct removal of eight individuals (during construction) and a relatively small portion of suitable habitat is unlikely to impact the persistence of the population along Limestone Creek. The Project is unlikely to cause the population to become severely disconnected due to the final constructed footprint of the Project Area being relatively narrow. Black ironbox disperses its seed via instream flow, with the seed capsule floating on the surface and depositing in a suitable location for germination downstream. Through the inclusion of bridges in the Project design, the hydrological flow regime of Limestone Creek will be maintained as well as the seed dispersal abilities for black ironbox.

The Project will result in the loss of a small patch of the brigalow (*Acacia harpophylla* dominant and co-dominant) TEC within the Project Footprint, however most of this TEC with the Project Area is outside of the Project Footprint and will be protected by a no-go zone. The Project is not likely to fragment the brigalow TEC as the relatively small area to be lost is on the northern margin of the community and the community will be connected to the tributary to the south and to the Fitzroy River and into several tributaries.

7.2.1.2.2 Indirect and Facilitated Degradation of Habitat via the Introduction and/or Spread of Invasive Weeds

Operation of the Project may introduce new weed species to black ironbox habitat at Limestone Creek. However, as discussed for the construction phase (Section 7.2.1.2.2), it is unlikely that rubber vine, or invasive species other than leucaena, would become established in the species' habitat due to the current infestation of Leucaena.

The Project Footprint is immediately adjacent to the brigalow TEC. Similar to the construction phase (Section 7.2.1.2.2), operation of the road may provide a conduit for new weed species to be introduced that may potentially cause a reduction in the quality or integrity of the brigalow TEC if treatment does not occur. As part of rehabilitation works, buffer planting will be undertaken around the brigalow to prevent/minimise weed incursion.

Weed management within the road corridor will be undertaken in accordance with TMR's Routine Maintenance Guidelines.

7.2.2 Aquatic Fauna

This section includes potential impacts to MNES aquatic fauna associated with construction and operational phase activities and key mitigation measures. The Environmental Management Plan (Appendix A) provides a full list of mitigation measures together with performance criteria and information regarding training, monitoring, reporting, responsibility, timing and corrective actions for each sub plan listed in Section 7.1.3, and is designed to inform the Environmental Management Plan (Construction) to be developed by the construction Contractor.

7.2.2.1 Construction Phase

7.2.2.1.1 Direct Fauna Mortality or Injury

Dewatering will be required in association with installation of bridge piles and pile caps at the Fitzroy River and may be required for other bridges. During the dewatering process, freshwater turtles and estuarine crocodiles have the potential to become entrapped in the area to be dewatered and suffer mortality or injury during the dewatering or relocation process. Salvage of aquatic fauna will be undertaken in accordance with the Guidelines for Fish Salvage (Queensland Government Department of Agriculture and Fisheries, 2018).

Freshwater turtles and estuarine crocodiles can also become entrapped and entangled in lines, chains or nets (e.g. sediment curtains) or other equipment used as part of the dewatering or other construction activities such as pile driving or bank stabilisation and/or be impacted by boat strikes. The Fitzroy River turtle and white-throated snapping turtle were not recorded in the Project Area and if present they are likely to be in present in small numbers along the margins, and/or in deeper pools in the case of the white-throated snapping turtle.

Freshwater turtles or estuarine crocodiles attempting to enter or cross the Project Area could be injured or killed by construction vehicles or machinery; however access to the construction area will be limited by the relatively high embankments of access tracks and construction fencing.

Aquatic fauna will be prevented from entering the dewatering area due to the contained nature of the works. Salvage will be undertaken in accordance with the Guidelines for Fish Salvage (Queensland Government Department of Agriculture and Fisheries, 2018). If aquatic fauna is injured during site works the following strategies are to be implemented:

- Cease works immediately in the vicinity of the injured animal
- Notify the Site Manager or Environmental Representative immediately

- The Environmental Representative must contact the nearest office of the Wildlife Management section of DES, a wildlife carer, veterinarian or the RSPCA (ph 1300 ANIMAL) immediately and proceed based on advice received
- Remove any actual or potential threats to the injured animal. The animal should be moved as little as possible and only by a qualified and experienced fauna spotter/catcher or wildlife carer. Only if the animal is in threat of further danger and if the welfare of people is not compromised, carefully move the animal to a safe and quiet place
- The incident must be reported in accordance with the site audit and inspection requirements.

7.2.2.1.2 Direct Loss of Habitat to Facilitate Construction and Potential Indirect Impacts to Fauna Movement Patterns

The temporary loss of small areas of freshwater turtle and estuarine crocodile habitat is likely in areas required for construction, including temporary haul roads, access roads, site offices and laydown areas. Vegetation clearing, bulk earthworks and habitat fragmentation is likely to result in small areas of floodplain wetlands and riparian areas along the Fitzroy River and Limestone Creek. Potential impacts arising from the temporary loss of habitat may include:

- Reduced foraging habitat for freshwater turtles in association with riparian areas as they are known to consume material from some riparian trees (bark and leaves) and possibly riffle habitat in Limestone Creek
- Reduced sheltering habitat for freshwater turtles where riparian vegetation, undercut banks, root tangles, woody debris and/or macrophytes (particularly ribbonweed beds although these were not recorded in the Project Area and typically occur in clear water) are lost
- Reduced breeding habitat where elevated areas of floodplain lagoons used by estuarine crocodiles for breeding are lost, however very small areas will be lost, and nesting habitat was not recorded in the Project Area.

The ability of aquatic fauna to move across the floodplain and through waterways can be impacted by linear infrastructure such as temporary roads. Temporary bridges or barges are expected to be used to facilitate construction of the Fitzroy River, and temporary access tracks will likely be used across other parts of the Project with culverts installed in wetlands and other waterways to maintain flow and fauna passage. Temporary access tracks are expected to have a low flood immunity and therefore overtop during flood events and allow estuarine crocodiles to move over these structures and across the floodplain to access breeding lagoons.

7.2.2.1.3 Indirect and Facilitated Degradation of Habitat via the Introduction and/or Spread of Invasive Weeds and/or Pest Animals

Construction activities can facilitate spread of weeds, which can impact riparian habitats used by freshwater turtles (e.g. reduce germination and recovery of preferred species), and to a lesser extent, floodplain lagoons used by estuarine crocodiles. Given the extent of weeds in these habitats the Project is unlikely to have a substantial impact.

Construction activities can facilitate access by feral predators (such as cats, foxes, and pigs), which are known to predate in freshwater turtle eggs, and to a lesser extent estuarine crocodile eggs. Impacts are unlikely to be substantial as nesting habitat was not observed in the Project Area.

Key mitigation measures include pre-clearing surveys to locate declared aquatic plants in the Project Area to inform removal and treatment, wash down of all vehicles and machinery, weed control and monitoring in the Project Area, pathogen management and spoil management, and covering of all putrescible waste (i.e. liable to decay or purification) generated during construction.

7.2.2.1.4 Indirect Degradation of Habitat via Increased Noise, Vibration and Light Pollution

There are no government policies or other widely accepted guidelines in respect to the noise levels which may be acceptable to aquatic fauna. The levels or character of noise that may startle, deter or otherwise affect the feeding or breeding pattern of aquatic fauns are also not firmly established in the technical literature.

During the construction phase, there is likely to be an increase in noise, vibration and light as a result of construction activities. Some of the impacts of noise and light pollution will be temporary, and impacts will not affect the entire Project Area simultaneously.

Piles will be driven into the ground to install bridges, with the exception of the Fitzroy River bridge where piles will be poured into casings. It has been reported that freshwater turtles within tens of meters of pile driving are at risk of behavioural disruption and recoverable injury, and that the risk drops to low for distances of hundreds to thousands of metres (JASCO Applied Sciences, 2017). Freshwater turtles could therefore be impacted by pile driving in Limestone Creek however pile driving is likely to be undertaken during dry conditions when turtles are not present.

Artificial light can affect both nocturnal (i.e. active during the night) and diurnal (i.e. active during the day) animals by disrupting patterns, with quality of light (e.g. wavelength, colour), intensity and duration potentially evoking different responses. Impacts from increased light levels include:

- Disorientation from or attraction toward artificial sources of light
- Mortality from collisions with structures (e.g. bridge piers)
- Effects on light-sensitive cycles of species (e.g. breeding and migration).

An increase in artificial light can increase the abundance and efficiency of predators which could result in aquatic fauna such as freshwater turtles avoiding some areas due to an increased perceived risk of predation and/or becoming more vulnerable to predation by aquatic fauna such as estuarine crocodiles.

Freshwater turtles are likely to avoid areas of noise, vibration and light, however impacts are likely to be limited to tens of meters and unlikely to be substantial as there is no nesting habitat, and only marginal foraging habitat in the Project Area. Estuarine crocodiles are unlikely to be negatively impacted and can be attracted to human activity.

7.2.2.1.5 Indirect Degradation of Habitat via Altered Surface or Groundwater Hydrology

The construction of temporary haul routes and access roads has the potential to cause temporary alterations to the local hydrology of wetlands and waterways, by altering surface water flows to wetlands and waterways.

Key mitigation measures include the low flood immunity of the access track, which will over topped during minor flood events, and cross drainage culverts to maintain wetland and waterway connectivity during low flow conditions. Any changes to surface water are likely to be temporary, minor and reversible.

Changes to groundwater levels are likely to be minor and reversible as discussed in Sections 7.1.2.3.

During construction, sediment-laden water will be directed to sediment basins for treatment to meet the Surface Water Quality Investigation Criteria in the Environmental Management Plan prior to discharge. Sediment basins will not discharge to wetlands.

7.2.2.1.6 Indirect Degradation of Habitat via Erosion and Alterations to Water Quality

Vegetation clearing, construction of temporary haul routes and access tracks, bulk earthworks and dewatering have the potential to negatively impact the water quality of wetlands and waterways including:

- Point and non-point sources such as sediment from exposed soils and stockpiles, and increases in erosion and sedimentation, or hydrocarbon spills associated with construction vehicles or plant
- Changes to soil chemistry including exposure of acid sulfate soils
- Increasing the opportunity for aquatic weed infestations, which can reduce oxygen levels in the water column overnight
- Potential salinisation of wetlands and waterways as a result of rising water tables from vegetation clearing
- Introduction of suspended sediment and other potential contaminants where dewatering releases water to the Fitzroy River.

Groundwater quality can be impacted by altered surface water flow. Contaminants such as hydrocarbons can be introduced to groundwater through contamination of surface waters. Potential impacts to surface water and key mitigation measures are discussed below.

Sediment and suspended solids can have substantial ecological impacts. Water with a high level of sediment restricts plant respiration and can influence feed behaviours of animals (negatively and positively). Increased turbidity can also inhibit cloacal respiration in turtles, particularly juveniles, and reduced habitat availability and water quality is likely to expose juveniles to increased predation (Australian Government Department of Agriculture, Water and the Environment, 2020b). Given the mobile nature of freshwater turtles and the large body of water available in the Fitzroy River, they are likely to be able to avoid areas of low oxygen (e.g. deep pools).

Nutrients can lead to increased risk of eutrophication and algal blooms, which can in turn reduce oxygen levels. Elevated nutrients in waterways can also increase the growth of invasive weeds, which can inhibit the growth of native plants and lead to a reduction in fruit as food for adult turtles. Loss of native plants can also reduce bank stability and freshwater turtle refugia provided by undercut banks and roots (Australian Government Department of Agriculture, Water and the Environment, 2020b).

Fuel and/or chemical spills may arise from vehicles carrying fuels and/or chemicals. These contaminants have the potential to directly enter the receiving environment and negatively impact the surrounding habitat and individual fauna. There are very few studies of hydrocarbon exposure to aquatic fauna, however one study suggests that freshwater turtle behaviour, home range size, and water temperature preference are not affected by crude oil exposure and rehabilitation. However, hydrocarbon exposure could affect other aspects of a freshwater turtle biology such as reproductive biology and endocrinology (Saba & Spotila, 2003).

During construction, any increases to turbidity, nutrients or hydrocarbons associated with the Project are unlikely given the temporary nature of the works, the small area of the project relative to the Fitzroy River catchment, the large Fitzroy River barrage weir pool (i.e. the main habitat) and the key mitigation measures outlined in the Groundwater and Surface Water and Erosion and Sediment Control sub plans of the Environmental Management Plan (Appendix A). Key mitigation measures include:

- erosion and sediment control management for turbidity and nutrients,
- appropriate spill prevention and response plans to cover Project activities and the types and quantities of fuel, oil and chemicals held on site, and moving potential contaminants to higher ground prior to periods of heavy or prolonged rainfall for hydrocarbons.

The water quality outcomes from these management practices are the permitted discharge criteria to waterways, for all rainfall events up to and including the design rainfall event, of:

- <50 mg/L total suspended soilds (or equivalent turbidity)
- No visible trace of hydrocarbons
- Dissolved oxygen 90% Saturation (lower limit).

Key threats to estuarine crocodiles include mortality due to fishing nets and the effects of habitat destruction (Australian Government Department of Agriculture, Water and Environment, 2021f). Estuarine crocodiles are unlikely to be substantially impacted by water quality, particularly elevated turbidity given they are ambush predators that typically forage by lunging at prey on banks from turbid water.

Dewatering

Construction of the Fitzroy River bridge will require dewatering to install the piles and pile caps. Dewatering from this relatively small area of the Fitzroy River into the large and permanently flowing Fitzroy River for a relatively short period of time is unlikely to impact water quality given the source water is the same as the receiving water and the water is relatively turbid compared to the Environmental Protection (Water) Policy 2009 water quality objective value of 50 NTU. Turbidity was 173.3 NTU during the June 2019 survey (AECOM, 2020e) and 75.86 NTU-field, 80.4 NTU-lab during the September 2019 survey (C&R Consulting, 2020).

Dewatering for construction of the floodplain or Limestone Creek bridges will be avoided, however may be required following heavy rainfall or where groundwater of surface water is encountered. Dewatering to 2 m is unlikely to encounter groundwater given the depth of the groundwater (recorded at > 3.85 m below the surface during July 2021 and recorded at > 12 m below the surface during the September 2021 baseline survey) and the geology (predominated by clay over siltstone). Surface water is unlikely to be encountered where works are undertaken outside of the wet season given the ephemeral nature of the waterway. Impacts to water quality and aquatic fauna habitat will be minimised where abstracted water is contained and used for dust suppression or released to the receiving environment where within the Surface Water Quality Investigation Criteria in the Environmental Management Plan (Appendix A).

Acid Sulfate Soils

Disturbance of acid sulfate soils have the potential to impact water quality including acidification and release of iron, aluminium and other metals. Aquatic fauna are likely to move away from contaminated areas where possible however may become trapped in wetlands or other water bodies. This is unlikely to be a significant impact given freshwater turtles are unlikely to occur in isolated water bodies, particularly those that dry, and estuarine crocodiles can remain out of the water for extended periods and travel across land to alternate water sources.

Measures outlined in Section 7.1.2.4 will be implemented to manage acid sulfate soils should they be encountered.

7.2.2.1.7 Indirect Upstream and Downstream Impacts to Aquatic Fauna

Freshwater turtles may occur within the Fitzroy Barrage pool, which extends approximately 83 km upstream and 4 km downstream of the Project. Estuarine crocodiles have been recorded large distances upstream and downstream of the Project Area (Australian Government Department of Agriculture, Water and Environment, 2021f).

Flows and flooding across the floodplain wetlands and in waterways may be temporarily reduced by construction haul roads and access tracks while the roads/tracks are installed. There may be upstream and downstream impacts associated with the ability of aquatic fauna to freely move across the floodplain and through waterways during this period. Potential impacts will be temporary in nature are mitigated by the low flood immunity of the temporary roads and tracks (i.e. overtopping on low flow events) and the inclusion of cross-culverts in low flow channels.

The Project is unlikely to bring about temporary loss of habitat to facilitate construction upstream or downstream of the Project Area. Temporary loss of habitat will be limited to the Project Area.

The Project could bring about habitat degradation, via the spread of invasive weeds or pest animals to areas upstream and/or downstream of the Project Area, particularly those areas adjacent to the Project Area. For example, the linear construction corridor could provide a conduit for aquatic weeds and aquatic pests (e.g. exotic fishes and turtles) to move upstream and downstream across the floodplain via waterways and/or wetlands. Pest predators (e.g. pigs, cats, dogs and foxes) could also travel along the corridor to gain access to eggs. Impacts are however unlikely to be substantial given the temporary nature of the construction and the extent of pests currently in the broader Project Area. All restricted invasive species will be controlled in accordance with the Queensland Department of Agriculture and Fisheries Biosecurity Queensland Invasive Species Guidelines (Queensland Government Department of Agriculture and Fisheries, 2016) (unless more up-to-date information is available).

Noise, vibration and light are unlikely to substantially impact aquatic fauna upstream or downstream of the Project Area given there is only marginal freshwater turtle foraging habitat in the Project Area. The nearest potential turtle breeding habitat identified during Project surveys was 1 km upstream of the Project Area and the nearest major nesting area is 45 km upstream of the Project Area. Estuarine crocodiles are unlikely to be negatively impacted and can be attracted to human activity.

There may be upstream and downstream impacts associated with degradation of habitat via erosion and sedimentation and alterations to water quality, particularly in waters adjacent to the Project. Potential contaminants can travel large distances downstream of across the floodplain, particularly particulate matter associated with suspended sediments in turbid water such as the Fitzroy River or across the flooded floodplain. Key mitigation measures include sediment basins to capture water for treatment prior to release where compliant with the Surface Water Quality Investigation Criteria in the Environmental Management Plan (Appendix A).

7.2.2.2 Operational Phase

7.2.2.2.1 Direct Fauna Mortality or Injury

Freshwater turtles or estuarine crocodiles attempting to cross the Project Area could be injured or killed by vehicles. However, the design includes bridges over wetlands and major waterways including the Fitzroy River and Limestone Creek, which will allow freshwater turtles and estuarine crocodiles to move largely unimpeded. All bridges will be designed such that bridge abutments are set back from the banks of waterways to minimise barriers to aquatic fauna movement and loss of in river habitat.

In areas where the road is on an earth embankment, the landscape is drier and aquatic fauna are not expected to be encountered. Furthermore, the embankment slope would discourage fauna from crossing the road.

7.2.2.2.2 Indirect Degradation of Habitat via Increased Noise and Light

The Project will have permanent lighting at roundabouts, interchanges and the Fitzroy River Bridge to meet safety standards and the Project will also generate ongoing noise from traffic. Potential impacts on aquatic fauna from lighting and noise will be similar to those discussed above for construction (Section 7.2.2.1.4), with the main difference being that operational noise is likely to be lower intensity due to the lack of construction activity but of permanent duration.

Freshwater turtles and estuarine crocodiles are unlikely to be substantially impacted by noise and light given the habitat is marginal and the relatively small area of the habitat for these species in the Project Footprint, compared to the broader floodplain and Fitzroy River.

7.2.2.2.3 Indirect Habitat Fragmentation from Vegetation Clearing and Bulk Earthworks

Vegetation clearing, bulk earthworks and habitat fragmentation is likely to result in the small area of permanent loss of floodplain wetlands and riparian areas along the Fitzroy River. The permanent loss of potential freshwater turtle and estuarine crocodile habitat has the potential to adversely affect these species, as described above for temporary loss of habitat (Section 7.2.2.1.2).

The ability of aquatic fauna to move across the floodplain and through waterways can be impacted by linear infrastructure such as roads. The design includes 18 bridges that span approximately 7 km and numerous culverts, which will allow freshwater turtles and estuarine crocodiles to move largely unimpeded through the Fitzroy River, and allow estuarine crocodiles to move across the floodplain to access breeding lagoons. Movement across the floodplain may be impeded in areas without bridges or culverts, however all waterways and wetlands will be bridged, and estuarine crocodiles are unlikely to be substantially impacted. Fitzroy River and Limestone Creek bridges have been designed to minimise barriers to turtle movement by setting bridge abutments above the high bank, and riparian zones will be rehabilitated post-construction.

7.2.2.2.4 Indirect Aquatic Habitat Degradation via Surface Water Runoff Contamination

Sediment and suspended solids are a significant road runoff pollutant in terms of ecological impacts. Water with a high level of sediment restricts plant respiration and the impacts feed behaviours of animals (Austroads Inc. , 2000) such as freshwater turtles.

Contaminants created or deposited by vehicles may become suspended in runoff and drainage waters. Typical road contaminants include sediment, heavy metals, hydrocarbons, pesticides, and biological material such as faecal matter and seed (from the transportation of livestock). Deposition of contaminated runoff can affect wetland communities and waterways.

When dissolved in the water, heavy metals and nutrients can lead to increased risk of eutrophication and algal blooms. Floating oil residues are also a common road pollutant and can impact the oxygenation of the water column needed for the respiration of aquatic fauna including freshwater turtles. Reduced biodiversity in wetland systems can result in trophic cascades which impacts the overall ability of ecosystems to function.

A range of water quality control devices have been incorporated into the design to minimise potential on aquatic fauna habitat including bioretention basins with inlet sediment ponds, bioretention swales, grass-lined swales and buffer strips along embankments.

- An inlet pond to bioretention basin system is designed to remove coarse sediment, allow for high flow to bypass the bioretention filter media, provide appropriate storage for coarse sediment, regulate flows entering filter media and also capture any spill on road.
- Bioretention basins have been provided at the bridge drainage and approach roadworks outlet locations at wetlands and waterways and are effective at removing litter, fine sediment, phosphorus, nitrogen, metal and hydrocarbons from stormwater.
- Bioretention swales are a type of bioretention system that both treat and convey stormwater and require less width compared to the bioretention basins. A bioretention swale is comprised of all the main components of a bioretention system co-located within the base of a swale.
- Grassed-lined swales are provided to convey longitudinal flow along the road where sufficient grade is available and buffer strips are provided along embankments.

Results of MUSIC modelling for the Project (Jacobs SMEC Design Joint Venture, 2021g) showed that total suspended solids, total phosphorus and total nitrogen are within the load reduction targets in potential freshwater turtle habitat provided by the Fitzroy River and Limestone Creek (Figure 7-1 and Figure 7-2).

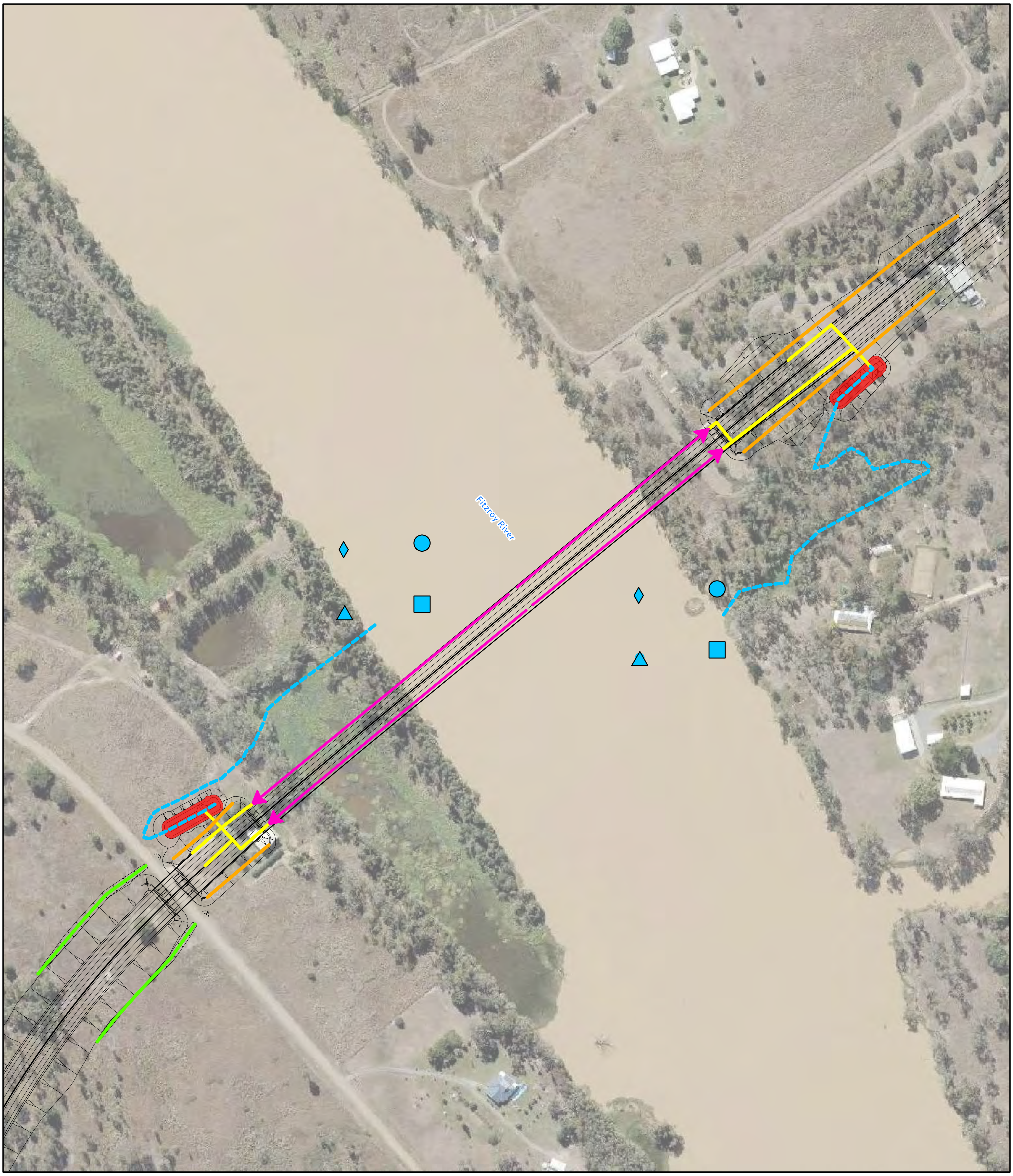
Gross pollutant load reduction is within the load reduction targets for the Fitzroy River. Gross pollutants marginally achieved (within 10%) the load reduction targets for Limestone Creek (Table 7-8), however this is unlikely to substantially impact freshwater turtles given the marginal habitat provided by Limestone Creek. This is discussed in Section 6.2.2, in that Limestone Creek is an ephemeral waterway and where the Project crosses, the stream bed and vegetation community have been highly impacted and alteration to the channel have disconnected the waterway from the downstream reaches and the Fitzroy River except in very high flow conditions.

As background, MUSIC (Model for Urban Stormwater Improvement Conceptualisation) is an industry accepted software tool that is used by local councils and state governments across Australia. It was first developed in 2001 by researchers at Monash University and is based on defining an impervious area and the properties of related pervious areas to estimate runoff. Urban developers, planners, engineers, local government and development approval agencies use MUSIC to manage the impact of urban development and other land use changes on waterways (eWater, 2022). The load-based reduction targets adopted on this project for the MUSIC modelling are provided by the *State Planning Policy 2017*. Pollutant load is defined as the amount of a particular pollutant delivered to a waterbody measured in units of mass per unit time, that is, kilograms per year for this Project.

The Project load reduction targets for the Fitzroy River (Table 7-7) and Limestone Creek (Table 7-8) are based on the State Planning Policy and are up to:

- 90% for total suspended solids (which represent the potential for fine sediments, i.e. when settled out of the water column)
- 73% for total phosphorus (includes particulate and dissolved phosphorus)
- 52% for total nitrogen (includes particulate and dissolved nitrogen).

Figure 7-1: Water quality management structures on the Fitzroy River



Legend

Pollutant
- ○ Gross pollutant
- □ Total nitrogen
- △ Total phosphorus
- ◊ Total suspended solid

Pollutant load-based reduction target
- Marginally achieved
- Achieved

Project-specific reduction target based on the State Planning Policy

- Water Flow Path
- Buffer Strips
- Grass Lined Channels
- Scuppers to Bridge Drainage
- Pit & Pipe
- Design
- Bioretention Basins

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GDA 1994 MGA Zone 56

A3 1:3,000

N 0 50 100 Meters

Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Jacobs: Design (2021); Metromap: Imagery (2020)

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Figure 7-2: Water quality management structures on Limestone Creek

Legend

Pollutant
- ◯ Gross pollutant
- ☐ Total nitrogen
- △ Total phosphorus
- ◊ Total suspended solid

Pollutant load-base reduction target
- ● Marginally achieved (purple)
- ● Achieved (blue)

Project-specific reduction target based on the State Planning Policy

- Water Flow Path
- Buffer Strips
- Grass Lined Channels
- Scuppers to Bridge Drainage
- Pit & Pipe
- Design
- Bioretention Basins

JSDJV does not warrant that this document is definitive nor free of errors and does not accept liability for any loss caused or arising from reliance upon information provided herein.

GDA 1994 MGA Zone 56

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0 50 100

Meters

Jacobs SMEC

Jacobs SMEC Design Joint Venture

Source: Jacobs: Design (2021); Metromap: Imagery (2020)

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These Project load-based reductions are more stringent than the Reef 2050 Plan reduction targets set in the *Reef 2050 Water Quality Improvement* Plan. Reef 2050 Plan water quality targets have been set for all catchments that drain to the Great Barrier Reef and the targets consider land use and pollutant loads from each catchment. Priorities for water quality improvement have also been identified based on the highest exposure of coastal or marine ecosystems from catchment sourced pollutants. The 2025 end-of-catchment anthropogenic load reductions targets (as a % reduction from the 2013 baseline) for the Fitzroy Basin are (Australian and Queensland Government, 2020a):

- 30% for fine sediment
- 30% for particulate phosphorus
- 30% for particulate nitrogen.

Further:

- Water quality studies conducted by multiple agencies on the Fitzroy River Basin identify specific industry sectors that have significantly higher impacts on water quality than urban development (for example, agriculture, mining).
- A CSIRO report (Douglas, et. al., 2006) and a latter report published by the then Queensland Department of Environment and Resource Management (Carroll, et al., 2010) calculated an existing sediment load of 4.5 M tonnes per annum to the Fitzroy River Estuary. The sediment volumes that may be discharged by the project would be insignificant when assessed against this documented load.
- Flood events larger than the design event (Q20) may also impact negatively on the pollution management regimes and assets designed and to be constructed as part of the project.

7.2.2.2.5 Indirect Loss of Habitat Values via Altered Surface Hydrological Regimes and Indirect Impacts to Fauna Movement Patterns

The ability of aquatic fauna to move across the floodplain and through waterways can be impacted by linear infrastructure such as roads and hydraulic changes acting as a barrier. In order to maintain the current hydrological characteristics of the area, the design includes 18 bridges that span approximately 7 km in total across all waterways and wetlands. The incorporation of bridges reduces the potential for hydraulic changes associated with the road and provide for the passage of estuarine crocodiles across the floodplain to access breeding lagoons. The Fitzroy River bridge will not impact estuarine crocodile or freshwater turtle movement patterns. The design also includes culverts at minor tributaries and overland flow paths, and no major diversion of waterways. Hydraulic changes are minor and not expected to directly or indirectly impact on the ability of aquatic fauna to move within the landscape under normal flow or flood conditions.

Movement across the floodplain may be impeded in areas without bridges or culverts, however given all waterways and wetlands will be bridged, and the extent of the large floodplain and nature of estuarine crocodiles, they are unlikely to be substantially impacted.

Freshwater turtles or estuarine crocodiles attempting to cross the Project Area could be injured or killed by vehicles. However, the bridges over all wetlands and waterways including the Fitzroy River and Limestone Creek will allow freshwater turtles and estuarine crocodiles to move largely unimpeded. All bridges will be designed such that bridge abutments are set back from the banks of waterways to minimise barriers to aquatic fauna movement and loss of instream habitat. In areas where the road is on an earth embankment, the landscape is drier and aquatic fauna are not expected to be encountered. Furthermore, the embankment slope would discourage fauna from crossing the road.

7.2.2.2.6 Indirect Upstream and Downstream Impacts to Aquatic Fauna

Freshwater turtles occur within the Fitzroy Barrage pool, which extends approximately 83 km upstream and 4 km downstream of the Project. Estuarine crocodiles have been recorded large distances upstream and downstream of the Project Area (Australian Government Department of Agriculture, Water and Environment, 2021f).

There are unlikely to be upstream and downstream impacts associated with the ability of aquatic fauna to move across the floodplain and through waterways associated with the road. Bridge abutments are set back from the banks of waterways to minimise barriers to aquatic fauna movement and loss of instream habitat, and in areas where the road is on an earth embankment, the landscape is drier and aquatic fauna are not expected to be encountered.

Upstream and downstream of the Project Footprint, freshwater turtles and estuarine crocodiles are unlikely to be substantially impacted by noise and light given the low intensity of the light and noise and the relatively small area of the habitat for these species in the Project Footprint, compared to the broader floodplain and Fitzroy River. Aquatic fauna are likely to move under the road, through bridges and culverts, to access habitat upstream and downstream of the road.

Vegetation clearing, bulk earthworks and habitat fragmentation will result in the permanent loss of small areas of floodplain wetlands and riparian areas along the Fitzroy River, Lion Creek and Limestone Creek. The permanent loss of potential habitat is limited to the Project Footprint with the Project Area will be rehabilitated and provides a buffer for impacts to adjacent areas.

There may be upstream and downstream impacts associated with degradation of habitat via surface water runoff contamination during operation of the road. A range of water quality control devices have been incorporated into the design to minimise the potential impact of the Project on habitat for aquatic fauna including bioretention basins with inlet sediment ponds, bioretention swales, grass-lined swales and buffer strips along embankments as discussed in Section 7.2.2.2.4.

Pest fauna species may increase as a result of the operational stage of the project, for example predatory and scavenging species are likely to be attracted to litter and roadkill. Pest fauna in the Rockhampton Region include:

- Feral cat (*Felis catus*)
- Feral goat (*Capra hircus*)
- Feral Rusa deer (*Rusa timorensis,* syn, *Cervus timorensis*)
- Feral pig (*Sus scrofa*)
- Wild dog (*Canis lupis familiaris*)
- Dingo (*Canis lupus dingo*)
- European fox (*Vulpes vulpes*)
- European rabbit (*Oryctolagus cuniculus*)
- Deer (*Cervus timorensis*) (Rockhampton Regional Council, 2017).

Of these, feral cats, wild dogs, dingoes, foxes and feral pigs are likely to be attracted to road kill. The potential for road kill will be minimised by fauna fencing that guides fauna under bridges, and where the road is on an earth embankment the embankment slope (and a drier landscape) would fauna are not expected to be encountered as frequently.

The principal current threat to the white-throated snapping turtle is the excessive (near total) loss of eggs and hatchlings at the aggregated nesting areas. This is due to predation by feral (fox, dog, pig, cat) and native (e.g. goanna, water rat) predators, and trampling of nests by cattle (Australian Government Department of Agriculture, Water and the Environment, 2020b). One of the most significant threats to the Fitzroy River turtle is also predation of eggs by feral (fox, pig, cat) and native (dingo, goanna, water rat), with over 90 per cent of nests being lost to predation predation (Australian Government Department of Agriculture, Water and the Environment, 2021l).

The nearest known freshwater turtle nesting areas at the Alligator Creek confluence is unlikely to be impacted by the project given it is in the upper reaches of the Fitzroy Barrage impoundment. It is approximately 45 km upstream of the Project Area and feral pigs and cats have small home ranges (e.g. 2 – 20 km for female and juvenile feral pigs and 8 – 50 km for adult males, 8 km for feral cats) and would not move from the Project Area to the nesting area) (Queensland Department of Agriculture and Fisheries, 2020d; Queensland Department of Agriculture and Fisheries, 2020e; Queensland Department of Agriculture and Fisheries, 2020f).

Fox territories range from 2 to 5 km^2 but vary with type of habitat, population density and food availability (New South Wales Government Department of Primary Industries, 2022) and foxes can roam up to 300 km (Queensland Department of Agriculture and Fisheries, 2020a). Foxes are known to dig up nests to eat eggs, and also kill adult nesting females of smaller turtle species, (Australian Government Department of Agriculture, Water and the Environment, 2020b) however, it is unknown whether foxes predate on nesting white-throated snapping turtles or Fitzroy River turtles.

Wild dogs have highly variable home ranges and are known to move up to 75 km in productive areas and up to 560 km in more arid environments, however they tend to favour parts of their home range, e.g. water points, rubbish tips and den sites (Centre for Invasive Species Solutions, 2015). There is evidence that wild dogs predate on female freshwater turtles as they lay eggs such as the Mary River turtle (Australia Government Department of Agriculture, Water and Environment, 2022) and the New South Wales Government Local Land Services has reported wild dog nest predation on the Manning River turtle (ABC, 2020), however information is not readily availble for the white-throated snapping turtle or Fitzroy River turtle.

In summary, it is possible that foxes and wild dogs attracted to road kill along the Rockhampton Ring Road could predate on turtle eggs and turtles at the Alligator Creek confluence nesting site. However, the potential for road kill and associated attraction of predators will be reduced by design features of the road and predators are generally less likely to search for food further afield when there is food available nearby.

Raptors, which prey on immature and small adult freshwater turtles, may be significant predators on small white-throated snapping turtles when the depth of water in isolated pools become low during drought periods, but the extent of this impact is unknown (Australian Government Department of Agriculture, Water and the Environment, 2020b). The presence of raptors may increase as a result of road kill however the Fitzroy River is deep in the Project Area and likely to provide protection from predation by raptors.

Based on a study of juvenile Mary River turtles, a species that utilises the same habitat as the white-throated snapping turtle in the Mary River, half of the predators were likely to be fish (e.g. freshwater eel, Mary River cod, fork-tailed catfish, sooty grunter) and the other half were likely to be birds or mammals (e.g. white-bellied sea eagle, water rat) (Australian Government Department of Agriculture, Water and the Environment, 2020b).

Based on the information available regarding predation of freshwater turtles, impacts are unlikely to be substantial given the distance to the distance to the nesting aggregation (approximately 45 km upstream of the Project Area), the extent of predatory pests currently in the broader Project Area, and design features that minimise road kill (e.g. fauna fencing and embankment slope). In additional, Rockhampton Regional Council actively monitors and manages pest fauna on public lands with a Biosecurity Surveillance Program in place across the floodplain of the Project Area.

7.2.3 Terrestrial Fauna

This section includes potential impacts to MNES terrestrial fauna associated with construction and operational phase activities and key mitigation measures. The Environmental Management Plan (Appendix A) provides a full list of mitigation measures together with performance criteria and information regarding training, monitoring, reporting, responsibility, timing and corrective actions for each sub plan listed in Section 7.1.3, and is designed to inform the Environmental Management Plan (Construction) to be developed by the construction Contractor.

7.2.3.1 Construction Phase

7.2.3.1.1 Direct and Indirect Fauna Mortality or Injury

Clearing of vegetation has the potential to result in injury or mortality of fauna which may be crushed by falling vegetation, machinery or struck by vehicles. Ground dwelling, less mobile, and juvenile fauna are most susceptible to directly injury or mortality, while arboreal fauna in trees may be injured as they are felled. Less mobile and small fauna may also become trapped in construction areas or trenches. In contrast, highly mobile fauna (e.g. birds, flying-fox and macropods) are likely to flee the area of works prior to being impacted.

All clearing will be undertaken in accordance with the Environmental Management Plan (Appendix A) and associated Construction MNES Flora and Fauna Sub Plan, including engagement of a suitably qualified, appropriately experienced and licensed fauna spotters/catchers for the Project. Vehicle speed limits will also be limited around wetlands and adjacent to retained fauna habitat (e.g. brigalow and mapped eucalypt woodlands) to reduce the likelihood or severity of vehicle strikes to ground dwelling and aerial fauna. Fencing will be erected along the length of the retained habitat to reduce the likelihood of species re-entering the Project area.

Changes to Public Utility Plant to accommodate the Project, such as electricity infrastructure, are unlikely to cause injury or mortality to MNES as works are within road reserves and/or do not require clearing of MNES fauna habitat such as wetlands or vegetation (remnant REs or high value regrowth) likely to support MNES fauna.

7.2.3.1.2 Direct Loss of Habitat to Facilitate Construction

The temporary loss of habitat is anticipated to occur in areas required for construction, including temporary haul roads, access roads, site offices and laydown areas. The temporary loss of habitat has the potential to adversely affect native fauna species, including the following:

- The temporary loss of fauna habitat including foraging, breeding and refugia habitat which may limit a species ability to persist in the locality
- The temporary fragmentation of populations, which may reduce the ability of fauna to access local foraging, breeding, and refugia habitat
- The temporary disturbance to habitat which can permit the establishment and/or spread of exotic species that may displace native species and reduce habitat quality by removing fauna resources
- Loss of microhabitat features such as leaf litter, tree hollows, ground timber which removes habitat for a wide variety of vertebrates and invertebrates.

Changes to Public Utility Plant to accommodate the Project, such as electricity infrastructure, are unlikely to cause loss of MNES fauna habitat as works are within road reserves and/or do not require clearing of MNES fauna habitat such as wetlands or vegetation (remnant REs or high value regrowth) likely to support MNES fauna.

Key mitigation measures include clear demarcation of no-go zones and rehabilitation of flora outside of the Project Footprint (Figure 4-4, Figure 4-5).

7.2.3.1.3 Indirect and Facilitated Degradation of Habitat via the Introduction and/or Spread of Invasive Weeds and/or Pest Animals and/or Pathogens

Given that current pest populations are well established in the Project Area and the broader region, the Project is unlikely to introduce new feral fauna species or exacerbate current pest populations. Nonetheless, construction activities can facilitate access by feral predators (such as wild dogs, cats and pigs) to areas of retained vegetation and fauna habitat. In addition, removal of fauna habitat during construction may increase the predation risk of native fauna by feral predators due to increased exposure and changes in movement patterns.

Weeds are already prevalent across the Project Area, however there is a risk that disturbance to native vegetation, changes to microhabitat and mobilisation of earthmoving equipment and materials may introduce or exacerbate weeds in areas which are currently host to only low or moderate density weeds. The introduction and/or spread of pathogens (e.g. *Phytophthora cinnamomi*) may result from construction activities moving around the landscape.

Key mitigation measures include pre-clearing surveys to locate declared plants in the Project Area and to inform removal and treatment, wash down of all vehicles and machinery, weed control and monitoring in the Project Area, pathogen management and spoil management, and covering of all putrescible waste generated during construction.

7.2.3.1.4 Indirect Degradation of Habitat via Increased Noise, Dust, Vibration and Light Pollution

During the construction phase, there is likely to be an increase in noise, dust, vibration and light as a result of construction activities. The impacts of noise, dust and light pollution will be temporary and will not affect the entire Project Area simultaneously. However, where construction activities are occurring adjacent to retained habitat, potential impacts may include the following:

- Avoidance of the area due to increased noise, vibration or light
- Reduced foraging ability by auditory predators due to increased background noise (e.g. grey-headed flying-fox)

- Increased risk of predation by visual predators due to increased background noise (e.g. birds)
- Behavioural changes due to increased noise (e.g. species that use calls as part of breeding behaviour, such as birds)
- Increased potential for collisions with vehicles (e.g. koalas)
- Human visitation causing disturbance to foraging or breeding behaviours (i.e. fauna species which rely on aural cues to locate mates such as koalas)
- Reduction of habitat quality due to noise, dust, vibration and light pollution.

There are no government policies or other widely accepted guidelines in respect to the noise levels which may be acceptable to wildlife. The levels or character of noise that may startle, deter or otherwise affect the feeding or breeding pattern of birds or other wild animals are also not firmly established in the technical literature.

Sudden loud, impulsive or impact noises are capable of causing birds and other fauna to become startled, which (if occurring over the longer term) may affect feeding and breeding behaviour in some species. Bulk earthworks including piling, excavation, construction and earthmoving associated with the project has the potential to cause disturbance to all groups of terrestrial fauna (especially migratory shorebirds as discussed in Section 7.2.4).

Artificial light can affect both nocturnal and diurnal animals by disrupting patterns, with quality of light (e.g. wavelength, colour), intensity and duration potentially evoking different responses. Impacts from increased light levels include:

- Disorientation from or attraction toward artificial sources of light
- Mortality from collisions with structures
- Effects on light-sensitive cycles of species (e.g. breeding and migration for fauna).

An increase in artificial light can increase the abundance and efficiency of predators which could result in fauna avoiding some areas due to an increased perceived risk of predation and/or becoming more vulnerable to predation.

Key mitigation measures include avoiding non safety-essential lighting, directing lights onto work areas, positioning lights at a height designed to reduce spill, quiet work practices (Standards Australia, 1981), regular service and maintenance of machinery and equipment, dust suppression and rehabilitation of disturbed surfaces. Construction activities will avoid non safety-essential lighting with lighting limited to office, stores and lay down areas and areas of night works (the entire construction site will not be lit). Construction lighting will be managed is accordance with Australian/New Zealand Standard Control of the obtrusive effects of outdoor lighting (AS/NZS 4282:2019) (Standards Australia / Standards New Zealand, 2019).

7.2.3.1.5 Indirect Degradation of Habitat via Erosion and Sedimentation and Alterations to Water Quality

Vegetation clearing, construction of haul routes and access tracks, and bulk earthworks have the potential to negatively impact the water quality of wetlands and waterways as discussed for aquatic fauna in Section 7.2.2.

Water quality also has the potential to impact terrestrial fauna such as squatter pigeons that need to access fresh water daily, and ornamental snakes that occur in wet habitats. Impacts are unlikely to be substantial given the highly mobile nature of these species, the likely limited extent of impacts to water quality in the Project Area and the relatively large area of potential habitat for these species across the floodplain and in association with waterways.

Key mitigation measures include sediment basins that capture and treat runoff prior to release where compliant with the Surface Water Quality Investigation Criteria in the Environmental Management Plan (Appendix A).

7.2.3.2 Operational Phase

7.2.3.2.1 Direct Fauna Mortality or Injury

Conflict between road traffic and fauna is anticipated to occur during the operational phase of the Project, particularly in areas where the road is an earth embankment as opposed to a bridge or culvert.

The koala is most likely to suffer mortality or injury from vehicle collisions. This species was not recorded in the Project Area and is expected to occur in low density in this broader region. Given the limited vegetation within the Project Area and the existing barriers to movement (high fragmentation and the existing Capricorn Highway), the Project Area is unlikely to substantially impact the koala.

With the introduction of moving traffic along the new road once it has been completed, there is the possibility of an increase in vehicle strikes to grey-headed flying-fox while moving between foraging habitat within the broader area on different sides of the Project Area. Following completion of the road, the initial period of operation is expected to result in the highest risk of flying-fox and vehicle collisions. After some time, flying-fox in the area are expected to become conditioned to the presence of the new road and adjust their local movement behaviours to avoid the road.

Fauna fencing will be installed at Limestone Creek where habitat is located either side of the bridge and there is local connectivity to surrounding vegetated areas. All bridges will be designed such that bridge abutments are set back from the banks of waterways to provide fauna passage.

7.2.3.2.2 Indirect Habitat Fragmentation from Vegetation Clearing and Bulk Earthworks

The permanent loss of habitat from vegetation clearing, habitat fragmentation and bulk earthworks can adversely affect terrestrial fauna. Potential impacts resulting from clearing native vegetation and bulk earthworks may include the following:

- The loss of habitat for fauna species including a loss of local foraging, breeding, refugia and dispersal habitat which limits a species ability to persist in the locality.
- Fragmentation of populations, which can reduce the ability of fauna to access local foraging, breeding, and refugia habitat, reduces gene flow between populations, reduces the potential for species to adapt to environmental change, and loss or severe modification of the interactions between species.
- Fragmentation of habitats has the potential to limit colonisation of suitable habitat, and also recolonisation of habitat temporarily impacted (e.g. by fire or floods).
- Fragmentation can be exacerbated by the creation of movement barriers (i.e. vegetation gaps, installation of construction fencing)
- Disturbance to habitat which can permit the establishment and/or spread of exotic species that may displace native species and reduce habitat quality by removing fauna resources.
- Loss of microhabitat features such as leaf litter, tree hollows, ground timber which removes habitat for a wide variety of vertebrates and invertebrates.

Given small areas in the Project Footprint are to be cleared during construction, with all areas in the Project Area to be rehabilitated (Figure 4-4, Figure 4-5), impacts are likely to be minimal.

7.2.3.2.3 Indirect and Facilitated Degradation of Habitat via the Introduction and/or Spread of Invasive Weeds and/or Pest Animals and/or Pathogens

Given that current pest populations are well established in the Project Area and the broader region, the Project is unlikely to introduce new feral fauna species or exacerbate current pest populations.

Weed management within the road corridor will be undertaken in accordance with the Department of Transport and Main Road (TMR) Routine Maintenance Guidelines.

7.2.3.2.4 Indirect Degradation of Habitat via Increased Noise and Light

The Project will have permanent lighting at roundabouts, interchanges and the Fitzroy Bridge to meet safety standards and the Project will also generate ongoing noise from traffic. Potential impacts on terrestrial fauna from lighting and noise will be similar to those discussed above for construction (Section 7.2.3.1.4), with the main difference being that operational noise is likely to be lower intensity due to the lack of construction activity but of permanent duration.

Typically, fauna will move away from noise and light sources as these may be perceived as a threat. Acclimatisation by some species may occur over the medium to long term and many of the species identified in the Project Area are known to occur in areas subject to noise, light and general activity. However, it is possible that some habitats will no longer be used by certain species due to their already small size, disturbance during construction and close proximity to the Project.

7.2.3.2.5 Indirect Impacts to Fauna Movement Patterns

Barriers to the movement of wildlife can lead to the fragmentation of populations and isolation from breeding, foraging and refuge habitat. The isolation of populations caused by physical barriers to movement, has the potential to reduce gene flow and the health of populations. Where roads present a permanent barrier to fauna movement, there is potential for reduced breeding opportunities, reduced access to foraging resources (leading to reduced health) and increased predation.

The design of the road allows for the movement of terrestrial fauna by the inclusion of 18 bridge, spanning approximately 7 km, which allow fauna to pass under the road. There is also fencing at Limestone Creek to guide fauna under bridges rather than onto road thereby facilitating safe passage under the road. Bridge abutments will also be set back from the banks of waterways to minimise barriers to fauna movement, and vegetation outside of the Project Footprint will be rehabilitated to provide habitat for fauna.

7.2.3.2.6 Indirect Loss of Habitat Values via Altered Surface Hydrological Regimes

As discussed for aquatic fauna (Section 7.2.2.2.4), surface hydrological regimes in and adjacent to the Project Area could be altered by the placement of a road altering overland surface flows.

In order to maintain the current hydrological characteristics of the area, the design includes 18 bridges that span approximately 7 km in total across all waterways and wetlands, together with numerous cross-culverts that reduce the potential for hydraulic changes associated with the road. The design also includes culverts at minor tributaries and overland flow paths, and no major diversion of waterways. Hydraulic changes are minor and not expected to impact on the ability of fauna to move within the landscape under normal flow or flood conditions.

7.2.3.2.7 Indirect Degradation of Habitat via Erosion and Sedimentation and Alterations to Water Quality

Results of MUSIC modelling for the Project (Jacobs SMEC Design Joint Venture, 2021g) showed that the proposed stormwater treatment design helps in reducing pollutant load reduction of total suspended solids, total phosphorus, total nitrogen, and gross pollutant at most waterways and wetlands.

A range of water quality control devices have been incorporated into the design to minimise the potential impact on water quality including bioretention basins with inlet sediment ponds, bioretention swales, grass-lined swales and buffer strips along embankments.

- An inlet pond to bioretention basin system is designed to remove coarse sediment, allow for high flow to bypass the bioretention filter media, provide appropriate storage for coarse sediment, regulate flows entering filter media and also capture any spill on road.
- Bioretention basins have been provided at the bridge drainage outlet locations at wetlands and waterways and are effective at removing litter, fine sediment, phosphorus, nitrogen, metal and hydrocarbons from stormwater.
- Bioretention swales are a type of bioretention system that both treats and convey stormwater and require less width compared to the bioretention basins. A bioretention swale is comprised of all the main components of a bioretention system co-located within the base of a swale.
- Grassed-lined swales are provided at roundabouts and to convey longitudinal flow along the road where sufficient grade is available and buffer strips are provided along embankments.

7.2.4 Migratory Birds

This section includes potential impacts to MNES flora associated with construction and operational phase activities and key mitigation measures. The Environmental Management Plan (Appendix A) provides a full list of mitigation measures together with performance criteria and information regarding training, monitoring, reporting, responsibility, timing and corrective actions for each sub plan listed in Section 7.1.3, and is designed to inform the Environmental Management Plan (Construction) to be developed by the construction Contractor.

The Project will impact wetlands, including wetland habitat and vegetated wetland margins. A total of approximately 9.5 ha of designated palustrine or lacustrine wetland is proposed to be temporarily disturbed along the length of the Project Area, of which approximately 2.41 ha of wetland habitat will be permanently impacted, largely due to bridge shading. Noting the substantial variability and suitability of these wetland habitat areas in response to water availability, many of these wetland areas provide key habitat features utilised by migratory birds for both foraging and roosting. Key habitat features required by several species include inundated muddy areas for foraging and low-lying, interspersed vegetation for both foraging and roosting.

The total area (ha) of temporary and permanent impact to the wetlands (calculated based on the field verified wetland extend) as a result of the Project is detailed in Table 7-1 and Table 7-2 and shown in Section 6. Changes to Public Utility Plant to accommodate the Project, such as electricity and telecommunications infrastructure, are unlikely to impact MNES as works do not require clearing of or substantial excavation within MNES fauna habitat such as wetlands or vegetation (remnant regional ecosystems (REs) or high value regrowth). Works are mostly within the Project Area or within road reserves where they are outside of the Project Area.

Key mitigation measures to reduce impacts to migratory birds are outlined in Table 7-9. Potential impacts have been minimised by the incorporation of bridges and culverts into the design to ensure hydrology is not significantly modified and active rehabilitation.

7.2.4.1 Construction Phase

7.2.4.1.1 Direct Loss of Foraging and Roosting Wetland Habitat

The potential removal of wetland areas during construction will result in a temporary loss of a small area of wetland habitat and vegetated wetland margins available for migratory birds during their non-breeding period within Australia. Loss of habitat has been identified as a threat to most migratory shorebird species throughout their global distributions. The loss of wetland habitat reduces the availability of foraging and roosting areas for migratory birds, which in turn impacts birds' ability to locate suitable wetland habitat areas and foraging resources, in order to accumulate the required energy stores necessary for successful migration. Areas of suitable wetland habitat can also provide year-round habitat for juvenile birds, with loss of these habitats potentially affecting the survivability of individuals in this region.

The loss, fragmentation and disturbance of wetland habitat has the potential to cause migratory birds to relocate to other wetland areas for foraging and/or roosting resources. This can lead to increased intraspecies competition in these wetlands for food resources, expedite resource depletion in adjacent suitable wetland habitat areas, and ultimately force birds to move additional or greater distances to find adequate resources.

7.2.4.1.2 Direct and Indirect Injury or Mortality of Individuals

During construction there is an increased risk of shorebird species being struck by mobile plant or road vehicles. This is due to a combination of factors including increased traffic, presence and use of construction machinery, size reduction of available habitat and increased disturbance the migratory shorebirds will experience.

The clearing of vegetation and bulk earthworks have the potential to result in injury or mortality to migratory birds which may be crushed by falling vegetation, machinery or be struck by or fly into moving vehicles as they seek alternative refuge in adjacent areas. In particular, there is a high risk of mobile plant or personnel movement disturbing and flushing birds from cover within the wetland, causing them to fly into other plant or oncoming traffic.

As migratory birds are anticipated to move away from sources of disturbance, this impact is anticipated to be minimal.

7.2.4.1.3 Indirect Degradation of Wetland Habitat via Alterations to Hydrology and Water Quality

Hydrology

The construction of temporary haul routes and access roads has the potential to cause temporary alterations to the local hydrology of wetlands and waterways by altering surface water flows. Key mitigation measures include the low flood immunity of the access track, which will over topped during minor flood events, and cross drainage culverts to maintain wetland and waterway connectivity during low flow conditions. Any changes to surface water are likely to be temporary, minor and reversible.

Changes to groundwater levels are likely to be minor and reversible as discussed in Sections 7.1.2.3.

During construction, sediment-laden water will be directed to sediment basins for treatment to meet the Surface Water Quality Investigation Criteria in the Environmental Management Plan prior to discharge. Sediment basins will not discharge to wetlands.

Increased water availability could potentially have long-term negative impacts to wetland ecosystems via increased nutrient loads, flow velocities and volumes. Some species of wetland plants are adversely affected by prolonged periods of inundation as it leads to a lack of oxygen available to their roots (Government of Western Australia, 2001). Over an extended timeframe, this can lead to significant changes in wetland vegetation diversity, structure and composition which in turn can reduce the habitat suitability for migratory birds. Substantial changes to surface water and groundwater hydrology are unlikely during construction and will be mitigated by measures such as the low flood immunity of temporary tracks, cross drainage culverts and capture of water in sediment basins.

Increased surface water availability and vegetation clearing can also lead to a localised rise in the water table, that is the upper surface of an area saturated with water (i.e. an aquifer), and associated rise in salinity (the presence of soluble salts in soils or waters). Water table salting is an increase in the concentration of salts associated with evaporation of water from a shallow aquifer. Capillary action draws water from the aquifer upwards through the soil and when the water evaporates, or is used by vegetation, the salts that were dissolved in the water accumulate at the soil surface or in the root zone. Seepage salting is a type of water table salting that occurs when groundwater seeps out at the ground surface. Seepage can reduce salt accumulation in the soil, when it is moved to the soil surface and flushed away, however, salt can accumulate in the area surrounding a seepage as a result of capillary action from the shallow water table (Queensland Government Department of Environment and Resource Management, 2011a).

In Queensland, areas with aquifers above 6 m below the ground surface with remnant vegetation, particularly tea tree (*Melaleuca* sp.), have the greatest potential to develop water table salinity following clearing (Queensland Government Department of Environment and Resource Management, 2011a). Water table salinity is unlikely to be a major issue across the floodplain given the aquifers of the floodplain typically sit below 5 m (as discussed in Section 4.3.4) and much of the vegetation is non-remnant (modified grassland) and not mapped as tea tree woodlands. It is possible that where and when the aquifer sits closer to the surface, for example when Pink Lily Lagoon sat at 4.3 m (east) to 5.5 m (east) after the 1991 major flood event (C&R Consulting, 2020), there could be salinisation but this is unlikely given the vegetation is already highly modified and dominated by grasses. Furthermore, the naturally elevated salinity levels that can be found in wetlands during extended dry periods (i.e. due to evaporation and wetlands being surface expressions of groundwater, which can be relatively saline in many parts of the Project Area).

Water Quality

During the construction phase, vegetation clearing, construction of haul routes and access tracks, and bulk earthworks have the potential to negatively impact the water quality of wetlands and waterways, resulting in a potential impact to migratory birds. These potential impacts include:

- Reduced water quality from point and non-point sources such as concentrated potential contaminants from impervious surfaces including nutrients, hydrocarbons and metals, sediment from exposed soils and stockpiles, and increases in erosion and sedimentation
- Stratification of temperature, dissolved oxygen and nutrients in the water column
- Changes to soil chemistry including exposure of acid sulfate soils
- Increased aquatic weeds, which can reduce oxygen levels in the water column overnight
- Potential salinization of wetlands and waterways as a result of rising water tables from vegetation clearing.

During construction, localised impacts to water quality may occur during periods of high rainfall, particularly during works on creek and wetland crossings, bridges and associated temporary structures. Water runoff from roads has the potential to be directed to sensitive wetland areas, which could be impacted through changes to water flow paths, flow velocities and frequency, and water quantities and quality, resulting in a potential impact to migratory birds. Where water from the road surface is discharged directly to adjacent land, higher peak flow rates in the discharge environments may occur. The increased frequency and magnitude of water may reduce habitat values in this area (increased erosion and reduction in refuge), and ultimately reduce the habitat quality for migratory birds (Austroads Inc. , 2000).

Sediment and suspended solids can have substantial ecological impacts. Water with a high level of sediment restricts plant respiration and can influence the foraging behaviour of migratory birds (negatively and positively). Nutrients can lead to increased risk of eutrophication and algal blooms, which can in turn reduce oxygen levels.

Fuel and/or chemical spills may arise from construction vehicles carrying fuels and/or chemicals. These contaminants have the potential to directly enter wetlands associated with the Project and negatively impact migratory bird habitat. Increased erosion and sedimentation can also alter the nature of the muddy margins and the diversity and abundance of benthic invertebrates, which provide food for most migratory birds.

Impacts to wetland water quality have been minimised by:

- Reducing the extent of clearing
- Rehabilitating all cleared areas within the Project Area (but outside of the Project Footprint)
- The requirement for the Construction Contractor to develop and implement an Erosion and Sediment Control plan.

Dewatering

Dewatering for construction of the floodplain or Limestone Creek bridges will be avoided, however may be required following heavy rainfall or where groundwater of surface water is encountered. Dewatering to 2 m is unlikely to encounter groundwater given the depth of the groundwater (recorded at > 3.85 m below the surface during July 2021 and recorded at > 12 m below the surface during the September 2021 baseline survey) and the geology (predominated by clay over siltstone). Surface water is unlikely to be encountered where works are undertaken outside of the wet season given the ephemeral nature of the waterway. Impacts to water quality and aquatic fauna habitat will be minimised where abstracted water is contained and used for dust suppression or released to the receiving environment within the Surface Water Quality Investigation Criteria in the Environmental Management Plan.

7.2.4.1.4 Indirect and Facilitated Degradation of Wetland Habitat via the Introduction and/or Spread of Invasive Weeds and/or Pest Animals

Given that current pest populations are well established in the Project Area and the broader region, the Project is unlikely to introduce new pest fauna species or exacerbate current weed populations. Nonetheless, construction activities can facilitate access by feral predators (such as wild dogs, cats and foxes) to areas of retained habitat, which can increase the predation risk to migratory shorebirds by feral predators.

Weeds are already prevalent and distributed across the Project Area. However, there is a risk that disturbance to vegetation, wetlands, changes to microhabitat and mobilisation of earthmoving equipment and materials may introduce or exacerbate weeds in areas which are currently host to only low or moderate density weeds. In the wetlands and adjacent riparian zones, continued grazing by livestock will further degrade wetland and riparian communities (specifically via decreased soil stability, increased erosion potential and eutrophication), and may impact habitat for migratory birds.

Key mitigation measures include pre-clearing surveys to locate declared plants in the Project Area, to inform removal and treatment, wash down of all vehicles and machinery, weed control and monitoring in the Project Area, pathogen management and spoil management, and covering of all putrescible waste generated during construction.

7.2.4.1.5 Indirect Degradation and Disturbance of Wetland Habitat via Increased Noise. Vibration and Light

Migratory birds respond to noise and vibration impacts with an alert response to the majority of noise levels; however, they may also be displaced from an area in response to loud noises or significant ground vibration. Sudden loud, impulsive or impact noises are capable of causing birds to become startled, which, if occurring over long periods, may affect foraging efficiency and roosting behaviour. Bulk earthworks (including excavation, construction and earthmoving) associated with the Project have the potential to cause temporary disturbance to migratory birds. Construction machinery will be a novel source of disturbance (both movement and noise related) and there may be some short-term disturbance associated with construction activities until birds become accustomed to these types of vehicles and activities.

Migratory birds that are routinely exposed to repetitive, non-lethal disturbance stimuli have energetic costs associated with their response to disturbance (West, et al., 2002; Goss-Custard, et al., 2006) and to minimise energy expenditure, migratory birds habituate to repetitive stimuli that do not present a direct mortality risk (Deniz, Lorenzo, & Hernandez, 2003; West, et al., 2002; Baudains & Lloyd, 2007; Smit & Visser, 1993). Acclimatisation by migratory birds may occur over the medium to long term and migratory birds are known to occur in areas subject to noise and light associated with a generally consistent or repetitive activity. For example, Latham's snipe and sharp-tailed sandpiper are both confiding species and particularly the snipe demonstrates elusive behavior characteristics, whereby they rely on their plumage and low-lying dense vegetative cover for protection. Both species are not easily flushed by small, routine disturbances such as loud noises or nearby human movement if accustomed to these disturbances at a given site.

As per the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds (Australian Government Department of Agriculture, Water and the Environment, 2020a):

> *… There is evidence that night-time lighting of migratory shorebird foraging areas may benefit the birds by allowing greater visual foraging opportunities. However, where nocturnal roosts are artificially illuminated, shorebirds may be displaced, potentially reducing their local abundance if the energetic cost to travel between suitable nocturnal roosts and foraging sites is too great. Artificial lighting could also act as an ecological trap by drawing migratory shorebirds to foraging areas with increased predation risk.*
>
> *Overall the effect of artificial light on migratory shorebirds remains understudied and consequently any assessment should adopt the precautionary principle and manage potential effects from light unless demonstrated otherwise.*

These guidelines state that artificial light sources should be managed so that shorebirds are not disrupted within or displaced from important habitat and are able to undertake critical behaviours such as foraging, roosting and dispersal. At important shorebird habitats, roosting and foraging numbers should remain constant and foraging birds should not be startled or at increased risk from predators as a result of increased illumination.

Many migratory birds have the ability to switch between visual foraging techniques and tactile (touch) foraging techniques with little loss in foraging efficiency (Robert & McNeil, 1989), yet artificial illumination of feeding habitat may also assist the foraging efficiency of species with a predominantly visual foraging strategy. One study of the influence of artificial illumination from street lighting on foraging efficiency found that artificial illumination had a positive effect on the nocturnal foraging of shorebirds, but on the other hand may draw them to degraded habitat areas close to the sources of illumination, and potentially elevates their exposure to native and introduced predators which are attracted to illuminated areas themselves (Santos, et al., 2009).

The Project may require temporary lighting of relatively small parts of the Project Area to illuminate construction and worksite areas at night. Artificial light can affect migratory birds by disrupting roosting and movement patterns, and foraging of nocturnal species, with quality of light (e.g. wavelength, colour), intensity and duration potentially evoking different responses. Impacts from increased artificial light levels include:

- Disorientation from or attraction toward artificial sources of light
- Mortality from collisions with structures
- Increase the abundance and efficiency of predators which could result in decreased populations of migratory birds, or migratory birds avoiding some areas due to an increased perceived risk of predation and/or becoming more vulnerable to predation.

Construction activities have the potential to cause a significant amount of disturbance to wetland habitats and surrounding areas. Increases in noise, lights, dust, vibrations and irregular vehicle movement that occurs during construction may disturb shorebird species, resulting in particular species avoiding or being displaced from suitable habitat areas during the presence of construction machinery and may affect their ability to forage effectively as they may display a heightened sense of vigilance. The longer periods of time birds spend being vigilant for perceived sources of danger or threats affects their foraging efficiency, especially leading up to northward migration in February through to April in which birds must amass the required fat reserves in order to successfully migrate to their breeding areas in the northern hemisphere.

Based on the multitude of suitable wetland habitats in proximity to the Project Area, there is the opportunity for birds that are present to seek alternative and suitable habitat for foraging and roosting nearby if they are disturbed from areas in proximity to Project works. Key mitigation measures to minimise potential impacts include:

- Avoid non safety-essential lighting with lighting limited to office, stores and lay down areas and areas of night works (the entire construction site will not be lit)
- Direct lights onto work areas
- Position lights at a height designed to reduce spill
- Quiet work practices in accordance with Australian Standard 2436-1981, Guide to noise control on construction, maintenance and demolition sites (Standards Australia, 1981)
- Machinery and equipment regularly serviced and maintained
- Appropriate selection of construction processes/methodologies and equipment
- Site vehicles to use dedicated haul roads where provided.

7.2.4.2 Operational Phase

7.2.4.2.1 Direct Loss of Foraging and Roosting Wetland Habitat

The loss of foraging and roosting habitat is also driven by the visual impairment caused by the construction of raised roadway and bridge structures. Wetland areas beneath proposed bridges, or adjacent to bridges or raised roadway are likely to be avoided by migratory birds, even if other habitat parameters are suitable. Such structures reduce the ability of foraging and roosting shorebirds to detect approaching predators such as diurnal and nocturnal raptors (e.g. falcons, owls) and therefore the behavioural response of migratory shorebirds present will most likely be a reluctance to use wetland areas within a certain distance of the constructed road.

7.2.4.2.2 Direct and Indirect Injury or Mortality of Individuals

Once the Project is complete, the Fitzroy River floodplain and associated wetland areas will be traversed by the new roadway. The introduction of moving traffic along the new road once it has been completed results in an increase in risk of collisions migratory birds and other waterbirds with road vehicles. Following completion of the road, the initial period of operation is expected to result in the highest risk of bird and vehicle collisions. After some time, waterbirds in the area are expected to become conditioned to the presence of the new road and adjust their local movement behaviours to avoid the road.

7.2.4.2.3 Indirect Degradation of Wetland Habitat via Alterations to Hydrology and Water Quality

Altered hydrology and water quality can impact wetlands and migratory birds as outlined for construction (Section 7.2.4.1.3) and aquatic fauna (Section 7.2.2.1.5 and 7.2.2.2.4).

During operation, the main risk of the Project to the degradation of migratory bird wetland habitat is the increase in pavement runoff associated with the new road surface area. An increase in impervious surfaces (i.e. paved roadway) is likely to lead to changes in temporality of inundation, wetland depths, and enables both sediment and pollutant/toxicant runoff into nearby wetland areas. Contaminants created or deposited by vehicles may become suspended in runoff and drainage waters. Typical road contaminants include sediment, heavy metals, hydrocarbons, pesticides, and biological material such as faecal matter and seed (from the transportation of livestock). Deposition of contaminated runoff can negatively impact water quality, which in turn can adversely impact wetland ecosystems upon which migratory birds depend. Reduced biodiversity in wetland systems can result in trophic cascades, which impacts the overall ability of ecosystems to function, and may lead to permanent changes to the viability of wetlands to support migratory shorebirds.

Results of MUSIC modelling for the Project (Jacobs SMEC Design Joint Venture, 2021g) showed that the proposed stormwater treatment design helps in reducing pollutant load reduction of total suspended solids, total phosphorus, total nitrogen, and gross pollutant at most waterways and wetlands. A range of water quality control devices have been incorporated into the design to minimise the potential impact of the Project on migratory bird wetland habitat. Key mitigation measures include in locations where bridges pass over wetlands, the intent is for runoff to be collected in scuppers (i.e. an outlet on a bridge to drain water from the bridge surface) and along longitudinal drainage pipes connected to the bridge deck and discharged outside of wetlands. Where possible, these pipes will outlet directly to bioretention basins which include spill containment devices to capture and treat runoff. Where this is not feasible due to the extents of flood inundation along the road corridor, or constraints associated with the bridge length and grade, the pipes will outlet outside of the wetlands.

In order to maintain the current hydrological characteristics of the area, the design includes 18 bridges, which span approximately 7 km in total including all floodplain wetlands. The design also includes culverts at minor tributaries and overland flow paths, and no major diversion of waterways. Hydraulic changes are minor and not expected to impact wetland habitat under normal flow or flood conditions.

7.2.4.2.4 Indirect Degradation of Wetland Habitat via the Introduction and/or Spread of Invasive Weeds and/or Pest Animals

Once the Project is operational, a significant increase in vehicular traffic will be directed through wetland, woodland and grassland areas that have been subject to limited if any vehicular movement. Roads and other transport corridors are subject to invasive vegetation becoming introduced and established from passing vehicles that are carrying seed or plant material from outside the Project Area. Runoff from impervious surfaces during and post-construction have the potential of distributing invasive plant material into nearby wetland habitats. Invasive plants establish easily in disturbed areas, particularly on the edge of intact natural habitats. The introduction of weeds and invasive plants can change the structure, complexity and characteristics of wetlands potentially making them less suitable or unsuitable for migratory bird species that current utilise these areas.

Once operational, the Project may lead to an increase in pest animal densities which are likely to take advantage of

- Improved facilitated accessibility through the landscape
- Illuminated areas which make foraging and hunting easier
- Scavenging opportunities, in areas in which roadkill may be present.

An increase in pest animals may lead to increased predation on migratory birds and disturbance to wetland areas.

Weed management within the road corridor will be undertaken in accordance with the Department of Transport and Main Road (TMR) Routine Maintenance Guidelines.

7.2.4.2.1 Indirect Degradation and Disturbance of Wetland Habitat via Increased Noise. Vibration and Light

The Project will have permanent lighting at roundabouts, interchanges and the Fitzroy Bridge to meet safety standards and the Project will also generate ongoing noise from traffic. Potential impacts on migratory birds from lighting and noise will be similar to those discussed above for construction (Section 7.2.4.1.5), with the main difference being that operational noise is likely to be lower intensity due to the lack of construction activity but of permanent duration.

As discussed in Section 7.2.4.1.5, several studies have shown that migratory birds habituate to many forms of repetitive disturbance (Deniz, Lorenzo, & Hernandez, 2003; West, et al., 2002; Baudains & Lloyd, 2007; Smit & Visser, 1993; Goss-Custard, Triplet, Sueur, & West, 2006). However, it is possible that some habitats will no longer be used by certain species due to their already small size, disturbance during construction and close proximity to the Project (i.e. wetlands within and adjacent to the Project area).

As discussed in Section 7.2.4.1.5, artificial light sources will be managed so that shorebirds are not disrupted within or displaced from important habitat and are able to undertake critical behaviours such as foraging, roosting and dispersal.

Where birds are not habituated to the disturbance associated with the operation of the road, and fly away in response to a perceived approaching threat, this can result in increased energy expenditure. The longer periods of time birds spend avoiding perceived sources of danger or threats affects their foraging efficiency and can affect their ability to migrate to their breeding areas in the northern hemisphere. The Project may also lead to increased disturbance and mortality due to an increase in natural predators, especially raptors or birds of prey. Completed infrastructure in the Project Footprint will provide additional perching and observation locations for raptor species in the vicinity of existing wetland areas which may also lead to increases in disturbance to foraging or roosting migratory birds. Based on the multitude of suitable wetland habitats in proximity to the Project Footprint, there is the opportunity for birds to seek alternative and suitable habitat for foraging and roosting nearby if they are disturbed from areas by noise, vibration or light.

Key mitigation measures to minimise potential impacts include limiting lighting to roundabouts, intersections and the Fitzroy Bridge.

7.3 Risk Assessment

This section provides an assessment of the potential risks to MNES flora, fauna and habitat associated with the Project without mitigation (left hand columns), and the residual risks with mitigation (right hand columns) (Table 7-9). For ease of assessment, and to avoid duplication of mitigation measures, impacts have been amalgamated into categories:

- Direct mortality or injury of fauna
- Direct loss or indirect fragmentation of flora or fauna habitat to facilitate construction (temporary) and operation (permanent)
- Indirect degradation of flora or fauna habitat via introduction or spread of invasive weeds
- Indirect degradation of flora or fauna habitat via introduction or spread of pest animals or pathogens
- Indirect degradation of flora or fauna habitat via increased dust or light pollution
- Indirect degradation of habitat via increased noise or vibration pollution
- Indirect degradation of habitat via erosion and sediment and alternations to water quality
- Indirect loss of habitat values via altered surface hydrological regimes

A residual risk (with mitigation) rating of ‘low’ is deemed to be an acceptable risk and indicates that the proposed mitigation measures are considered to be appropriate to the level of the risk. The outcomes of the environmental risk assessment indicate that the majority of the environmental risks associated with the Project can be effectively mitigated.

The only residual risk with a rating of ‘high’ is the loss or fragmentation of habitat to facilitate operation (permanent), which cannot be avoided but has been minimised to the greatest extent possible. The loss or fragmentation of habitat to facilitate construction (temporary) and degradation of habitat via erosion and sediment and alternations to water quality during construction have a residual risk of ‘medium’, but cannot be completely avoided, but have been minimised the greatest extent possible.

Further details of the management of potential impacts, include the full suite of mitigation measures, are provided in the Environmental Management Plan (Appendix A) and relevant subplan:

- MNES Flora and Fauna
- Erosion and Sediment Control
- Groundwater and Surface Water
- Acid Sulfate Soils
- Weed and Pest
- Landscape and Revegetation.

Each sub plan provides proposed mitigation and management measures that consider the S.M.A.R.T principle, that is:

S – Specific (what and how)

M – Measurable (baseline information, number/value, auditable)

A – Achievable (timeframe, money, personnel)

R – Relevant (conservation advices, recovery plans, threat abatement plans)

T – Time-bound (specific timeframe to complete).

Each sub plan provides measures which include an assessment of the predicted effectiveness and environmental outcomes of the proposed measures (i.e. performance outcomes), including details of any baseline data or proposed monitoring required to demonstrate progress towards achieving these outcomes, and details of ongoing management, including monitoring programs to support an adaptive management approach (e.g. reporting and corrective actions) and determine the effectiveness of the proposed measures.

Table 7-9 Environmental risk assessment for matters of national environmental significance fauna

Potential impact	Phase	Likelihood	Consequence	Risk Rating	Key Mitigation/Management Measures Relevant Sub Plan in the Environmental Management Plan	Likelihood	Consequence	Residual Risk
Direct mortality or injury of fauna	Construction	5	3	15	Engage fauna spotter/catcher during vegetation clearing. Pre-clearing surveys. All no-go zones clearly identified. Staged vegetation clearing. Fauna exclusion fencing at fauna habitat. Trees remain in place until koala vacates of own accord. Relocate or transport fauna to a wildlife carer/vet/animal hospital in accordance with Damage Mitigation Permit. Trenches inspected morning and afternoon. Flushing transects within 150 m of a wetland. Re-inspect all potential habitat immediately prior to clearing. Salvage of fish and turtles in accordance with Guidelines. Site induction for all personnel involved in clearing. Construction MNES Flora and Fauna Sub Plan.	2	2	4
Direct mortality or injury of fauna	Operation	5	3	15	Fauna fencing at Limestone Creek to direct fauna under the bridge and assist with connectivity. Fauna fencing in accordance with TMR Standard Drawing No. 1603. Bridge abutments are set back from the banks of waterways to provide fauna passage.	3	2	6

Potential impact	Phase	Likelihood	Consequence	Risk Rating	Key Mitigation/Management Measures Relevant Sub Plan in the Environmental Management Plan	Likelihood	Consequence	Residual Risk
Indirect loss or fragmentation of habitat to facilitate construction (temporary)	Construction	5	2	10	Minimise clearing extents. Locate ancillary infrastructure in cleared areas. Staged and sequential clearing. Fauna fencing and no-go zones define clearing limits. Trenches inspected morning and afternoon. Fauna spotter/catcher surveys, monitoring and reporting. Lighting in accordance relevant standards. Progressive rehabilitation of temporarily disturbed areas. Active rehabilitation within the riparian zone of Fitzroy River, Lion Creek and Limestone Creek and wetlands. Maintain wetland connectivity through and culverts. Bridges over the Fitzroy River and Limestone Creek to minimise barriers to turtle movement. All bridge abutments set back from waterways and wetlands to provide dry fauna passage, and passage of fishes and turtles. Construction MNES Flora and Fauna Sub Plan. Construction Groundwater and Surface Water Sub Plan. Construction Landscape and Revegetation Sub Plan.	3	2	6
Indirect loss or fragmentation of habitat to facilitate operation (permanent)	Operation	5	3	15	Minimise clearing extents. Avoid Black Duck Lagoon. Lighting in accordance with relevant standards. Maintain wetland connectivity through 18 bridges spanning approximately 7 km over all waterway and wetlands and culverts. Bridges over the Fitzroy River and Limestone Creek to minimise barriers to turtle movement. All bridge abutments set back from waterways and wetlands to provide dry fauna passage, and passage of fishes and turtles. Bridges to increase movement across floodplain and fauna fencing. Bridge abutments set back from banks to provide passage.	5	2	10

Potential impact	Phase	Likelihood	Consequence	Risk Rating	Key Mitigation/Management Measures Relevant Sub Plan in the Environmental Management Plan	Likelihood	Consequence	Residual Risk
Indirect degradation of habitat via introduction or spread of invasive weeds	Construction	4	2	8	Machinery and vehicles cleaned where Biosecurity Matters known to occur. All restricted invasive species are to be controlled in accordance with Biosecurity guidelines. Ongoing monitoring and reporting. Minimise clearing extents. Progressively rehabilitation. Pre-clearing survey to locate declared pest plants within the Project Area to inform removal or treatment. Construction Weed and Pest Sub Plan.	3	1	3
Indirect and facilitated degradation of fauna habitat via introduction or spread of invasive weeds	Operation	3	2	6	Weeds managed in accordance with TMR's Routine Maintenance Guidelines (2017). All restricted invasive species are to be controlled in accordance with Biosecurity guidelines. Operation Weed and Pest Sub Plan.	3	1	3
Indirect and facilitated degradation of habitat via introduction or spread of pest animals or pathogens	Construction	2	2	4	All restricted invasive species are to be controlled in accordance with Biosecurity guidelines. Management measures to reduce the risk of spreading *Phytophthora cinnamomi.* Construction Weed and Pest Sub Plan.	1	2	2
Indirect and facilitated degradation of habitat via introduction or spread of pest animals or pathogens	Operation	2	2	4	All restricted invasive species are to be controlled in accordance with Biosecurity guidelines. Operation Weed and Pest Sub Plan.	1	2	2
Indirect degradation of habitat via increased dust or light pollution	Construction	5	2	10	Avoid unnecessary light spill into the adjoining fauna habitat areas. Dust suppression measures. Disturbed surfaces rehabilitated as soon as practical. Use dedicated haul roads where provided. Construction MNES Flora and Fauna Sub Plan.	3	1	3

Potential impact	Phase	Likelihood	Consequence	Risk Rating	Key Mitigation/Management Measures Relevant Sub Plan in the Environmental Management Plan	Likelihood	Consequence	Residual Risk
Indirect degradation of habitat via increased dust or light pollution	Operation	5	2	10	Lighting in accordance relevant standards. Avoid unnecessary light spill into the adjoining fauna habitat areas. No dust expected during operation.	3	1	3
Indirect degradation of habitat via increased noise or vibration pollution	Construction	3	1	3	Construction works and consideration of quiet work practices carried out in accordance with Australian Standard. Machinery and equipment regularly serviced and maintained. Appropriate selection of construction processes/methodologies and equipment which minimise the generation of noise. Construction MNES Flora and Fauna Sub Plan.	2	1	2
Indirect degradation of habitat via erosion and sediment and alternations to water quality	Construction – Erosion and sediment control	4	3	12	ESCP in accordance with The Best Practice Erosion and Sediment Control Manual and TMR Main Roads Technical Standard 52 – Erosion and Sediment Control (MRTS52). Erosion and Sediment Control Plan signed off by a Certified Professional in Erosion and Sediment Control. Sediment and erosion controls adequate and operational at the beginning and end of each working day. All erosion and sediment controls maintained in effective working order and operated and maintained in a manner that minimises the risk of environmental harm. Pumping out sediment basins and/or flocculating turbid water in basins prior to periods of heavy or prolonged rainfall. Minimised duration of works within drainage lines and tributaries. Minimised vegetation clearing to that necessary to conduct the works. Stage works to minimise the area of exposed earth. Divert clean flows around disturbed areas. Where suitable cleared vegetation not infested by weeds, will be mulched and re-used on site as a surface cover to reduce erosion and growth of weeds. Construction Erosion and Sediment Control Sub Plan. Construction Groundwater and Surface Water Sub Plan. Construction Landscape and Revegetation Sub Plan.	3	2	6

Potential impact	Phase	Likelihood	Consequence	Risk Rating	Key Mitigation/Management Measures Relevant Sub Plan in the Environmental Management Plan	Likelihood	Consequence	Residual Risk
Indirect degradation of habitat via erosion and sediment and alternations to water quality	Construction – Water quality	4	3	12	Spill prevention and response plans. Water required for construction not sourced from mapped wetlands. Monitoring of surface water and groundwater quality and groundwater levels. Spill containment devices installed at all bio-basins that capture and treat runoff. No material or debris falls or is deposited into drainage lines or waterways during construction. No waste or litter in drainage lines or waterways. Discharge, dewatering to land and/or waterway (where relevant) compliant with the Surface Water Quality Investigation Criteria in the Environmental Management Plan. Construction Erosion and Sediment Control Sub Plan. Construction Groundwater and Surface Water Sub Plan. Construction Landscape and Revegetation Sub Plan.	3	2	6
Indirect degradation of habitat via erosion and sediment and alternations to water quality	Operation	3	2	6	Permanent water quality treatment devices. Stormwater not directly discharged into the mapped extent of retained wetlands or waterways where practical. Spill containment devices are to be included in the design of all bridges and bioretention basins.	2	1	2
Indirect loss of habitat values via altered surface hydrological regimes	Construction	4	3	12	Temporary access tracks and crane pads use transverse culverts and pipes or porous material. Stormwater discharge is to be appropriately managed to avoid significant local changes in the volume and velocity.	3	1	3
Indirect loss of habitat values via altered surface hydrological regimes	Operation	3	3	9	Maintain wetland hydrology through inclusion of 18 bridges (approximately 7 km) and numerous cross-culverts. Avoid diversion or retraining of watercourses. Stormwater discharge is to be appropriately managed to avoid significant local changes in the volume and velocity. Bridge abutments set back from banks.	2	1	2

7.4 Cumulative Impacts

TMR is a State Government agency which plans, manages and delivers Queensland's integrated transport environment and have delivered a range of Projects within the Rockhampton region and across Queensland. The current Project will integrate with major infrastructure already completed within the Rockhampton Region, including Yeppen North and Yeppen South Projects, as well as current works in construction including the Rockhampton Northern Access Upgrade Project and the Capricorn Highway Duplication (Rockhampton – Gracemere) Project.

The current Project will integrate with the above-mentioned projects; however, is not considered to form part of a staged development related to the above-mentioned projects. Although all the projects in the region intend to improve the transportation network and function, as well as provide increased flood resilience, the current Project is considered an independent action which is not dependent on the other regional road upgrade projects. The above-mentioned projects have both undergone environmental assessments and developed appropriate mitigation measures based on the project specific impacts. There does not appear to be significant impacts to Latham's snipe as a result of the above-mentioned projects which would increase the cumulative impacts to the species.

At the time of writing this Preliminary Documentation Report, the only other action referred under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in the Rockhampton area in the past five years is the South Rockhampton Flood Levee Project (2019/8466) being undertaken by the Rockhampton Regional Council. This project was assessed as not having a significant impact on migratory birds and was declared not a controlled action on 30 August 2019.

In consideration of other projects being undertaken in the locality, the cumulative impacts to the current Project is anticipated not to significantly impact additional MNES or increase the significance of the impacts to Latham's snipe.

7.4.1 Cumulative Impacts to MNES

This section provides an assessment of cumulative impacts, including accumulating or compounding impacts, associated with the Project for a particular MNES.

The risk assessment (Table 7-9) has been used to inform the cumulative impacts assessment. A residual risk (with mitigation) rating of 'low' is deemed to be an acceptable risk and indicates that the proposed mitigation measures are considered to be appropriate to the level of the risk. The outcomes of the environmental risk assessment indicate that the majority of the environmental risks associated with the Project can be effectively mitigated.

The only residual risk with a rating of 'high' is the loss or fragmentation of habitat to facilitate operation (permanent), which cannot be avoided but has been minimised to the greatest extent possible.

The loss or fragmentation of habitat to facilitate construction (temporary) and degradation of habitat via erosion and sediment and alternations to water quality during construction have a residual risk of 'medium', but cannot be completely avoided, but have been minimised the greatest extent possible.

Where particular MNES are subject to high or moderate residual risks they have been assessed in conjunction with the other potential impacts for that particular MNES to inform potential cumulative impacts for that MNES.

7.4.1.1 Flora

As discussed in Section 7.2.1:

- A small area of suitable black ironbox habitat will be temporarily lost and the population is likely to be physically fragmented, particularly during the construction phase, however the area will be rehabilitated and given this species disperses seeds through the waterway there will be no long term impacts to genetic connectivity.

- The Project will result in the loss of a small patch of the brigalow TEC within the Project Footprint, however most of this TEC with the Project Area is outside of the Project Footprint and will be protected by a no-go zone. The Project is not likely to fragment the brigalow TEC.

This loss of habitat, and potential fragmentation of black ironbox habitat, could be compounded by temporary impacts associated with construction such as altered surface hydrology, dewatering or the introduction of weeds, or permanent impacts associated with operation such as the introduction or spread of weeds.

Weed impacts to black ironbox are unlikely to be substantial given the understorey was dominated by the weed species *Leucaena leucocephala* (leucaena) and the sparse to mid-dense groundcover was dominated by weedy grasses during the Project surveys. Exotic species in the brigalow TEC comprised < 1% of the total vegetation cover and were mainly concentrated around the edges during the Project surveys, therefore there is the potential for weeds to spread through the habitat however this is unlikely given works will be limited to the edge of the community. Potential impacts of weeds to flora will be mitigated by weed control, minimising clearing, rehabilitation and defined no go zones.

Dewatering is unlikely to be required for the installation of the Limestone Creek bridge given the ephemeral nature of the waterway, the depth of the groundwater (recorded at > 3.85 m below the surface during July 2021 and recorded at > 12 m below the surface during the September 2021 baseline survey), and the geology (predominated by clay over siltstone), however it may be required following heavy rain. Where dewatering is required, the surface water and/or groundwater level is unlikely to be unaltered given the relatively small area to be dewatered, the shallow depth to be dewatered, and the short duration of dewatering. Dewatering would only take place during construction, with each pier requiring dewatering for up to approximately six weeks where water is encountered (and a total construction duration of approximately three years). Potential impacts would be temporary and potential impacts would be temporary and reversible.

The brigalow TEC is unlikely to be impacted by dewatering given water abstracted from the Fitzroy River is surface water proposed for return to the river where within the Surface Water Quality Investigation Criteria in the Environmental Management Plan. The level of groundwater or surface water are unlikely to be altered in the vicinity of the TEC.

7.4.1.2 Aquatic Fauna

As discussed in Section 7.2.2, the temporary loss and fragmentation of small areas of freshwater turtle and estuarine crocodile habitat along the riparian areas of Fitzroy River and Limestone Creek is anticipated to occur as a result of vegetation clearing, bulk earthworks, construction of haul routes and access tracks. These construction activities also have the potential to negatively impact the water quality of wetlands and waterways. This loss of habitat, and potential impacts to water quality, could be compounded by fauna injury and mortality, the introduction or spread of weeds and pests, degradation to habitat via noise and vibration, and impacts to aquatic fauna movement patterns.

The Environmental Management Plan (Appendix A) includes mitigation measures for working around freshwater turtles and estuarine crocodiles. Sub plans developed to manage impacts, include MNES Flora and Fauna, Groundwater and Surface Water, Acid Sulfate Soils and Weed and Pest. Cumulative impacts will be low where management measures in these sub plans are implemented.

7.4.1.3 Terrestrial Fauna

As discussed in Section 7.2.3, the temporary loss and fragmentation of habitat for terrestrial fauna is anticipated to occur due to vegetation clearing, bulk earthworks, construction of temporary haul roads, access roads, site offices and laydown areas. These activities also have the potential to negatively impact the water quality of wetlands and waterways and impact terrestrial fauna such as squatter birds (that need to access fresh water daily) and ornamental snakes (that occur in wet habitats but were not recorded during the Project surveys). This loss and/or fragmentation of habitat, and potential impacts of degraded water quality for some species, could be compounded by fauna injury and mortality, the introduction or spread of weeds and pests, degradation to habitat via noise, vibration and light adjacent to retained habitats, and impacts to fauna movement patterns.

The Environmental Management Plan (Appendix A) includes mitigation measures for working around terrestrial fauna. Several sub plans have been developed to manage impacts, including MNES Flora and Fauna, Groundwater and Surface Water, Weed and Pest and Landscape and Revegetation. Cumulative impacts will be low where management measures in these sub plans are implemented.

7.4.1.4 Migratory Birds

As discussed in Section 7.2.4, potential loss, fragmentation and disturbance of wetland areas will result in a loss of wetland habitat and vegetated wetland margins available for migratory birds during their non-breeding period within Australia, and the loss and disturbance of wetlands has the potential to impact water quality. This loss of habitat, and potential impacts of degraded water quality, could be compounded by migratory bird injury and mortality, the introduction or spread of weeds and pests, and degradation to habitat via noise, vibration and light.

The Environmental Management Plan (Appendix A) includes mitigation measures for working around migratory birds. Several sub plans have been developed to manage impacts to aquatic fauna, including MNES Flora and Fauna, Groundwater and Surface Water, and Weed and Pest. Cumulative impacts will be low where management measures in these sub plans are implemented.

7.4.2 Other Projects

Other projects in the Rockhampton region (Figure 7-3) are unlikely to have a cumulative impact to MNES given the scale, nature and timing of the projects as outlined below. As described in section 2.4.3, the below projects were identified as relevant for assessment of potential cumulative impacts because they:

- are located within 50km of the Rockhampton Ring Road
- will be in construction at a time that overlaps with the Rockhampton Ring Road construction, and/or
- have the potential to impact on MNES that the RRR also has a moderate or high risk of impact.

7.4.2.1 Lower Fitzroy River Infrastructure Project

The Lower Fitzroy River Infrastructure Project was approved with conditions on 8th December 2016. The project was assessed under the Bilateral Agreement with the Queensland Government by the Queensland Office of the Coordinator-General through an environmental impact statement. The Queensland Coordinator-General completed the Assessment Report, which assessed impacts on all MNES for this project.

The project involves the raising of Eden Bann Weir and construction of a new weir at Rookwood on the Fitzroy River, which are 62 km north-west and 66 km south-west of Rockhampton respectively. The project also involves associated infrastructure, including turtle and fish passage structures, and augmentation of access roads and river crossings affected by the project.

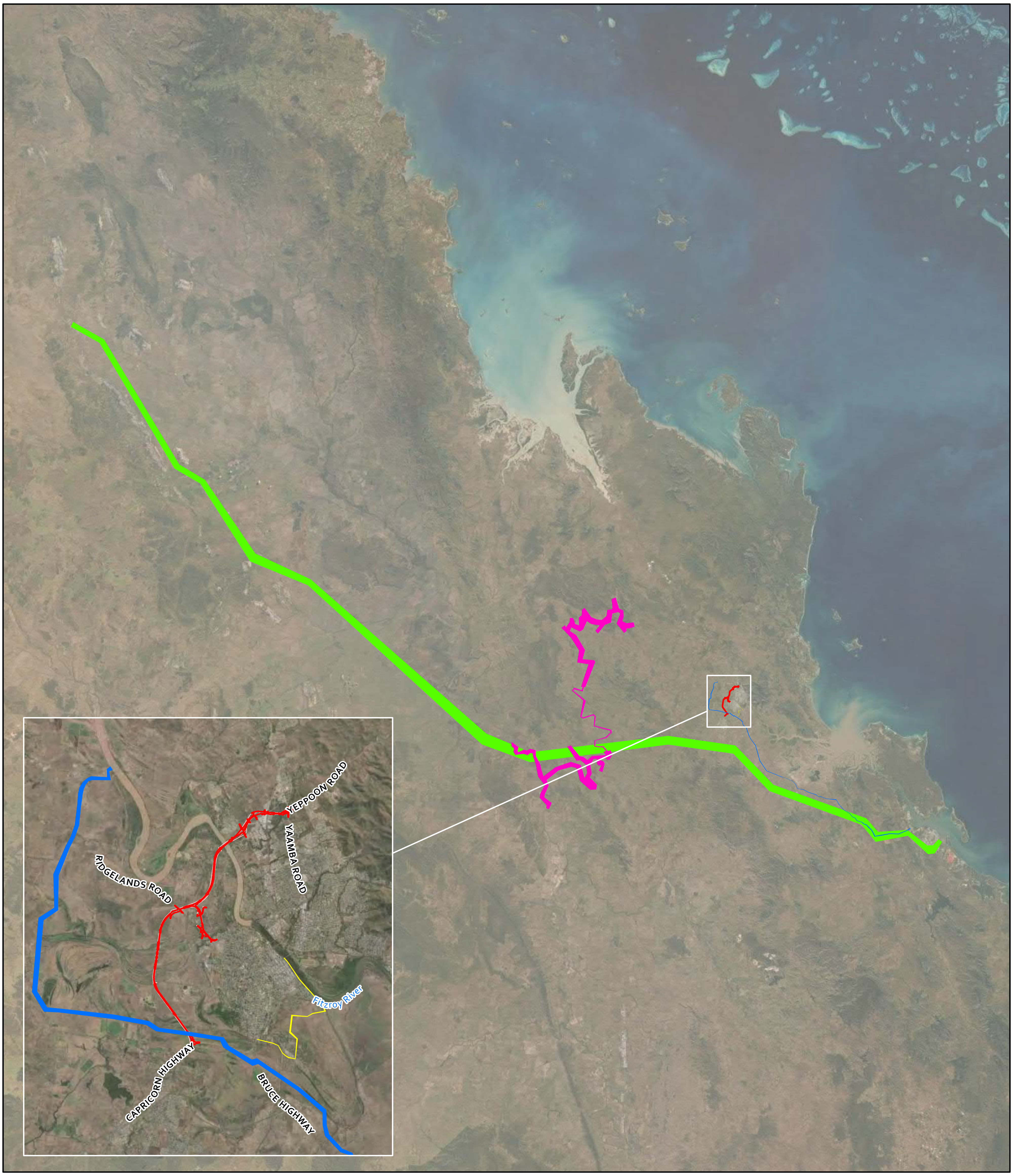
The Lower Fitzroy River Infrastructure Project works have commenced with an expected completion date of 2023. The construction periods of the Lower Fitzroy River Infrastructure Project and the Rockhampton Ring Road are expected to overlap, however accumulating impacts are unlikely as outlined below.

The Lower Fitzroy River Infrastructure Project has the potential to impact MNES (Queensland Government The Coordinator-General, 2016a) with residual impacts to the following relevant MNES (Australian Government Department of the Environment and Energy, 2020a):

- Brigalow (*Acacia harpophylla* dominant and co-dominant) ecological community
- Black ironbox (*Eucalyptus raveretiana*)
- Fitzroy River turtle *(Rheodytes leukops*).

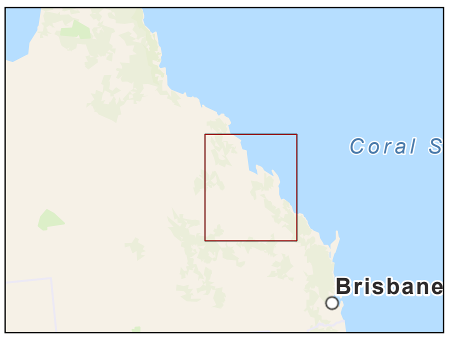
The Rockhampton Ring Road also has the potential to impact a relatively small area of brigalow TEC (approximately 0.3 ha) and black ironbox (approximately 0.3 ha). The geographic distance between the two projects and the small size of the Rockhampton Ring Road impacted area of brigalow and black ironbox do not result in a net negative cumulative impact on these species.

Figure 7-3 Other projects in the Rockhampton area



Legend

- Central Queensland Gas Pipeline
- Gladstone-Fitzroy Water Pipeline
- Proposed South Rockhampton Flood Levee
- Lower Fitzroy River Infrastructure Project
- Project Footprint
- Project Area



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Jacobs SMEC
Jacobs SMEC Design Joint Venture

Source: Jacobs: Design (2021); Metromap: Imagery (2020)

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Impacts of reduced water quality on freshwater turtles are unlikely to be accumulating as MUSIC modelling shows that significant water quality impacts are not predicted during the operational phase of the Rockhampton Ring Road due to the inclusion of water treatment. These devices are discussed in Section 7.1.2.2.1 and shown in Figure 7-1 and Figure 7-2. Potential impacts will be managed during the construction phase by way of an erosion and sediment control plan as outlined in the Environmental Management Plan (Appendix A).

7.4.2.2 Gladstone-Fitzroy Pipeline

The Gladstone-Fitzroy Pipeline project was approved with conditions on 3rd November 2011. It involves a 115 km pipeline to enable the transfer of 30,000 ML of water per annum from the lower Fitzroy River to Gladstone. The pipeline will run within the Stanwell-Gladstone Infrastructure Corridor for the majority of its length before connecting with existing water infrastructure in the Gladstone State Development Area (Figure 7-3). The project involves an underground pipeline, intake and pump stations, reservoirs and a water treatment plant. The pipeline crosses the Rockhampton Ring Road near the Capricorn Highway.

The Gladstone-Fitzroy Pipeline project is expected to appoint a preferred contractor in April 2022. The construction period of the Gladstone-Fitzroy Pipeline and the Rockhampton Ring Road may overlap however it is not known when works will take place in the vicinity of the Rockhampton Ring Road.

This project was also assessed under the Bilateral Agreement with the Queensland Government by the Queensland Office of the Coordinator-General through an environmental impact statement. Activities associated with the construction of the project that have the potential to impact upon EPBC Act listed threatened species and threatened ecological communities include:

- vegetation clearing and habitat disturbance
- habitat fragmentation and disturbance to wildlife movement corridors
- disturbance to wetlands and waterways, and
- introduced fauna and flora.

The project was however deemed unlikely to have a significant impact on MNES (Queensland Government The Coordinator General, 2010), hence accumulating impacts to MNES associated with the Rockhampton Ring Road are unlikely.

7.4.2.3 Central Queensland Gas Pipeline

The Central Queensland Gas Pipeline was approved with conditions on 15th October 2007 and involves a 450-kilometre, underground, high-pressure gas transmission pipeline from the Bowen Basin to Gladstone (Figure 7-3). The pipeline involves a 30-metre-wide easement and 300mm- to 400mm-diametre pipeline, buried at a depth of at least 900mm.

The Central Queensland Gas Pipeline has the potential to also impact brigalow ecological community, through clearing of 24 ha, however this community is widely represented in the region, and the impact of the corridor will not affect the status of these communities (Queensland Government The Coordinator-General, 2007a). Due to large distance between the projects and the relatively small area of brigalow to be cleared by each project compared to the much larger extent of this community in the broader area, the impacts are not expected to be accumulating.

7.4.2.4 Proposed South Rockhampton Flood Levee

Rockhampton Regional Council proposed to construct the South Rockhampton Flood Levee around the southern outskirts on the western bank of the Fitzroy River and floodplain. The proposed 8.7 km levee would run from the Rockhampton CBD to the Bruce Highway at Upper Dawson Road, and was identified as the most cost-effective option to mitigate the effects of flooding in Gladstone Road, the lower CBD, Depot Hill, Port Curtis and Allenstown (Figure 7-3) (Rockhampton Regional Council, 2020).

The Project included an 8.7km long levee across 58 properties. The levee consisted of sections of earth embankment, crib wall, vertical composite flood wall, temporary demountable flood barriers and an emergency spillway together with backflow prevention devices and three pump stations. This project was declared not a controlled action under the *Environment Protection and Biodiversity Conservation Act 1999* on 30 August 2019.The proposal was made as a Ministerial Infrastructure Designation under the *Planning Act 2016*. The

Infrastructure Designation Request was made by Rockhampton Regional Council to the Planning Minister under Chapter 2, Part 5 of the *Planning Act 2016*.

This is an unfunded project. On 13 October 2020, Council resolved to formally ask the State and Federal Governments to redirect already committed money for the South Rockhampton Flood Levee to other priority projects in the region (Rockhampton Regional Council, 2020).

That is, the South Rockhampton Flood Levee is unlikely to proceed in the short term and an assessment of MNES has not been undertaken. The Ministerial Infrastructure Designation identified state requirements associated with acid sulfate soils, landscaping (rehabilitation), flora and fauna (vegetation and fauna management associated with clearing, biosecurity), wetlands (water levels, flow and fish passage), stormwater (water quality management) and contaminated land.

If the project progressed the following matters may need to be considered for assessment as accumulating impacts:

- Water quality, however accumulating impacts are unlikely to impact freshwater turtles given the levee would be located downstream of the Fitzroy Barrage and impacts associated with each project would effectively be separated by the barrage.
- Water flow and wetlands, however accumulating impacts are unlikely to be substantial given the broader floodplain associated with the Rockhampton Ring Road is a relatively large area compared to that proposed to be influenced by the levee, and that the floodplain is flooded from both the north and south via areas not altered by the levee (i.e. Gavial Creek).

If funded in 2022 or later this project is unlikely to be built prior to the completion of the Rockhampton Ring Road. There would therefore be no cumulative construction impacts on the environment.

7.5 Significant Impact Assessment

To determine if the Project will have a significant impact on the MNES identified in the Preliminary Documentation Request for Further Information (RFI), a significant impact assessment has been undertaken for each relevant MNES. The assessments assume implementation of all mitigation and management actions described in Section 7.2.

Unless otherwise defined for a particular MNES, an important population is a population that is necessary for long-term survival and/or recovery of a species or community. This may include populations identified as such in recovery plans and or that are:

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

Unless otherwise defined for a particular MNES, habitat critical to the survival of a species (i.e. critical habitat) includes areas that are necessary:

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

Extent of occurrence is defined as the area that includes all the known, inferred or projected sites of present occurrence of a species, excluding cases of vagrancy (i.e. when individual animals appear well outside their normal range). Area of occupancy is defined as the area within the extent of occurrence, which is occupied by a species (excluding cases of vagrancy) and reflects the fact that a species will not usually occur throughout the total extent of occurrence due to unsuitable or unoccupied habitats (Australian Government Department of the Environment and Energy, 2018).

7.5.1 Flora

7.5.1.1 Black Ironbox (Eucalyptus raveretiana) – Vulnerable

To determine if the Project is likely to have a significant impact on black ironbox (*Eucalyptus raveretiana*), a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-10).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the black ironbox (*Eucalyptus raveretiana*).

Black ironbox has a wide distribution in Queensland coastal and sub-coastal areas, from Townsville to Nebo, around Rockhampton and areas 100 km to the west of Rockhampton in tributaries of the Fitzroy River (Australia Government Department of Agriculture, Water and the Environment, 2021s). The Project Area is near the southern extent of distribution and the population is therefore considered an important population.

The area of extent is estimated to be between 4 million ha (excluding vagrant records near Cairns) (Atlas of Living Australia, 2021) and 9 million ha (Queensland Herbarium, 2008). The conservative area of occupancy is likely to include records on the lower Fitzroy floodplain, up to 17 km to the west of the Project Area and spanning approximately 18,200 ha (Atlas of Living Australia, 2021). The area of occupancy may extend to Apis Creek, a tributary of the Mackenzie River in the Upper Fitzroy Basin which is approximately 300 km upstream of the Project Area, given there are two main subpopulations and two main areas of occurrence (Nebo to Ayr, and Apis Creek to Rockhampton) (Halford, 1997; Queensland Herbarium, 2008).

The population survey identified 63 individual mature black ironbox in the vicinity of the Project Area. Most were growing within the riparian vegetation of Limestone Creek, which was dominated by black ironbox, with two of the individuals growing to the east, outside of the riparian zone, and in the Project Footprint. Additional individuals are anticipated to be present along the unsurveyed extent of Limestone Creek, and there are several records of black ironbox on the lower Fitzroy floodplain.

The Project is anticipated to impact eight individuals with the Project Area. The southern section of the Project Area is declared a no-go-zone, and the northern section of the Project Area is to be actively rehabilitated. There is approximately 1.0 ha of suitable habitat along Limestone Creek within the Project Area, of which the Project will result in the permanent loss of approximately 0.30 ha of habitat, approximately 0.50 ha will temporarily be impacted by construction and actively rehabilitated and the remaining area will be demarcated as a no-go zone and protected during construction.

Table 7-10 Significant Impact Assessment – Black Ironbox

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** The black ironbox population associated with Limestone Creek is an important population due to the location of the population near the known limit of the species' range. The Project is unlikely to lead to a long-term decrease in the size of this important population given the relatively small size of habitat in the Project Area, availability of nearby habitat, the no-go zone, and the active rehabilitation.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Reduce the area of occupancy of an important population	**Unlikely.** The area of occupancy is up to approximately 18,200 ha. There is approximately 1.0 ha of suitable habitat along Limestone Creek within the Project Area, of which the Project will result in the permanent loss of approximately 0.30 ha of habitat, approximately 0.50 ha will temporarily be impacted by construction and actively rehabilitated and the remaining area will be demarcated as a no-go zone and protected during construction. The Project is unlikely to reduce the area of occupancy of this important population of black ironbox, given the large area of occupancy compared to the relatively small size of habitat likely to be impacted.
Fragment an existing important population into two or more populations	**Unlikely.** The Project is likely to physically fragment the existing black ironbox population in Limestone Creek. The inclusion of a bridge, as opposed to an embankment with no opening or the inclusion of culverts, will minimise this fragmentation by not causing the individuals on either side of the road to become genetically isolated as the bridge will not form a barrier to pollinators. Black ironbox disperses seed via instream flow, with the seed capsule floating on the surface and depositing in a suitable location for germination downstream. Through the inclusion of bridges in the Project design, the hydrological flow regime of Limestone Creek will be maintained (as opposed to if culverts were included) as well as the seed dispersal abilities for black ironbox, and the Project is therefore unlikely to fragment the existing important population at Limestone Creek.
Adversely affect habitat critical to the survival of a species	**Unlikely.** The Project is unlikely to adversely affect habitat critical to the survival of the species given: ▪ The species has a wide distribution with extent of occurrence of approximately 4 million ha ▪ The relatively small area of the Project and the No-go-zone and the active rehabilitation ▪ No impacts to seed dispersal given black ironbox disperses seed via instream flow (with the seed capsule floating on the surface and depositing in a suitable location for germination downstream), given there are no predicted change to the hydrology of Limestone Creek.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Disrupt the breeding cycle of an important population	**Unlikely.** Through the inclusion of bridges in the Project design, the hydrological flow regime of Limestone Creek will be maintained, allowing for seed dispersal along the waterway. Furthermore, a relatively small number of mature trees are to be removed, the no-go zone will increase seed input, and the active rehabilitation may remove weed cover and increase suitable substrate for germination. The Project is unlikely to disrupt the breeding cycle of this important population of black ironbox.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** There is approximately 1.0 ha of suitable habitat along Limestone Creek within the Project Area, of which the Project will result in the permanent loss of approximately 0.30 ha of habitat, approximately 0.50 ha will temporarily be impacted by construction and actively rehabilitated and the remaining area will be demarcated as a no-go zone and protected during construction. The Project will physically fragment the black ironbox population in Limestone Creek, however through the inclusion of bridges in the Project design, the hydrological flow regime of Limestone Creek will be maintained, allowing for seed dispersal hence and genetic connectivity. Roads by the nature have the potential to introduce weeds and/or potential contaminants (e.g. sediment, hydrocarbons and litter), however the quality of habitat within and adjacent to the Project Area is already degraded due to an infestation of *Leucaena leucocephala* (leucaena) in the mid storey. The Project is unlikely to decrease habitat availability or quality to the extent that the species declines, due to the small area of clearing, the degraded nature of the habitat, the ability of the species to regenerate following disturbance, and the no-go zone and active rehabilitation.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat	**Unlikely.** The main identified threat to black ironbox is habitat disturbance and smothering by rubber vine (*Cryptostegia grandiflora*). It is unlikely that rubber vine, or invasive species other than leucaena, would become established in the species' habitat due to the current infestation of Leucaena. Active rehabilitation of the northern section also has the potential to reduce invasive species.
Introduce disease that may cause the species to decline	**Unlikely.** Myrtle rust (*Puccinia psidii*) is identified as a disease which, if introduced, may threaten the survival of the black ironbox population in Limestone Creek. Implementing biosecurity hygiene procedures during construction will assist in managing the risk of the introduction of myrtle rust to the black ironbox population.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Interfere substantially with the recovery of the species	**Unlikely.** At a regional scale, it is unlikely that the Project will interfere substantially with the recovery of the species due to the wide distribution of black ironbox. At a local level, it is unlikely that the Project will interfere substantially with the recovery of the species due to the weed-infested and degraded nature of the black ironbox habitat along Limestone Creek, and active rehabilitation which will take place in the northern section of the black ironbox habitat in the Project Area.

7.5.1.2 Brigalow (Acacia harpophylla dominant and co-dominant) TEC – Endangered

To determine if the Project is likely to have a significant impact on brigalow (*Acacia harpophylla* dominant and co-dominant) threatened ecological community (TEC) a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-11).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the brigalow TEC.

The listed brigalow TEC extends from Charters Towers in Queensland to Bourke in New South Wales and west to Blackall, Charleville and Cunnamulla. In Queensland, it occurs predominantly within the Brigalow Belt North, Brigalow Belt South, Darling Riverine Plains and Southeast Queensland bioregions. The original extent of this TEC was estimated to be more than 7 million hectares, however in 2003, no more than eight per cent remained (Butler, 2007). The area of extent of the brigalow TEC is not available but the extent of *Acacia harpophylla* in Queensland is estimated to be 59 million ha (Atlas of Living Australia, 2021) and the area of occupancy, based on mapping of high value regrowth 11.3.1, extends approximately 5 km along the western bank of the Fitzroy River and into several tributaries.

Habitat critical to the survival of brigalow TEC across Australia is considered to be patches which meet the condition thresholds and diagnostic characteristics of brigalow TEC, including the buffer zones around these communities (i.e. the area immediately adjacent to the patch) (Australian Government Department of the Environment, 2013). The main means of reproduction of *Acacia harpophylla* is shooting profusely from lateral roots (suckering), as *Acacia harpophylla* does not flower every year and seed production is rare with no dormancy period (i.e. germinating rapidly once wetted and remaining viable in soil for less than a year). The tendency of *A. harpophylla* to sucker following disturbance assists in the natural rehabilitation of this vegetation type (Peeters & Butler, 2014).

A 0.7 ha patch of the brigalow TEC was identified within the Project Area during the Detailed Business Case phase of the Project in February and October 2019 (AECOM, 2020f). In July 2021 (Ecosure, 2021b), the habitat was re-surveyed and found to be larger than previously reported, covering approximately1.9 ha within the Project Area with only a small portion of the habitat inside the Project Footprint (approximately 0.3 ha).

The alignment of the road was refined during the Preliminary and Detailed Design to avoid the TEC, however following the re-survey of the habitat in July 2021, approximately 0.3 ha cannot be avoided and is within the Project Footprint. The remaining habitat in the Project Area will be demarcated as a no-go zone and protected during construction.

Table 7-11 Significant Impact Assessment – Brigalow TEC

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Reduce the extent of an ecological community	**Unlikely.** Approximately 0.3 ha of the brigalow TEC will be cleared as a result of the Project. Brigalow TEC in the Project Area, but outside of the Project Footprint, will be demarcated as a no-go zone and protected during construction. The area of brigalow TEC to be lost is a very small, single patch of high value regrowth which is also well represented in the wider area (extending 5 km along the Fitzroy River and into several tributaries). The small patch of TEC to be cleared is not considered an ecologically important community, however clearing as a result of the Project will slightly reduce the local extent of this community but is unlikely to reduce the extent of the community in a regional context, particularly given *Acacia harpophylla* reproduces primarily by suckering, which provides for relatively rapid natural rehabilitation following disturbance.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines	**Unlikely.** The area of brigalow TEC to be cleared is located on the northern edge of the patch in the Project Area (which will be retained as a no-go zone) and is therefore unlikely to fragment or increase fragmentation of an ecological community. The retained patch is connected to mapped high value regrowth brigalow along the tributary to the south of the alignment, which is in turn connected to high value regrowth brigalow along the Fitzroy River and into several tributaries.
Adversely affect habitat critical to the survival of an ecological community	**Unlikely.** The area of brigalow TEC to be cleared is unlikely to adversely affect habitat critical to the survival of an ecological community given the extent of brigalow along the tributary to the south of the alignment, and along the Fitzroy River and into several tributaries. Furthermore, reproduction of *Acacia harpophylla* is primarily by suckering, which will provide for relatively rapid natural rehabilitation following disturbance.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Modify or destroy abiotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns	**Unlikely.** Surface water drainage patterns are unlikely to be altered as a result of hydrology modelling for the Project (Jacobs SMEC Design Joint Venture 2020b; 2020d), hence groundwater levels are unlikely to be reduced in the vicinity of the brigalow TEC. Furthermore, the vegetation species and regional soil and geology types suggest that the level of groundwater dependence is likely to be low within this patch of brigalow TEC and vegetation is likely to be able to satisfy plant water requirements using retained soil moisture. Modification or destruction of abiotic factors to the extent that the brigalow TECs survival is compromised outside of the area of impact is unlikely.
Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting	**Unlikely.** The area of the brigalow TEC lost to the Project is unlikely to cause a substantial change in the species composition of the patch of brigalow TEC in the Project Area of the broader ecological community which extends 5 km along the Fitzroy River and into several tributaries. Furthermore, it is unlikely that the brigalow TEC in the Project Area will be intentionally regularly burned, or harvested, given the proximity to the road.
Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: ▪ Assisting invasive species, that are harmful to the listed ecological community, to become established ▪ Causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community	**Unlikely.** The area of brigalow TEC to be lost to the Project is unlikely to cause a substantial reduction in the quality or integrity of the patch of brigalow TEC in the Project Area or the broader ecological community which extends 5 km along the Fitzroy River and into several tributaries, given it is a small area on the northern edge of the patch. Construction and operation in the Project Area may bring about erosion and sedimentation, and/or introduce weed species or potential contaminants to surface water (e.g. hydrocarbons and litter). Given the management measures in place, the Project is unlikely to impact on the quality or integrity of the brigalow TEC.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Interfere with the recovery of an ecological community	**Unlikely.** The Commonwealth environment minister has declared that a national recovery plan for the brigalow TEC is not required, however current threats to this species include clearing, inappropriate fire regimes, invasive species, inappropriate grazing regimes and climate change (Threatened Species Scientific Committee, 2013). Management measures will be put in place to manage threats during construction and operation and the Project is unlikely to interfere with the recovery of the brigalow TEC. A small area of brigalow TEC will be lost but the tendency of brigalow to sucker following disturbance will provide for relatively rapid natural rehabilitation.

7.5.2 Aquatic Fauna

7.5.2.1 Estuarine Crocodile (Crocodylus porosus) – Migratory, Marine

To determine if the Project is likely to have a significant impact on the estuarine crocodile, a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) (Table 7-12).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the estuarine crocodile.

Estuarine crocodiles in Queensland inhabit reefs, coastal and inland waterways north of Gladstone, with an area of extent spanning approximately 19 million ha (excluding vagrant south of Gladstone). The Project Area is near the southern extent of distribution and the population is therefore considered an important population.

The area of occupancy is likely to be approximately 772,000 ha which includes known records in the vicinity of the Fitzroy River from Shoalwater Bay Training Area in the north to Curtis Island in the south and 150 km up the Fitzroy River (Atlas of Living Australia, 2021).

Table 7-12 Significant Impact Assessment – Estuarine Crocodile

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species	**Unlikely.** Important habitat is not defined for the estuarine crocodile and is considered to be breeding habitat. For much of the year and during extended dry periods, movements are likely to be restricted by the Fitzroy Barrage, however during flood events when the barrage overtops and the floodplain and its lagoons are inundated and connected, estuarine crocodiles can disperse up and down the river, and across the floodplain to access breeding habitat in floodplain lagoons above tidal influence. In order to maintain the current hydrological characteristics of the area, which supports these breeding movements, numerous bridges and culverts have been incorporated into the design of the Project and hydraulic modelling predicts no significant hydrological changes. Furthermore, the area of habitat in the Project is relatively small (approximately 12.9 ha) compared to the area of extent for this species (approximately 19 million ha) and the likely area of occupancy for this population (approximately 772,000 ha extending north to Shoalwater Bay Training Area, south to Curtis Island and 150 km up the Fitzroy River) (Atlas of Living Australia, 2021), and the quality of habitats in the Project Area (e.g. heavily grazed and impacted by weeds and feral animals) are poor compared to many other parts of the area of occupancy. As the Project will not create barriers to movement during flooding/breeding, the Project is unlikely to substantially modify, destroy or isolate an area 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 migratory species.	**Unlikely.** Estuarine crocodiles are apex predators and generally not impacted by invasive species. Predatory pests, such as feral pigs (*Sus scrofa*), can impact nests and predate eggs, however estuarine crocodiles are known to guard their nests. Weeds can impact breeding habitat however this is unlikely to be significant given this species nests on elevated, vegetated banks. It is unlikely that the Project will exacerbate invasive species impacts beyond current levels. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through project activities. Control efforts will be increased in areas particularly sensitive to invasion, riparian and wetland habitats.

An action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	**Unlikely.** The Project Area is near the southern extent of distribution and the population is therefore considered an important population. The Project Area provides breeding/nesting habitat in elevated, isolated floodplain lagoons that do not experience the influence of tidal movements. During flood events, estuarine crocodiles would disperse up the river and across the floodplain to access breeding habitat. The Project Area provides foraging, dispersal and resting habitats in the Fitzroy River and marginally in the Limestone Creek subject to water levels. In order to maintain the current hydrological characteristics of the area, which supports these breeding movements, numerous bridges and culverts have been incorporated into the design of the Project and hydraulic modelling predicts no significant hydrological changes. As the Project will not create barriers to movement during flooding/breeding, and hydraulic modelling for the Project predicts no significant hydrological changes, including to tidal movements and flooding of nests, the Project is not expected to seriously disrupt the lifecycle of this important population.

7.5.2.2 The Fitzroy River Turtle (Rheodytes leukops) – Vulnerable

To determine if the Project is likely to have a significant impact on Fitzroy River turtle, a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) (Table 7-13).

The Project Area is unlikely to support an important population of the Fitzroy River turtle necessary for long-term survival and/or recovery of the species or community. No individuals were recorded in the Project Area during the field surveys and the Project Area was identified as providing marginal foraging and dispersal habitat at the Fitzroy River, with limited suitable foraging habitat present at Limestone Creek subject to water levels.

The area of extent and area of occupancy are difficult to estimate according to the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and Environment Protection and Biodiversity Conservation Regulations 2000 (Australian Government Department of the Environment and Energy, 2018) due to the aquatic nature of the species. The total area inhabited by this species (i.e. area of extent) is approximately 1 million ha (Cogger, Cameron, Sadlier, & Eggler, 1993; McDonald, Covacevich, Ingram, & Couper, 1991). This species has been recorded up to approximately 500 km upstream of the Project Area (Atlas of Living Australia, 2021).

Populations in the Fitzroy River are fragmented by impoundments and the Fitzroy Barrage inundation pool is likely to represent a maximal area of occupancy for this population, which extends approximately 83 km upstream to the next major barrier (Eden Bann Weir). There are few records in this area (Atlas of Living Australia, 2021), and the area of occupancy is likely to be smaller due to the small home range of this species in association with riffles (mean distance of 258 – 359 m to a riffle zone).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the Fitzroy River turtle (Table 8-4).

Table 7-13 Significant Impact Assessment – Fitzroy River Turtle

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Lead to a long-term decrease in the size of an important population of a species.	**Unlikely.** The Project Area is unlikely to support an important population of the Fitzroy River turtle, and the Project is therefore unlikely to lead to a long-term decrease in the size of an important population. Furthermore, hydraulic modelling for the Project Jacobs SMEC Design Joint Venture 2021b; 2021d) predicts no significant hydrological changes for the Fitzroy River or Limestone Creek as a result of the Project.
Reduce the area of occupancy of an important population.	**Unlikely.** The Project Area is unlikely to support an important population of the Fitzroy River turtle, and the Project is therefore unlikely to reduce the area of occupancy of an important population. Some localised impacts to the Fitzroy River may occur to high banks where hardstands are located, however large trees in the riparian zones will be retained wherever possible ensuring shade and debris (food) is provided and bank structure maintained. Potential construction impacts such as sedimentation and erosion are likely to have minimal impact due to the small area of construction and the high turbidity of the river in the Project Area. Marginal habitat is present in Limestone Creek and direct clearing impacts will also be minimised by the inclusion of bridges in the design. It is unlikely the Project will reduce the area of occupancy, particularly given the small area of marginal habitat to be impacted (6.4 ha or less than 1 km of waterway), the relatively large area of occupancy (up to 83 km of waterway), the small home range of the species (258 – 359 m), the lack of hydrological changes associated with the Project, and the mitigation measures proposed.
Fragment an existing important population into two or more populations.	**Unlikely.** The Project Area is unlikely to support an important population of the Fitzroy River turtle, and the Fitzroy River population is currently fragmented due to numerous barriers including the Fitzroy Barrage. Furthermore, the Fitzroy River turtle has very small home ranges associated with riffles and is unlikely to be fragmented by the Project given the distance to the nearest riffle. The Project is unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species.	**Unlikely.** Habitat considered critical to the survival of this species is breeding habitat. No breeding habitat occurs within the Project Area and given the small home range of this species in association with riffles, the Project is unlikely to adversely affect habitat critical to the survival of the species as there are no riffles in the Project Area.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Disrupt the breeding cycle of an important population.	**Unlikely.** The Project Area is unlikely to support an important population of the Fitzroy River turtle, and no breeding habitat occurs within the Project Area. Furthermore, given the small home range of this species, the Project is unlikely to disrupt the breeding cycle of this species.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Unlikely.** Marginal habitats in the Fitzroy River and Limestone Creek will be modified by the Project, however impacts are anticipated to be minimal due to the inclusion of bridges at both waterways. Impacts to habitat in the Fitzroy River are also likely to be minimal due to the rivers large size and high banks, and large trees in the riparian zones will be retained wherever possible ensuring shade is still provided and bank structure maintained. Hydraulic modelling for the Project predicts no significant hydrological changes for the Fitzroy River or Limestone Creek as a result of the Project. Habitats are degraded by weeds and development (e.g. barriers to flow) and the Project is unlikely to reduce the quality of habitat. The Project is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat.	**Unlikely.** The greatest threat to the Fitzroy River turtle is nest destruction and egg predation by feral pigs (*Sus scrofa*), foxes (*Vulpes vulpes*) and dogs (*Canis lupus*). These species are present within the Project Area and it is unlikely that the Project will exacerbate invasive species beyond current levels. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through project activities. Control efforts will be increased in areas particularly sensitive to invasion, riparian and wetland habitats. The Project is unlikely to result in invasive species, that are not already established in the habitat, becoming established in the Vulnerable species habitat.
Introduce disease that may cause the species to decline.	**Unlikely.** Disease has not been identified as a threat to the Fitzroy River turtle.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Interfere substantially with the recovery of the species.	**Unlikely.** No recovery plan has been developed for this species, however Conservation Advice (Australian Government Department of the Environment, Water, Heritage and the Arts, 2008) provides information on priority actions, direction to mitigate against key threats and enable recovery. Key threats that have been identified include habitat loss disturbance and modification, trampling and animal predation. Threat abatement and recovery actions include: ▪ Identify populations of high conservation priority ▪ Protect areas of riparian habitat where the species may occur ▪ Ensure mining operations and other infrastructure does not impact on known populations ▪ Manage changes to hydrology that may result in changes to the water table levels ▪ Investigate formal conservation arrangements ▪ Develop and implement a stock management plan for riparian habitats and ▪ Develop a pest fauna management plan for areas of potential nesting. Proposed mitigation measures include several of these actions (e.g. managing hydrology and a Weed and Pest Sub Plan). The Project is unlikely to substantially increase threats to the species to the extent that it will interfere with the recovery of the species.

7.5.2.3 White-throated Snapping Turtle (Elseya albagula) – Critically endangered

To determine if the Project is likely to have a significant impact on white-throated snapping turtle (*Elseya albagula*), a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-14).

Along the east coast of Queensland, the white-throated snapping turtle has been recorded in freshwaters from Cooktown in the north to the New South Wales border. Populations within the Fitzroy, Mary and Burnett catchments are considered important populations, with important habitat defined as all in-stream habitat and adjacent banks to within approximately 50 m (Australian Government Department of the Environment, 2014a). No individuals were recorded in the Project Area during the field surveys and the Project Area was identified as providing marginal foraging and dispersal habitat at the Fitzroy River, with limited suitable foraging habitat present at Limestone Creek subject to water levels.

The area of extent and area of occupancy are difficult to estimate according to the Commonwealth EPBC Act and Environment Protection and Biodiversity Conservation Regulations 2000 (Australian Government Department of the Environment and Energy, 2018) due to the aquatic nature of the species. The total area inhabited by this species (i.e. area of extent) is estimated to be between approximately 2,150 km (Australian Government Department of the Environment and Energy, 2017) and 3,350 km of waterway, equating to < 50,000 ha (Australian Government Department of Agriculture, Water and the Environment, 2020b).

All white-throated snapping turtle populations within the Mary, Burnett and Fitzroy River catchments are considered important, with important habitat defined as all in-stream and adjacent banks to within approximately 50 m. The Fitzroy River population is currently fragmented due to numerous weirs and the Fitzroy Barrage, and impacted by poor water quality in impoundments (Australian Government Department of the Environment, 2014a). The Fitzroy River Barrage pool is likely to represent a maximal area of occupancy for this species, which extends approximately 83 km upstream to the next major barrier (Eden Bann Weir). There are however few records in this area (Atlas of Living Australia, 2021).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the white-throated snapping turtle (*Elseya albagula*) (Table 7-14).

Table 7-14 Significant Impact Assessment – White-throated Snapping Turtle

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Lead to a long-term decrease in the size of a population.	**Unlikely.** Direct (clearing) impacts to habitat at both locations will be reduced by the inclusion of bridges in the design of the Project. Hydraulic modelling for the Project (Jacobs SMEC Design Joint Venture 2021b; 2021d) predicts no significant hydrological changes for the Fitzroy River or Limestone Creek. Results of the water quality modelling using MUSIC software for the Project (Jacobs SMEC Design Joint Venture, 2021g) showed that total suspended solids, total phosphorus and total nitrogen achieved the load reduction targets in potential freshwater turtle habitat provided by the Fitzroy River and Limestone Creek (Figure 7-1 and Figure 7-2). Due to the limited clearing, unlikely hydrological changes, and water quality mitigation measures proposed, the Project is unlikely to lead to a long-term decrease in the size of the population.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Reduce the area of occupancy of the species.	**Unlikely.** The primary white-throated snapping turtle habitat identified within the Project Area is the Fitzroy River. Some localised impacts to the Fitzroy River may occur to high banks where hardstands are located, however large trees in the riparian zones will be retained wherever possible ensuring shade and debris (food) is provided and bank structure maintained. Potential construction impacts such as sedimentation and erosion are likely to have minimal impact due to the small area of construction and the high turbidity of the river in the Project Area. Marginal habitat is present in Limestone Creek and direct clearing impacts will also be minimised by the inclusion of bridges in the design. No significant hydrological changes are expected as a result of the Project, therefore, it is unlikely the Project will reduce the area of occupancy in Limestone Creek. The Project is unlikely to reduce the area of occupancy of the species, given the small area of marginal habitat to be impacted (10.8 ha or less than 1 km of waterway), the relatively large area of occupancy (up to 83 km of waterway), the lack of hydrological changes associated with the Project, and the mitigation measures proposed.
Fragment an existing population into two or more populations.	**Unlikely.** The Fitzroy River population is currently fragmented due to numerous barriers including the Fitzroy Barrage, and impacted by poor water quality in associated impoundments. Hydraulic modelling for the Project indicates that no significant hydrological changes are predicted for the Fitzroy River or Limestone Creek and the Project is unlikely to further fragment an existing population into two or more populations.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Adversely affect habitat critical to the survival of a species.	**Unlikely.** Habitat critical to the survival of the white-throated snapping turtle is defined as: ▪ parts of riverine systems with permanent water, including pools, within the species' distribution that contain shelter and refuges (e.g. bank overhangs, overhanging riparian vegetation, macrophyte beds, moderate to high densities of submerged boulders and/or log jams) ▪ all currently known and new aggregated nesting sites (all nesting sites should be considered to be part of an aggregation unless it can be demonstrated otherwise) (Australian Government Department of Agriculture, Water and the Environment, 2020b). There is approximately 10.8 ha of habitat critical to the survival of the species in the Project Area, with approximately 1,628.1 ha of similar habitat in the Fitzroy River and major tributaries (Figure 6-10). These areas include important habitat defined as all in-stream and adjacent banks to within approximately 50 m, subsequently: ▪ Potential habitat within the Project Area is disturbed to some extent and considered marginal except in the Fitzroy River. ▪ Potential impacts to habitat are expected to be localised, and the Project is unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population.	**Unlikely.** Breeding habitat for the white-throated snapping turtle does not occur within the Project Area and given the small home range of this species, the Project is unlikely to disrupt the breeding cycle of this species.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Unlikely.** Marginal habitats in the Fitzroy River and Limestone Creek will be modified by the Project, however impacts are anticipated to be minimal due to the inclusion of bridges at both waterways. Impacts to habitat in the Fitzroy River are also likely to be minimal due to the river's large size and high banks, and large trees in the riparian zones will be retained wherever possible ensuring shade is still provided and bank structure maintained. Hydraulic modelling for the Project predicts no significant hydrological changes for the Fitzroy River or Limestone Creek. Habitats are degraded by weeds and development (e.g. barriers to flow) and the Project is unlikely to reduce the quality of habitat. On this basis, the Project is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat	**Unlikely.** The principal current threat to the white-throated snapping turtle is the excessive (near total) loss of eggs and hatchlings at the aggregated nesting areas. This is due to predation by feral (fox, dog, pig, cat) and native (e.g. goanna, water rat) predators, and trampling of nests by cattle. The nearest known aggregated nesting areas at the Alligator Creek confluence is unlikely to be impacted by the project given it is in the upper reaches of the Fitzroy Barrage impoundment, approximately 45 km upstream of the Project Area on the northern bank. Of the pest fauna known to occur in the Rockhampton Region, feral cats, wild dogs, dingoes, foxes and feral pigs are likely to be attracted to road kill and could predate on turtle eggs or turtles. The potential for road kill will be minimised by the inclusion of bridges across the Fitzroy River and Limestone Creek (Figure 3-20 and Figure 3-21) and fauna fencing and steep embankment slopes on the approach to bridges, which will direct fauna under bridges. Based on the information available regarding predation of freshwater turtles, impacts are unlikely to be substantial given the distance to the distance to the nesting aggregation (approximately 45 km upstream of the Project Area), the extent of predatory pests currently in the broader Project Area, and design features that minimise road kill (e.g. fauna fencing and embankment slope). In addition, Rockhampton Regional Council actively monitors and manages pest fauna on public lands with a Biosecurity Surveillance Program in place across the floodplain of the Project Area.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
	Species-specific management will be undertaken by the Project for identified key weed and pest species at risk of spread through project activities. Control efforts will be increased in areas particularly sensitive to invasion, riparian and wetland habitats. The Project is unlikely to result in invasive species becoming more prevalent than currently known.
Introduce disease that may cause the species to decline	**Unlikely.** Disease has not been identified as a threat to the white-throated snapping turtle.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Interfere with the recovery of the species	**Unlikely.** The National Recovery Plan for the white-throated snapping turtle (Australian Government Department of Agriculture, Water and the Environment, 2020b) identifies key threats as: ▪ habitat loss disturbance and modification, ▪ obstruction of migration within rivers, ▪ injury and death during over-topping and water releases, ▪ inappropriate water allocation, ▪ flooding of nesting areas and loss of riparian vegetation leading to reduction in available food. The Project may cause loss of riparian vegetation leading to reduction in available food, however this is not likely to interfere with the recovery of the species due to (1) the marginal nature and small area of habitat to be cleared in the Project Area, (2) the project mitigation measures, and (3) the hydraulic modelling for the Project predicts no significant hydrological changes for the Fitzroy River or Limestone Creek. Threat abatement and recovery actions include (Australian Government Department of Agriculture, Water and the Environment, 2020b): ▪ Increased protection of nesting banks from predation and from trampling by herbivores ▪ Recommence and maintain hatchery programs to supplement recruitment of hatchlings into the population ▪ Modify water infrastructure design and/or operation to minimise mortality of adult turtles during flood events and water releases ▪ Ensure that water planning includes allocation for flows that maintain water quality that allows cloacal respiration, particularly during low flow periods. The Project is unlikely to interfere with these threat abatement and recovery action or interfere with the recovery of the species.

7.5.3 Terrestrial Fauna

7.5.3.1 Australian Painted Snipe (Rostratula australis) – Endangered

To determine if the Project is likely to have a significant impact on Australian painted snipe (*Rostratula australis*), a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-15).

Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to waterbirds and shorebirds is also highly variable between years and within seasons. As a result, suitable habitat areas at any given wetland at one time may only be suitable once in a series of consecutive years, and may not provide suitable habitat on a consistent or predictable annual basis. In the broader local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain and Delta are expected to collectively provide a range of suitable habitat in differing locations at different times - every wetland within the Fitzroy River floodplain is not expected to provide suitable habitat on an annual consistent basis.

In optimal conditions, there is approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, with approximately 4,041.5 ha of potentially suitable habitat in the broader area (Figure 6-9). Within the Project Area, 2.41 ha of potential habitat will be permenantly impacted, largely due to shading from bridges. Therefore, there is a very large area of potential habitat outside of the Project Area compared to the small area potentially impacted in the Project Footprint.

While the wetlands within the Project Area contribute to what may constitute Important Habitat for Australian painted snipe in the broader Fitzroy River floodplain, given the acute impacts at the Project Area scale relative to the amount of wetland habitat that would be available in ideal conditions, it is **unlikely** that the Project will have a significant impact on the species.

Table 7-15 Significant Impact Assessment – Australian Painted Snipe

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Lead to a long-term decrease in the size of a population	**Unlikely.** The Australian painted snipe is inferred to have undergone a severe decline in the number of mature individuals since the 1950s and specifically over the last three generations (~26 years) due to the loss and degradation of its wetland habitat across Australia. There has also been a substantial decline in the reporting rate of Australian painted snipe since the 1950s, despite an increase in survey effort in recent decades, which further suggests that the snipe is now less widespread than it once was (Lane & Rogers, 2000; Rogers, et al., 2005). In light of this evidence, the area of occupancy is suspected to be decreasing at the present time (Garnett & Crowley, 2000) Based on available data, in the vicinity of the Project Area, Australian painted snipe have been recorded once at Murray Lagoon in 2013. In optimal conditions, there is approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, with approximately 4,041.5 ha of

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
	potentially suitable habitat in the broader area (Figure 6-9). Within the Project Area, 2.41 ha of potential habitat will be permenantly impacted, largely due to shading from bridges. Therefore, there is a very large area of potential habitat outside of the Project Area compared to the small area potentially impacted in the Project Footprint. The clearing of potential breeding, foraging and dispersal habitat at Pink Lily and Lotus Lagoons has been minimised during the detailed design of the Project through the inclusion of bridges and micro-siting to non-remnant areas within the corridor. However, some vegetation clearing and cut and fill impacts at Pink Lily and Lotus Lagoons may occur to create hardstands. Hydraulic modelling for the Project (Jacobs SMEC Design Joint Venture 2021b; 2021d) predicts no significant hydrological changes at wetlands within or adjacent to the Project Area. Although a small area of potential wetland habitat within the Project Area may be subjected to direct and indirect impacts, these impacts are highly unlikely to lead to a long-term decrease in the size of the Australian painted snipe population.
Reduce the area of occupancy of the species	**Unlikely.** The area of occupancy of the Australian painted snipe is estimated, with low reliability, to be approximately 100,000 ha. The area of occupancy has undoubtedly declined as approximately 50% of wetlands in Australia have been removed since European settlement (Australia Government Department of Agriculture, Water and the Environment, 2021o). In optimal conditions, there is approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, with approximately 4,041.5 ha of potentially suitable habitat in the broader area (Figure 6-9). Within the Project Area, 2.41 ha of potential habitat will be permenantly impacted, largely due to shading from bridges. Therefore, there is a very large area of potential habitat outside of the Project Area compared to the small area potentially impacted in the Project Footprint. These impacts are not of the size and scale that are considered likely to reduce the area of occupancy of the species, especially when taking into account the species has been recorded in the vicinity of the Project Area on one occasion, and in an adjacent wetland (Murray Lagoon) which offers more stable and suitable habitat conditions.
Fragment an existing population into two or more populations	**Unlikely.** Australian painted snipe have been recorded on one occasion in the vicinity of the Project Area (Birdlife Australia, 2021). The species is not resident within or adjacent to the Project Area, nor a routine annual or seasonal visitor to the region.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
	The Project Area is narrow and linear and will not result in barriers to movement within or between habitat for this species which is highly mobile. Based on these considerations, the Project will not fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of a species	**Unlikely.** Critical habitat for the survival of this species is defined as shallow wetlands suitable for foraging and breeding. This habitat may be present at Pink Lily and Lotus Lagoons pending local rainfall and resultative water levels at these wetlands within the Project Area. Habitat critical to the survival of Australian painted snipe comprises wetland areas which are known to be utilised for nesting or breeding, and those which consistently support large proportions of the species population, repeatedly and predictably between seasons (site fidelity) and/or for prolonged periods of time (site persistence). Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to Australian painted snipe, is also highly variable between years and within seasons. As a result, suitable habitat areas present at any given wetland at a given time may only be suitable once in a series of consecutive years and are unlikely to provide suitable habitat on a consistent, reliable or annual basis. In addition to the high degree of habitat variability, only approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, of which 2.41 ha is within the Project Footprint. Australian painted snipe have been recorded on one occasion in the vicinity of the Project Area (Birdlife Australia, 2021). The species is not resident within or adjacent to the Project Area, nor a routine annual or seasonal visitor to the region. No significant hydrological variations are expected to occur at wetlands as a result of the Project. However, operation of the Project will result in increased noise due to traffic and lighting across the entire Project Area. Considering the potential impacts to suitable habitat affect a small area relative to similar habitat available in the broader Fitzroy River floodplain, the Project is unlikely to adversely affect any habitat that is critical to the survival of the species.
Disrupt the breeding cycle of a population	**Unlikely.** The Australian painted snipe may breed in response to favourable wetland conditions rather than during a particular season. Breeding in northern Queensland has been recorded between May and October. Australian painted snipe have been recorded on one occasion in the vicinity of the Project Area (Birdlife Australia, 2021). The species is not resident within or adjacent to the Project Area, nor a routine annual or seasonal visitor to the region. Based on available database records, no Australian painted snipe breeding events have been recorded in the Rockhampton region.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
	Project related impacts such as removal of vegetation and disturbance caused by access by construction vehicles may impact on visiting individuals; however, this is highly unlikely to disrupt the breeding cycle at a population scale.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely**. Australian painted snipe have been recorded on one occasion in the vicinity of the Project Area (Birdlife Australia, 2021). The species is not resident within or adjacent to the Project Area, nor a routine annual or seasonal visitor to the region. Consideration of habitat usage at both the local and regional scale is important for migratory bird species that frequent dynamic inland wetland areas as they are particularly responsive to changes in habitat conditions. Wetlands within the Project Area are all part of the broader Fitzroy River Floodplain and Delta Important Bird Area or Key Biodiversity Area. The majority of these wetlands are highly variable in terms of their size, depth, bank profile, water permanency, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer. Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to migratory and nomadic shorebirds, is also highly variable between years and within seasons. As a result, suitable habitat areas at any given wetland at one time may only be suitable once in a series of consecutive years and may not provide suitable habitat on a consistent or predictable annual basis. In the broader local and regional landscape context, the wetland mosaic affords nomadic shorebirds an abundance of options upon arrival, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until such time that conditions deteriorate and they seek more optimal conditions elsewhere. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain and Delta are expected to collectively provide a range of suitable habitat in differing locations at different times - every wetland within the Fitzroy River floodplain is not expected to provide suitable habitat on an annual consistent basis. There are likely to be direct impacts at all wetlands that the Project Area traverses associated with construction and operation of the Project. Direct impacts are expected to occur at Pink Lily Lagoon, Lotus Lagoon, Dunganweate Lagoons, and Nelson Lagoon. Lotus Lagoon and Pink Lily Lagoon may provide suitable habitat conditions for Australian painted snipe when they are inundated. The Project alignment traverses the southern extent of Pink Lily Lagoon which would be expected to provide suitable habitat for Australian painted snipe only when Pink Lily Lagoon is at or over capacity. Nelson Lagoon is generally severely degraded through livestock damage and lacks the required habitat features to support Australian painted snipe. Dunganweate Lagoons are also subject to livestock access and are similarly degraded.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
	Direct impacts at each of these wetlands have been minimised through the inclusion of bridges in the Project design. Some vegetation clearance and ground disturbance works will be required to create hardstands at all proposed bridge locations. There are also likely to be indirect impacts associated with wetland shading, resultative changes in wetland associated vegetation composition and structure and therefore potential changes to habitat characteristics required by Australian painted snipe. The disturbance footprint equates to approximately 9.5 ha impacted by construction of the 4,041.5 ha of potentially suitable habitat in the broader area (Figure 6-9). Once built, the Project will impact approximately 2.41 ha of current mapped wetland area, largely through shading and expected resultative changes in wetland vegetation. At a landscape scale or Shorebird Area scale, these direct and potential indirect impacts to potential Australian painted snipe habitat will not substantially destroy or isolate an area identified as important for the species and are therefore considered to be insignificant. Significant changes to existing floodplain hydraulics and the current hydroperiod of wetlands within the Project Area are unlikely to occur as a result of the Project once completed, therefore resulting in no substantial modification to (through altering hydrological cycles) the current floodplain and associated wetland hydrological regime. While there will be some disruption to potential foraging habitat for Australian painted snipe during construction of the Project, these impacts are likely to be relatively short-term. During the construction phase, there is likely to be an increase in noise, dust, vibration and light as a result of construction activities. The impacts of noise, dust and light pollution will be temporary and will not affect the entire Project Area simultaneously. Where construction activities are occurring adjacent to suitable wetland habitat, potential impacts may include the following: ▪ Avoidance of the area due to increased noise, vibration or construction related lighting ▪ Increased risk of predation by visual predators due to increased background noise, subsequent disturbance and flight initiation ▪ Behavioural changes due to increased noise (e.g. aversion to potentially suitable habitat areas due to their proximity to construction works ▪ Increased potential for collisions with vehicles ▪ Human visitation causing disturbance to foraging or breeding behaviours ▪ Reduction of habitat quality due to noise, dust, vibration and light pollution. Sudden loud, impulsive or impact noises are capable of causing birds to become startled, which (if occurring over the long periods) may affect feeding efficiency and breeding behaviour. Bulk earthworks including piling, excavation, construction and earthmoving associated with the project have the potential to cause short-term and spatially acute disturbance to all groups of terrestrial fauna.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
	Artificial light can affect both nocturnal and diurnal animals by disrupting behavioural patterns, with quality of light (e.g. wavelength, colour), intensity and duration potentially evoking different responses. Impacts from increased light levels include: ▪ Degradation in habitat suitability leading to an aversion to illuminated wetland areas by wetland bird species ▪ Disorientation from or attraction toward artificial sources of light and subsequent mortality from collisions with structures ▪ Attraction of introduced predators to areas that are artificially illuminated leading to an increase in predation An increase in artificial light can increase the abundance and efficiency of predators which could result in fauna avoiding some areas due to an increased perceived risk of predation and/or becoming more vulnerable to predation. During operation, the Project will have permanent lighting at roundabouts, interchanges and the Fitzroy River Bridge to meet safety standards and generate ongoing noise from consistent vehicular traffic. Lighting and vehicle noise related impacts during operation of the new road may initially discourage Australian painted snipe from using wetland areas in proximity to the completed road, although the prevalence of Australian painted snipe and other shorebird species in wetland habitats which are proximal to existing transport corridors in other parts of eastern Australia demonstrates an inherent ability to become accustomed to novel but consistent sources of disturbance. Intermittent periods of increased noise and lighting may be associated with maintenance activities (e.g. resurfacing, bio-basin sediment removal etc), although these are expected to be of a short duration and intensity compared to construction activities. Increases in traffic and road noise and associated road lighting are not expected to substantially modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a Critically Endangered or Endangered species becoming established in the Endangered or Critically Endangered species' habitat	**Unlikely.** The replacement of endemic wetland vegetation by invasive, noxious weeds could render habitats less suitable or unsuitable. Weeds and pest fauna species are already prevalent within the Project Area and broader region, however Project construction activities and operation of the road once built have the potential to exacerbate weed species beyond current levels. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through Project activities. Control efforts will be increased in areas particularly sensitive to invasion, such as wetlands. With these mitigation measures in place, it is considered unlikely that the Project would result in further proliferation of invasive species.

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will	Outcome of assessment and justification
Introduce disease that may cause the species to decline	**Unlikely**. Disease has not been identified as a key threat to the species.
Interfere with the recovery of the species	**Unlikely.** Australian painted snipe have been recorded on one occasion in the vicinity of the Project Area (Birdlife Australia, 2021). The species is not resident within or adjacent to the Project Area, nor a routine annual or seasonal visitor to the region. The Species Profile and Threats (SPRAT) database profile identifies that a Recovery Plan for the Australian painted snipe is required; however, no such plan exists at the time of this report. In 2001, a project was initiated by the Threatened Bird Network and the Australasian Wader Studies Group to improve knowledge of the Australian painted snipe so that meaningful conservation actions could be developed. Recovery actions implemented as part of this project include: the development of a database of records; the introduction of national targeted surveys conducted twice per year at important historic and contemporary sites and other sites of interest; and an assessment of habitat preferences. Based on these objectives, the Project is unlikely to interfere with the recovery of the species and will not exacerbate known threats to the species.

7.5.3.2 Grey-headed Flying-fox (Pteropus poliocephalus) – Vulnerable

To determine if the Project is likely to have a significant impact on grey-headed flying-fox (*Pteropus poliocephalus*), a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-16).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the grey-headed Flying-fox (*Pteropus poliocephalus*).

The grey-headed flying-fox inhabits coastal areas from Rockhampton to Melbourne, with a large area of extent. The area of occurrence is difficult to estimate because this species is highly mobile with the national population moving up and down the east coast in search of food, however only a small proportion of this large range is used at any one time based on food availability. Presence and abundance varies between seasons and years and locally the species may occur intermittently and irregularly (Australia Government Department of Agriculture, Water and the Environment, 2021o). The population in the Project Area is considered important as it is at the northern extent of distribution.

Table 7-16 Significant Impact Assessment – Grey-headed Flying-fox

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** Foraging habitat only was identified within the Project Area. Grey-headed flying-foxes commute daily to foraging areas, usually within 15 km of the day roost site. Previous studies of movements of the species in northern New South Wales and southern Queensland have indicated that various seasonal movements occur between camps. The Project is narrow and linear in nature and has avoided large tracts of remnant vegetation. In the context of the surrounding landscape, habitat within the Project Area is already highly fragmented and higher quality roosting habitat occurs in the surrounding region outside of the Project Area. As grey-headed flying-foxes are not restricted in their dispersal ability and regularly move between foraging areas, impacts to an important population as a result of the Project are unlikely. As there is higher quality foraging habitat in the broader area, there is the possibility of an increase in vehicle strikes to grey-headed flying-fox while moving between foraging habitat within the broader area on different sides of the Project Area. During the construction phase, vehicle speed limits will be limited around wetlands and adjacent to retained fauna habitat (e.g. brigalow and mapped eucalypt woodlands) to reduce the likelihood or severity of vehicle strikes to flying-foxes. Following construction, moving traffic will be introduced along the new road. The initial period of operation is expected to result in the highest risk of flying-fox and vehicle collisions. After some time, flying-fox in the area are expected to become conditioned to the presence of the new road and adjust their local movement behaviours to avoid the road. The increased risk of vehicle strike can also be mitigated by avoiding the inclusion of all potential fruiting and flowering trees and shrubs that may be used by flying-foxes during post-construction landscaping within areas such as median strips. This will minimise the risk of flying-foxes flying at vehicle height to forage within landscaped areas of the Project. As the initial period of operation is expected to result in the highest risk of vehicle collisions, with the risk decreasing once the flying-fox have become conditioned to the new road, it is unlikely that the Project will impact an important population.
Reduce the area of occupancy of an important population	**Unlikely**. The area of occupancy for this important population is hard to estimate due to the highly mobile nature of the species and very large area of extent that includes coastal areas from Rockhampton to Melbourne. Approximately 33.9 ha of potential foraging, opportunistic roosting and dispersal habitat may be impacted by the Project, however the surrounding landscape is already fragmented, and areas of continuous habitat clearing have been avoided by the Project. Due to the absence of major roosts within the Project Area, the limited extent of clearing, and the highly mobile nature of this species and very large area of extent, it

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
	is unlikely that the Project will result in a reduction to the area of occupancy of this important population.
Fragment an existing important population into two or more populations	**Unlikely.** The species is highly mobile and limited vegetation clearing will be linear, hence the Project is unlikely to result in dispersal challenges for this important population.
Adversely affect habitat critical to the survival of a species	**Unlikely.** Flowering tree species during spring are considered habitat critical to the survival of the species. There are spring-flowering canopy trees in the potential habitat for the grey-headed flying-fox in the Project Area (approximately 33.9ha as shown in Figure 6-11). However, there is a very large area of potential foraging habitat outside of the Project Area (approximately 14,056.7 ha) and given the limited amount of linear clearing, it is unlikely that the Project will adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population	**Unlikely.** Mating occurs in early autumn, after which time the larger camps begin to break up, reforming in late spring/early summer, as food resources become more abundant. Males and females segregate in October when females usually give birth. Fauna spotter/catchers during clearing activities, particularly during these seasons, will ensure disruptions to this species are reduced. Due to the distance from the Project Area, noise and lighting associated with construction/operation of the Project is not anticipated to have a significant impact on known roost sites. Impacts to the breeding cycle of any important population present as a result of the Project are likely to be minimal.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** Some suitable foraging habitat occurs within the Project Area, but no roosting camps were identified. Given the species extensive range and the mitigation measures proposed, including retaining large habitat trees and avoiding impacts wherever possible, it is unlikely the Project will modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat	**Unlikely.** No invasive species are known to harm the grey-headed flying-fox. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through Project activities. Control efforts will be increased in areas particularly sensitive to invasion.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Introduce disease that may cause the species to decline	**Unlikely**. Disease has not been identified as a threat to the grey-headed flying-fox.
Interfere substantially with the recovery of the species	**Unlikely.** No recovery plan has been developed for this species; however, the Conservation Advice (Threatened Species Scientific Committee, 2001) provides information on priority actions, direction to mitigate against key threats and enable recovery. Key threats that have been identified including habitat loss and fragmentation, exploitation, competition and hybridisation (i.e. an animal breeding with an individual of another species), and pollutants and electrocution. Threat abatement and recovery actions include: ▪ Stabilise the population at its 1999 level ▪ Define patterns of landscape use and identify and protect essential habitat ▪ Develop non-destructive methods for crop protection ▪ Develop non-destructive methods for management of camps in problem areas ▪ Ensure consistent management of the species across relevant States. Mitigation measures proposed will reduce impacts to potential habitat on site. The Project is not expected to significantly increase threats to the species to the extent that it will interfere with the recovery of the species.

7.5.3.3 Koala (Phascolarctos cinereus) (combined populations of Queensland, New South Wales and the Australian Capital Territory) – Vulnerable

An assessment against the EPBC Act Referral Guidelines for the Vulnerable Koala (Australian Government Department of the Environment, 2014b) was undertaken to determine whether the Project Area supports habitat critical to the survival of the koala and whether the Project is likely to have a significant impact to koalas.

The EPBC Act Referral Guidelines for the Vulnerable Koala defines habitat as ‘critical to the survival of the koala’ if a score of five or more is achieved for the whole Project Area using the koala habitat assessment tool. This assessment determined that habitat within the Project Area is habitat critical to the survival of the koala (due to a total score of 5) (Table 7-17).

As outlined in Figure 2 of the EPBC Act Referral Guidelines for the Vulnerable Koala, the upper (≥20 ha in areas with a habitat score of ≥8) and lower (≤2 ha in areas with a habitat score of 5) ‘thresholds’ give an indication of the level of impact that is likely to be significant. The Project proposes to clear approximately 12.7 ha of potential koala habitat in the Project Footprint (i.e. permanent loss to the road development), with additional clearing of up to approximately 19.2 ha of potential koala habitat in the Project Area for infrastructure such as access roads and lay down areas (totalling approximately 31.9 ha).

The clearing proposed by the Project does not fit within these thresholds and impacts are considered uncertain. The EPBC Act Referral Guidelines for the Vulnerable Koala (Figure 2) advises that where impacts are uncertain, the referral decision depends on the nature of the action and consideration of the factors listed in Table 7-18 will assist in making a decision.

The EPBC Act Referral Guidelines for the Vulnerable Koala provides the example, that a significant impact would be expected if 25 ha of habitat scoring 6 or 7, or 100 ha of score 5, was being completely cleared. Given the Project is proposing to clear up to 31.9 ha of habitat scoring 5 (i.e. substantially less than the 100 ha provided in the example), the impact is **unlikely** to be significant.

Figure 2 of the EPBC Act Referral Guidelines for the Vulnerable Koala identifies that significant impacts may be likely for other reasons, including by interfering substantially with the recovery of the koala through the introduction or exacerbation of key threats in areas of habitat critical to the survival of the koala. An assessment of the Project against the koala recovery objectives has been undertaken, which identified that the Project is **un-likely** to interfere with the recovery of the koala (Table 7-19).

Table 7-17 Koala habitat assessment tool

Attribute	Score	Description
Koala occurrence	0 (low)	A score of 0 is assigned where there is no evidence of one or more koalas within the last two years or no evidence of one or more koalas within 2 km of the edge of the impact area within the last five years. The field survey did not find evidence of one or more koalas occurring within the Project Area. The Atlas of Living Australia has no koala records within 2 km of the Project Area within the last 10 years. The most recent record is from August 2011.
Vegetation composition	+2 (high)	A score of +2 is assigned where the area has forest or woodland with two or more known koala food tree species. The Project Area has remnant vegetation with two or more known koala food trees.
Habitat connectivity	+1 (medium)	A score of +1 is assigned where the area is part of a contiguous landscape < 500 ha, but ≥ 300 ha. Remnant woodlands within the broader area are < 500 ha but ≥ 300 ha.
Key existing threats	+1 (medium)	A score of +1 is assigned where the Project Areas scores 0 for koala occurrence and is likely to have some degree dog or vehicle threat present. Data obtained from the Department of Environment and Science koala hospital database identified one verifiable koala record from 2011 which was associated with non-fatal vehicle strike (DES, 2019). This record is located 2 km to the south of the most northern extent of the Project Area. Wild dogs occur within the Project Area, however koala hospital data does not identify any koalas attacked by dogs within the Rockhampton region. The koala hospital database shows records between 1996-2019, of which only two koalas were recorded within proximity of the northern extent of the Project Area. Only one of these was a vehicle strike and neither were dog attack victims. No koala records exist south of the Fitzroy River. The Project Area occurs in proximity to the Capricorn Highway (a major arterial road).

		The limited records within the Rockhampton region indicate that there is unlikely to be an increase in the threat of dog attacks as a consequence of the Project. Whilst the Project will see an increase in vehicular traffic, koala records over an extended period of time, suggest that koala activity in the Project Area is very low, consequently the Project is unlikely to increase vehicle strikes.
Recovery value	+1 (medium)	A score of +1 is assigned where it is uncertain whether the habitat is important for achieving the interim recovery objectives for the relevant context. The vegetation within the Project Area has limited potential to support a viable breeding population and allow movement of koalas between large areas of habitat, however it is uncertain whether the habitat is important for recovery.
Total	**5**	**Decision: Habitat is Critical to the Survival of the Koala**

Table 7-18 Assessment of the Project where impacts to koala are uncertain

Characteristics that determine, in combination with each other, whether the action is likely to adversely affect habitat critical to the survival of the koala	Outcome of assessment and justification
The score calculated for the impact area (higher score = greater risk of significant impact)	5
Amount of koala habitat being cleared (more habitat cleared = greater risk of significant impact).	The Project proposes to clear approximately 12.7 ha of potential koala habitat in the Project Footprint (i.e. permanent loss to the road development), with additional clearing of up to approximately 19.2 ha of potential koala habitat in the Project Area for infrastructure such as access roads and lay down areas (totaling approximately 31.9 ha). Trees in the Project Area will be retained where possible, i.e. the area not required to facilitate construction. A small area of suitable black ironbox (*Eucalyptus raveretiana*) habitat, including several mature trees, will be temporarily lost along the northern side of the bridge across Limestone Creek, however it will be actively rehabilitated following completion of construction. The area of black ironbox to the south of the bridge across Limestone Creek will also be declared a no-go zone and will not be cleared and will contribute to recovery of the cleared area north of the bridge. During the operational phase, the road verge will be maintained and mowed however other parts of the Project Area will naturally regenerate and are expected to support koala habitat in the longer term.
Method of clearing (i.e. clear-felling has greater risk of significant impact than selective felling with understorey and koala food tree retention)	Trees will be sequentially and incrementally felled in the Project Footprint and Project Area. Clearing will be in accordance with the Environmental Management Plan (Appendix A). Following the removal of all identified fauna from within the clearing area, a two-stage clearing process, as directed in conjunction with the fauna spotter/catcher. If a koala is found prior to or during clearing activities, it will not be forcibly relocated.

Characteristics that determine, in combination with each other, whether the action is likely to adversely affect habitat critical to the survival of the koala	Outcome of assessment and justification
	The first stage of clearing will involve the removal of all vegetation NOT identified as suitable fauna habitat, or breeding habitat, or habitat trees. The retained fauna habitat and breeding habitat/places and habitat/trees are to be left standing for 24hrs to allow fauna to leave the clearing area on their own accord. Any tree that has a koala present, as well as any tree with its crown overlapping that tree, must not be removed. The trees must remain in place until the koala vacates the tree of its own accord.
The density or abundance of koalas (relatively high density or abundance for the region means greater risk of significant impact).	The field survey did not find evidence of one or more koalas occurring within the Project Area. The Atlas of Living Australia has no koala records within 2 km of the Project Area within the last 10 years. The most recent record is from August 2011.
Level of fragmentation caused by the clearing (greater degree of fragmentation has greater risk of significant impact).	**North of the Fitzroy River** In the north, clearing has the potential to fragment potential koala habitat along Limestone Creek and near Alexandra Street. The habitat to the north of the Project is connected to an extensive area of likely koala habitat on Mount Archer and is unlikely to impact the availability of koala habitat (Figure 6-12). The large area of habitat to the north of the Project can be accessed from the small patch of habitat to the south of the Limestone Creek bridge with fauna fencing used to guide koalas under the bridge and abutments set back from the waterway to allow for movement along the bank. The patch near Alexandra Street is relatively small and already fragmented by an existing road in an urban setting. The bridges in the northern part of the Project Area are shown (Figure 3-20). **Fitzroy River area** Along the Fitzroy River, clearing has the potential to fragment potential koala habitat however access would also be provided under the bridge with fauna fencing used to guide koalas and abutments set back from the waterway to allow for movement along the bank. **South of the Fitzroy River** The habitat to the south of the Project is connected to potential koala habitat along the bank of the Fitzroy River and large tributaries (e.g. Lion Creek) and is unlikely to impact the availability of koala habitat. The habitat to the south of the Project can be accessed from the small area of habitat to the north of the Fitzroy River bridge with fauna fencing used to guide koalas under the bridge and abutments set back from the waterway to allow for movement along the bank. On the floodplain, clearing has the potential to fragment potential koala habitat along Lion Creek based on regional ecosystem mapping however field-verified koala habitat was not recorded along Lion Creek.

Table 7-19 Assessment of the Project against the recovery of the koala

Impacts which are likely to substantially interfere with the recovery of the koala may include one or more of the following	Outcome of assessment and justification
Increase koala fatalities in habitat critical to the survival of the koala due to dog attacks to a level that is likely to result in multiple, ongoing mortalities	**Unlikely.** Dog attack is a key threat to the species. Dogs are known to exist within the Project Area and may be attracted to road kill however the road has been designed to reduce fauna fatalities (e.g. bridges with fauna fencing and sloped embankments) and dog populations are not expected to be exacerbated beyond current levels. Therefore, the Project is unlikely to cause multiple, ongoing mortalities.
Increase koala fatalities in habitat critical to the survival of the koala due to vehicle-strikes to a level that is likely to result in multiple, ongoing mortalities	**Unlikely.** The Project will result in a development of a major road, with increased vehicular traffic to current levels and higher speeds. Fauna-sensitive road design principles have been incorporated into the design via the inclusion of bridges, which allow fauna to pass under the road (Figure 3-20 and Figure 3-21). While not considered likely to increase fauna fatalities, there remains the possibility for mortality from vehicle strike.
Facilitate the introduction or spread of disease or pathogens, for example Chlamydia or *Phytophthora cinnamomi*, to habitat critical to the survival of the koala, that are likely to significantly reduce the reproductive output of koalas or reduce the carrying capacity of the habitat	**Unlikely.** The Project is not expected to facilitate the introduction or spread of disease or pathogens such as Chlamydia or *Phytophthora cinnamomi*. Standard vehicle hygiene practices will be implemented.
Create a barrier to movement to, between or within habitat critical to the survival of the koala that is likely to result in a long-term reduction in genetic fitness or access to habitat critical to the survival of the koala	**Unlikely.** The potential habitat within the Project Area is severely fragmented. The Project has been designed to avoid dissecting remnant vegetation where possible, with large patches of habitat unaffected by the Project. Roads and other barriers to koala movement currently exist in the Project Area. Therefore, the Project is not expected to result in a long-term reduction in genetic fitness or access to critical habitat areas.
Change hydrology which degrades habitat critical to the survival of the koala to the extent that the carrying capacity of the habitat is reduced in the long-term	**Unlikely**. Hydraulic modelling for the Project (Jacobs SMEC Design Joint Venture 2021b; 2021d) indicates that no significant hydrological changes are predicted for floodplain (including water quality), therefore, the Project is not expected to result in degradation of habitat that would lead to a long-term reduction in the carrying capacity of critical habitat for this species.

Regardless of the above assessment identifying that the koala was not required to be included in a referral, a significant impact assessment has been undertaken in Table 10-9 against the Commonwealth's Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013).

If present within the Project Area, the population does not meet the definition of an important population.

This assessment determined that the Project is **unlikely** to result in a significant impact (Table 7-20).

Table 7-20 Significant Impact Assessment – Koala

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** The habitat identified during the field surveys is not considered extensive and, if present, koalas are expected to occur in low densities. If present within the Project Area, the koala population does not meet the definition of an important population. Therefore, the Project is unlikely to lead to a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	**Unlikely.** The area of occupancy of this species is unknown. Koalas were not recorded in the Project Area however if present the population does not meet the definition of an important population. The Project is unlikely to reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	**Unlikely.** The construction of a major arterial will reduce the ability of any potentially present population to move in an east-west direction. However, numerous bridges have been incorporated into the design of the Project which may facilitate underpass for koalas. If present within the Project Area, the population does not meet the definition of an important population, therefore the Project is unlikely to fragment an existing important population into two or more populations.
Adversely affect habitat critical to the survival of a species	**Unlikely.** The assessment of the Project Area against the Habitat Assessment Tool determined that it does contain habitat that is critical to the survival of the koala. The Project is unlikely to adversely affect the habitat critical to the survival of the koala given the habitat is already fragmented and the Project will not substantially fragment the habitat further given the fauna sensitive design. There is also a very large area of more suitable koala habitat in the broader area associated with Mount

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
	Archer, and the area to be cleared is a relevatively small area of habitat with a relatively low habitat score (5).
Disrupt the breeding cycle of an important population	**Unlikely.** Koalas give birth between October and May each year. This species does not use a habitual breeding place. If present within the Project Area, the population does not meet the definition of an important population, therefore the Project is unlikely to disrupt the breeding cycle of an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** The potential habitat within the Project Area is severely fragmented and not considered to be of a high quality. The Project has been designed to minimise impacts on potential koala habitat and avoid large patches of remnant vegetation. The Project is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat	**Unlikely.** Dog attack is a key threat to the species. Dogs are known to exist within the Project Area and may be attracted to road kill however the road has been designed to reduce fauna fatalities (e.g. bridges with fauna fencing and sloped embankments) and populations are not expected to be exacerbated beyond current levels. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through Project activities. Control efforts will be increased in areas particularly sensitive to invasion. The Project is unlikely to result in invasive species that are harmful to the koala becoming established in koala habitat.
Introduce disease that may cause the species to decline	**Unlikely.** Threats to the koala include the root fungus phytophthora, bell miner-associated dieback and myrtle rust, all of which are known to impact on the health of eucalypts. The koala is known to contract strains of chlamydia and the koala retrovirus. Chlamydia infections are known to cause reduced fertility in females of the species and are expected to reduce the reproductive potential of koala populations. The koala retrovirus can cause a range of conditions including leukaemia and immunodeficiency syndrome.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
	The Project does not involve any processes that are likely to introduce a disease that may result in the decline of the koala.
Interfere substantially with the recovery of the species	**Unlikely.** Assessment of the Project against the Referral Guidelines for the koala determined that the Project is not likely to substantially interfere with the recovery of this species.

7.5.3.4 Ornamental Snake (Denisonia maculata) – Vulnerable

To determine if the Project is likely to have a significant impact on the ornamental snake, a significant impact assessment against the Commonwealth's Significant Impact Guideline 1.1 (Australian Government Department of the Environment, 2013) (Table 7-21).

There is no species-specific guideline for determining habitat critical to the survival of the ornamental snake, however important habitat is a surrogate for an important population of the species (Australian Government Department of Agriculture, Water and the Environment, 2021e), with a description of important habitat provided by the Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles as gilgai depressions and mounds and habitat connectivity between gilgais and other suitable habitats. Gilgai was not present, however cracking clays were recorded around some mapped wetlands such as Pink Lily lagoon. Impacts to wetland habitat are anticipated to be minimal as the hydraulic modelling for the Project (Jacobs SMEC Design Joint Venture 2021b; 2021d) indicates that no significant hydrological changes are predicted for the Project.

There is no evidence that the Project Area supports an important population. The area of extent spans the Brigalow Belt and an area of approximately 11 million ha. The area of occupancy is likely to be approximately 12,300 ha which includes known records in the vicinity of Rockhampton (Atlas of Living Australia, 2021).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the ornamental snake.

Table 7-21 Significant Impact Assessment – Ornamental Snake

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Lead to a long-term decrease in the size of an important population of a species.	**Unlikely** There is no evidence that the Project Area supports an important population, hence the Project is unlikely to lead to a long-term decrease in the size of an important population.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Reduce the area of occupancy of an important population.	**Unlikely** There is no evidence that the Project Area supports an important population, hence the Project is not expected to reduce the area of occupancy of an important population. Furthermore, the approximate area of potential habitat in the Project Area (approximately 35.6 ha) is substantially smaller than the area of occupancy (approximately 12,300 ha) for the population. Localised light spill from the road may negatively impact use of nocturnal foraging habitats, however this is unlikely to be significant given the limited extent of foraging habitat in the Project Area compared to the broader area of occupancy.
Fragment an existing important population into two or more populations.	**Unlikely** There is no evidence that the Project Area supports an important population, hence the Project is unlikely to fragment an existing important population into two or more populations. Localised light spill from the road may negatively impact movements under the road (through culverts and bridges), however this is unlikely to be significant given the limited extent of foraging habitat in the Project Area compared to the broader area of occupancy
Adversely affect habitat critical to the survival of a species.	**Unlikely** There is no species-specific guideline for determining habitat critical to the survival of the ornamental snake, however gilgai depressions and mounds and habitat connectivity between gilgais and other suitable habitats are defined as important habitat in the Draft Referral Guidelines for the Nationally Listed Brigalow Belt Reptiles (Australian Government Department of Sustainability, Environment, Water, Population and Communities, 2011a). Gilgai was not present within the Project Area hence habitat within the Project Area is not considered critical to the survival of this species. Furthermore, wetland habitat is considered marginal based on impacts from cattle grazing and low abundance of native frogs, which is the ornamental snake's preferred food source.
Disrupt the breeding cycle of an important population.	**Unlikely** There is no evidence that the area supports an important population, hence the Project is not expected to disrupt the breeding cycle of an important population. There is however limited information about the breeding cycle of the ornamental snake.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the	**Unlikely** Habitat quality in the Project Area is currently considered poor due to the high level of disturbance from cattle use, the naturally variable rainfall and water levels at most wetlands given the ornamental snake is associated with moist areas, and the lack of native frogs.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
species is likely to decline.	Areas of potential habitat will be lost under the Project Footprint however they are relatively small areas compared to the areas available across the floodplain and this loss is unlikely to cause the species to decline. Hydraulic modelling for the Project (Jacobs SMEC Design Joint Venture 2021b; 2021d) indicates that no significant hydrological changes are predicted for these habitats, and it is therefore considered unlikely the Project will modify, destroy, remove, isolate or decrease the availability or quality of wetland habitat to the extent that the species is likely to decline. Light spill from the road may negatively impact use of nocturnal foraging habitats, however this is unlikely to be significant given the limited extent of foraging habitat in the Project Area compared to the broader floodplain.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat.	**Unlikely** Threats to the ornamental snake include contact with the cane toad, predation by feral species and invasive weeds, many of which are present within the Project Area currently. It is unlikely that the Project will exacerbate invasive species beyond current levels. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through project activities. Control efforts will be increased in areas particularly sensitive to invasion, riparian and wetland habitats. These activities are likely to benefit the ornamental snake.
Introduce disease that may cause the species to decline.	**Unlikely** Disease has not been identified as a threat to the ornamental snake.
Interfere substantially with the recovery of the species.	**Unlikely** A recovery plan for the Queensland Brigalow Belt Reptiles, including the ornamental snake, was drafted by WWF-Australia in 2006 (Richardson, 2006). The Project is unlikely to interfere with activities outlined this plan, and the recovery of the species more generally. For example, the Project will protect key habitats in the Project Area such as wetlands and incorporate a fire management plan.

7.5.3.4.1 Squatter Pigeon (Geophaps scripta scripta) – Vulnerable

To determine if the Project is likely to have a significant impact on squatter pigeon (*Geophaps scripta scripta*), a significant impact assessment against the Commonwealth's Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-22).

The significant impact assessment identified that the Project is **unlikely** to have a significant impact on the squatter pigeon.

Important populations of squatter pigeon (southern) have been defined as per those listed in the SPRAT database (Department of Agriculture, Water and the Environment, 2021f):

- Populations occurring in the Condamine River catchment and Darling Downs of southern Queensland

- The populations known to occur in the Warwick-Inglewood-Texas region of southern Queensland
- Any populations potentially occurring in northern NSW.

None of the aforementioned important populations occur within or in proximity to the Project Area. This species remains common north of the Carnarvon Ranges in Central Queensland and is considered to be distributed as a single, continuous (i.e. inter-breeding) sub-population. Any population of squatter pigeon (southern) in the Project Area does not meet the definition of an important population.

Table 7-22 Significant Impact Assessment – Squatter Pigeon (Southern)

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Lead to a long-term decrease in the size of an important population of a species	**Unlikely.** Squatter pigeon (southern) was recorded on several occasions during the survey program. In addition to observations recorded during the survey program there are multiple records in the wider Rockhampton region and Fitzroy River Floodplain and as such the species is considered to be reasonably common in suitable habitat areas within the region (Birdlife Australia, 2021). As such, squatter pigeons (southern) occurring within the Project Area are not considered an important population. Nonetheless, the clearing of potential foraging, roosting and dispersal habitat especially in proximity to inundated wetland locations has been minimised during the detailed design via the use of bridges. Given the prevalence of the species in the local area, variable hydroperiod of wetlands within the Project Area, and relatively small areas of woodland vegetation likely to be impacted by the Project, it is highly unlikely that the Project will lead to a long-term decrease in the size of an important population.
Reduce the area of occupancy of an important population	**Unlikely.** The area of occupancy of the squatter pigeon (southern) was estimated to be approximately 1 million ha in the year 2000. The Project Area does not occur near the limits of the species' current known distribution. Any population of squatter pigeons (southern) in the Project Area is not considered an important population. Therefore, it is unlikely that the Project will reduce the area of occupancy of an important population.
Fragment an existing important population into two or more populations	**Unlikely.** Although the Project is linear, it is unlikely to form a barrier to movement for the species as it is highly mobile and will continue to have opportunity to disperse. The clearing of dispersal habitat especially near wetland locations has been minimised during the detailed design via the use of bridges and micro-siting the majority of the project alignment in areas of modified grassland. Any population of squatter pigeons (southern) in the Project Area is not considered an important population. Therefore, it is unlikely that the Project will fragment an existing important population into two or more populations.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
Adversely affect habitat critical to the survival of a species	**Unlikely.** Habitat critical to the survival of this species is not present within the Project Area. Only four squatter pigeon (2 pairs) were seen over the course of the field survey program, in two different areas. The species was not frequently encountered in the vicinity of or within the Project Area but is routinely found in other areas of higher quality habitat in the region (Hedlow Creek, Lake Mary). Natural foraging habitat for the squatter pigeon (southern) is any remnant or regrowth open-forest to sparse, open-woodland or scrub dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* spp., on sandy or gravelly soils, within 3 km of a suitable, permanent or seasonal waterbody (Australian Government Department of Agriculture, Water and the Environment, 2021f). Dispersal habitat consists of forest or woodland occurring between patches of foraging and breeding habitat and suitable waterbodies. Waterbodies in the Project Area may be used by the species however, no foraging or breeding habitat is present within the Project Area. Dispersal habitat is present; however, this is not considered to be habitat critical to the survival of the species. Breeding habitat occurs on stony rises occurring on sandy or gravelly soils, within 1 km of a suitable, permanent waterbody (Squatter Pigeon Workshop 2011). Based on habitat types within the Project Area, foraging and dispersal habitats are considered to be present. Given the modified nature of vegetation and habitat values present within the Project Area, impacts to foraging and dispersal habitat that will adversely affect the survival of squatter pigeons are not expected to occur. Detailed design of the Project currently includes bridges which allow existing waterbodies to persist and maintains their current hydrological regimes. Direct vegetation clearing and cut and fill impacts to wetlands may still occur for bridge abutments and crane pads during construction. The clearing of vegetation adjacent to wetlands may reduce the availability of dispersal habitat, however in the context of the already fragmented landscape this impact is expected to be minimal and is not expected to significantly impact potential squatter pigeon habitat. The Project should not significantly alter the hydrological conditions (including water quality) of the wetlands within and adjacent to the Project Area (Jacobs SMEC Joint Venture 2021b; 2021d). The operation of the Project will result in an increase in lighting as well as increased noise due to traffic. However, given the species' known utilisation of disturbed habitats including road reserves, it is considered unlikely this will reduce the habitat suitability for squatter pigeon in the local area.
Disrupt the breeding cycle of an important population	**Unlikely.** Habitat within the Project Area is not considered to be suitable for breeding as preferred soil substrates are not present (land zone 5 or 7) (Australian Government Department of Agriculture, Water and the Environment, 2021f).

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
	In addition, any population of squatter pigeon (southern) in the Project Area is not considered an important population.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	**Unlikely.** Breeding habitat is unlikely to be present within the Project Area. Foraging and dispersal habitat is present within the Project Area, and wetlands may be used for the species requirement to drink water daily. Given the modified nature of vegetation and habitat values present within the Project Area, impacts to foraging and dispersal habitat resulting from the construction and operation of the project are not expected to facilitate a decline in the local squatter pigeon population. No significant hydrological impacts (including water quality) are expected to occur as a result of the Project, indicating that permanent waterbodies should remain suitable. In addition, the species is known to persist in areas of active grazing and substantial habitat degradation and is resilient to impacts. As such the Project is unlikely to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat	**Unlikely.** Invasive flora and fauna species (i.e. buffel grass, fox) have been identified on the SPRAT database as a key threat to the species; however it is unlikely that the Project will exacerbate invasive species beyond current levels as a range of pest and weed species are already prevalent and well established across the Project Area. Management measures to reduce the risk of introducing novel invasive species to the region will be implemented. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through the construction of the Project. Pest animal and invasive vegetation control efforts will be increased in areas particularly sensitive to invasion.
Introduce disease that may cause the species to decline	**Unlikely.** Disease has not been identified as a main threat to the species. The delivery of the Project is unlikely to lead to the introduction of disease that would lead to the decline of the local squatter pigeon population.
Interfere substantially with the recovery of the species	**Unlikely.** The federal environment minister has declared that a national recovery plan for the squatter pigeon (southern) is not required; however current threats to this species include loss and fragmentation of habitat due to broad scale clearing for agricultural purposes, the degradation of habitat by overgrazing by domesticated herbivores, the degradation of habitat by invasive weeds, and predation by numerous avian and terrestrial predators.

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:	Outcome of assessment and justification
	While some habitat may be impacted by the Project, these areas are minimal and limited to foraging and dispersal habitats only. Higher value habitat is widely available in the surrounding region. In addition, the species is known to utilise a wide range of different habitats including highly disturbed areas, minimising the severity of impacts on the species that may occur as a result of the delivery of Project. As a result, the Project is unlikely to interfere with the recovery of the squatter pigeon (southern) at the species level.

7.5.4 Migratory Birds

To determine if the Project is likely to have a significant impact on migratory birds, a significant impact assessment against the EPBC Act Policy Statement 3.21 Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of Agriculture, Water and the Environment, 2015) is required.

When assessing the impacts to migratory birds, the identification of Important Habitat for migratory shorebirds is a key concept in determining the likelihood of significant impact from proposed actions. Important habitat for migratory shorebirds is outlined in the Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of Agriculture, Water and the Environment, 2015) and refers to areas which are nationally or internationally important.

Wetland habitat should be considered internationally important if it regularly supports[1]:

- 1% of the individuals in a population of one species or subspecies of waterbird or
- A total abundance of at least 20,000 waterbirds.

Wetland habitat should be considered nationally important if it regularly supports:

- 0.1% of the flyway population of a single species of migratory shorebird or
- 2,000 migratory shorebirds or
- 15 migratory shorebird species.

'Ecologically significant proportion of the population' refers to the proportions of each migratory species population likely to result in a significant impact if affected. This varies from species to species and as such each species will need to be evaluated based on factors such as the species':

- Population status
- Genetic distinctiveness
- Species specific behavioural patterns (i.e. site fidelity; dispersal rates).

For species that aggregate in flocks, 1% of the population is considered internationally important and 0.1% as nationally important.

The results of the targeted shorebird surveys suggest that, with the exception of Latham's snipe, there are no internationally or nationally important sites or locations for migratory shorebirds present within or adjacent to the Project Area.

Specifically, in response to the criteria provided by the Commonwealth for assessing Important Habitat for migratory shorebirds, the following is provided:

- The Project Area is not located adjacent to, nor contained within any sites identified as internationally important for migratory shorebirds.
- With the exception of Latham's snipe, the Project Area is not located adjacent to, nor contained within any sites that support 0.1% or more of the flyway population of any of the recorded migratory shorebird species, given the very low densities of birds recorded during the surveys.
- The Project Area is not located adjacent to, nor contained within any sites that were observed to support 2,000 or more individual migratory shorebirds.
- The Project Area is not located adjacent to, nor contains any sites that were observed to support 15 or more migratory shorebird species.

7.5.4.1 Latham's Snipe (Gallinago hardwickii) – Migratory, Marine

To determine if the Project is likely to have a significant impact on Latham's snipe (*Gallinago hardwickii*), a significant impact assessment against the Commonwealth's Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013) has been undertaken (Table 7-23).

Latham's snipe does not commonly aggregate in large flocks or use the same habitats as other migratory shorebird species. Consequently, habitat important to Latham's snipe cannot be identified using the process outlined above and different criteria are necessary. Important habitat for Latham's snipe occurs at sites that have previously been identified as internationally important for the species, or sites that:

- Support at least 18 individuals of the species (ecologically significant proportion of the population), and
- Are naturally occurring open freshwater wetlands with vegetation cover nearby (for example, tussock grasslands, sedges, lignum or reeds within 100m of the wetland).

Based on the locations and habitat types in which Latham's snipe were observed during the survey, there are likely to be extensive areas in the broader Fitzroy River floodplain where Latham's snipe may potentially occur. These extensive areas would range from areas that have been previously heavily disturbed (i.e. wet paddocks trodden over by cattle) to less disturbed areas such as the vast Fitzroy delta south east of Rockhampton. In the broader Fitzroy River floodplain and associated wetlands mosaic context, the approximately 2.41 ha of wetlands permanently impacted by the Project would likely comprise a very small proportion of the habitat available in the Rockhampton region at any given time.

7.5.4.1.1 Significant Impact Assessment

Based on the threshold criteria detailed above and outlined in the Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Australian Government Department of Environment and Energy, 2017a), taking into consideration the highly dynamic nature of wetlands within and in the vicinity of the Project Area, the broader Fitzroy River floodplain and associated wetland mosaic is considered to be Important Habitat for Latham's snipe. In optimal conditions, there is approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, with approximately 4,041.5 ha of potentially suitable habitat in the broader area (Figure 6-9). Within the Project Area, 2.41 ha of potential habitat will be permenantly impacted, largely due to shading from bridges. Therefore, there is a very large area of potential habitat outside of the Project Area compared to the small area potentially impacted in the Project Footprint.

While the wetlands within the Project Area contribute to what constitutes Important Habitat for Latham's snipe in the broader Fitzroy River floodplain, given the acute impacts at the Project Area scale relative to the amount of wetland habitat that would be available in ideal conditions, it is **unlikely** that the Project will have a significant impact on the species.

Table 7-23 Significant Impact Assessment – Latham's Snipe

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	Outcome of assessment and justification
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of Important Habitat for a migratory species	**Unlikely.** Important Habitat for Latham's snipe 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 (Australian Government Department of Environment, 2015a). Consideration of habitat usage at both the local and regional scale is important for migratory bird species that frequent dynamic inland wetland areas as they are particularly responsive to changes in habitat conditions. A key defining feature of the National Migratory Shorebird Program (formerly Shorebirds 2020) run by BirdLife Australia is the notion of a 'Shorebird Area'. Following (Clemens, Weston, Haslem, Silcocks, & Ferris, 2010) a shorebird area is defined as: the geographic area that has been used by the same group of shorebirds over the main non-breeding period (Austral summer), which is effectively the home range of the local shorebird population when present. Shorebird areas may include multiple roosting and feeding habitats. While most migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of the same area where there is evidence of regular bird movement between them. Migratory shorebird areas therefore often extend beyond the boundaries of a property or project area and may also extend beyond Ramsar boundaries for internationally important areas. In order to assess the relative importance of wetlands present within the Project Area, migratory bird surveys were conducted at all suitable wetland areas within a 6 km radius of the Project Area, which were consider to be the Shorebird Area within which the local Latham's snipe population is expected to utilise suitable habitat and respond to annual and seasonal variation in local wetland conditions. Wetlands within the Project Area are all part of the broader Fitzroy River Floodplain and Delta Important Bird Area or Key Biodiversity Area. The majority of these wetlands are highly variable in terms of their size, depth, bank profile, water permanency, vegetative characteristics and surrounding land use, but are all recharged by local catchment runoff or riverine flooding, or a combination of both under certain conditions. As a result, the habitat conditions they each provide is also highly variable, largely driven by the availability and amount of water they each hold, particularly during the austral summer when the majority of migratory shorebird populations are in Australia. This is particularly evident by reviewing wetland conditions and resultative bird diversity and abundances observed over the course of the migratory bird survey program (February 2019 – one survey, March 2020 – one survey, March 2021 – two surveys). Given the dynamic nature of wetland habitat within and adjacent to the Project Area, their respective importance to Latham's snipe, and other migratory shorebirds, is also highly variable between years and within seasons. As a result, identified Important Habitat areas defined by the presence of 18 birds or more Latham's snipe at any given wetland, may only constitute Important Habitat once in a series of consecutive years, and may not be considered Important Habitat on a consistent or predictable annual basis (e.g. when dry). In a local and regional landscape context, the wetland mosaic affords visiting migratory shorebirds an abundance of options when they begin arriving from August

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	Outcome of assessment and justification
	each year, and their ability to adapt and respond to local conditions allows them to seek out and colonise wetlands that provide adequate water levels, foraging resources, and roosting sites to support them until they depart northwards around the end of March each year. At the local and regional landscape scale, the wetlands in the Fitzroy River Floodplain collectively comprise Important Habitat for Latham's snipe. There are likely to be direct impacts at all wetlands that the Project Area traverses associated with construction and operation of the Project. Direct impacts are expected to occur at Pink Lily Lagoon, Lotus Lagoon, Dunganweate Lagoons, and Nelson Lagoon. Based on surveys and available database records, Lotus Lagoon and Pink Lily Lagoon provide suitable habitat conditions for Latham's snipe when they are inundated. The Project alignment traverses the southern extent of Pink Lily Lagoon which provides suitable habitat for Latham's snipe only when Pink Lily Lagoon is at or over capacity. Nelson Lagoon is generally severely degraded through livestock damage and lacks the required habitat features to support Latham's snipe. Dunganweate Lagoons are also subject to livestock access and are similarly degraded, although Latham's snipe was recorded here in 2019 (AECOM, 2020d). In optimal conditions, there is approximately 9.5 ha of potential foraging, roosting and dispersal habitat occurs within the Project Area, with approximately 4,041.5 ha of potentially suitable habitat in the broader area (Figure 6-9). Within the Project Area, 2.41 ha of potential habitat will be permenantly impacted, largely due to shading from bridges incorporated at all wetlands. Some vegetation clearance and ground disturbance works will be required to create hardstands at all proposed bridge locations to facilitate construction. During operation of the Project there are also likely to be indirect impacts associated with wetland shading, resultative changes in wetland associated vegetation composition and structure and therefore potential changes to habitat characteristics required by Latham's snipe. At a landscape scale or Shorebird Area scale, these direct and potential indirect impacts to potential Latham's snipe habitat will not substantially destroy or isolate an area of Important Habitat for a migratory species and are therefore considered to be insignificant. Wetlands traversed by the Project, and those present in the wider floodplain area, are all subject to variable hydroperiods. Based on their respective condition during the four migratory shorebird surveys that have been undertaken for the Project, wetlands traversed by the Project were largely unsuitable for the species. In the March 2021 surveys, the majority of wetlands in the region were completely dry. Latham's snipe do not utilise dry wetland habitats as they do not provide adequate foraging resources and generally lack suitable vegetation structure for roosting. Following migration or large-scale movements, upon arrival to the region the species is expected to seek out wetlands which provide suitable foraging and roosting habitat. This requires them to demonstrate a high degree of adaptability to local site

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	Outcome of assessment and justification
	conditions. Based on the above, wetlands within the Project Area are only expected to provide suitable habitat conditions on an intermittent and unpredictable basis, driven by the incidence of rainfall, localised catchment flooding and subsequent wetland inundation leading up to August and September when the species is arriving in the area each year. Significant changes to existing floodplain hydraulics and the current hydroperiod of wetlands within the Project Area are unlikely to occur as a result of the Project once completed (Jacobs SMEC Design JV, 2021b; 2021d), therefore the resulting in no substantial modification to (through altering hydrological cycles) an area of Important Habitat for a migratory species. The operation of the Project may lead to indirect disturbance related impacts to wetland habitats through increased lighting and road traffic noise. While the extent of these impacts has not been determined at this stage, the prevalence of Latham's snipe and other migratory shorebird species in wetland habitats which are proximal to existing transport corridors in other parts of eastern Australia demonstrates an inherent ability to become accustomed to novel but consistent sources of disturbance. Increases in traffic and road noise and associated road lighting are not expected to substantially modify an area of Important Habitat for Latham's snipe.
Result in an invasive species that is harmful to the migratory species becoming established in an area of Important Habitat for the migratory species	**Unlikely.** It is unlikely that the Project will exacerbate invasive species beyond current levels. Species-specific management will be undertaken for identified key pest animal and plant species at risk of spread through Project activities. Management efforts will be increased in areas particularly sensitive to weed invasion such as wetlands.
Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	**Unlikely.** Latham's snipe breed in Japan and south eastern Russia, no breeding occurs within Australia, therefore only foraging, migratory and roosting behaviours are relevant in this context. As discussed above, wetlands traversed by the Project Area contribute to a floodplain wetland landscape mosaic which collectively support an ecologically significant proportion of the population of Latham's snipe during the Austral summer (>18 birds). Although the occurrence and abundance of the species within the Project Area within successive years has been demonstrated to be highly variable, largely in response to wetland habitat suitability, the Project Area does provide suitable habitat for the foraging and roosting requirements of this species when wetland habitats are inundated.

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	Outcome of assessment and justification
	There are likely to be direct impacts at all wetlands that the Project Area traverses, associated with construction and operation of the Project. Direct impacts are expected to occur at Pink Lily Lagoon, Lotus Lagoon, Dunganweate Lagoons, and Nelson Lagoon. Based on surveys and available database records, Lotus Lagoon and Pink Lily Lagoon provide suitable habitat conditions for Latham's snipe when they are inundated. The Project alignment traverses the southern extent of Pink Lily Lagoon which provides suitable habitat for Latham's snipe only when Pink Lily Lagoon is at or over capacity. Nelson Lagoon is generally severely degraded through livestock damage and lacks the required habitat features to support Latham's snipe. Dunganweate Lagoons are also subject to livestock access and are similarly degraded, although Latham's snipe was recorded here in 2019 (AECOM, 2020d). Direct impacts at each of these wetlands have been minimised through the inclusion of bridges in the Project design. Some vegetation clearance and ground disturbance works will be required to create hardstands at all proposed bridge locations. There are also likely to be indirect impacts associated with bridge crossings, such as wetland shading, resultative changes in wetland associated vegetation composition and structure and therefore potential changes to habitat characteristics required by Latham's snipe. In the context of wetlands in the broader locality traversed by the Project, approximately 9.5 ha of potential habitat will be impacted by construction of the 4,041.5 ha of potential habitat for the species in the locality. Once built, the Project will impact approximately 2.41 ha of current mapped wetland area, largely through shading and expected resultative changes in wetland vegetation. At a landscape scale or Shorebird Area scale, these direct and potential indirect impacts to wetland areas in which Latham's snipe could currently opportunistically forage or roost will not seriously disrupt the lifecycle (feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species and are therefore considered to be insignificant. Impacts to wetlands will be managed through appropriate mitigation measures and avoided wherever practical through detailed design. Significant changes to existing floodplain hydrology and the current wetland hydroperiods are unlikely to occur as a result of the Project. Wetlands traversed by the Project, and those present in the wider floodplain area, are all subject to variable hydroperiods. Based on their respective condition during the four migratory shorebird surveys that have been undertaken for the Project, wetlands traversed by the Project were largely unsuitable for the species. In the March 2021 surveys, the majority of wetlands in the region were completely dry. Latham's snipe do not utilise dry wetland habitats as they generally do not provide adequate foraging resources and suitable vegetation structure for roosting. Following migration or large-scale movements, upon arrival to the region the species is expected to seek out wetlands which provide suitable foraging and roosting habitat. This requires them to demonstrate a high degree of adaptability to local site conditions.

An action is likely to have a significant impact on a critically endangered or endangered ecological community if there is a real chance or possibility that it will:	Outcome of assessment and justification
	While there will be some disruption to potential foraging habitat for Latham's snipe during construction of the Project, these impacts are likely to be short-term. The abundance of wetland habitat in the immediate surrounding area and floodplain provides alternative foraging and roosting habitat for the species during construction activities. Once the Project has been completed, lighting and vehicle noise related impacts may initially discourage Latham's snipe from using wetland areas in proximity to the completed road. As discussed above, the prevalence of Latham's snipe and other migratory shorebird species in wetland habitats which are proximal to existing transport corridors in other parts of eastern Australia demonstrates an inherent ability to become accustomed to novel but consistent sources of disturbance. While an important population of Latham's snipe is known to be present within the region, based on the above considerations it is highly unlikely that the Project will seriously disrupt the lifecycle (by altering foraging, roosting or migratory behaviours) of an ecologically significant proportion of the species.

7.5.4.2 Migratory Birds

One significant impact assessment has been undertaken for all other migratory bird species (with the exception of Latham's snipe) due to their similar habitat requirements, habitat use and migration patterns. Migratory listed species with a moderate or higher likelihood of occurrence within the Project Area include:

- Black-tailed godwit (*Limosa limosa*)
- Caspian tern (*Hydroprogne caspia*)
- Common Greenshank (*Tringa nebularia*)
- Common Sandpiper (*Actitis hypoleucos*)
- Curlew sandpiper (*Calidris ferruginea*)
- Eastern osprey (*Pandion haliaetus*)
- Glossy ibis (*Plegadis falcinellus*)
- Little curlew (*Numenius minutus*)
- Marsh sandpiper (*Tringa stagnatilis*)
- Pectoral sandpiper (*Calidris melanotos*)
- Red-necked stint (*Calidris ruficollis*)
- Sharp-tailed sandpiper (*Calidris acuminata*)
- White-winged black tern (*Chlidonias leucopterus*)
- Wood sandpiper (*Tringa glareola*).

Based on habitat quality, type and variability, previous records in available databases in the vicinity of the Project Area and outcomes of the survey program, the following species are considered unlikely to occur within the Project Area or surrounding region in numbers which would constitute an ecologically significant proportion of their respective populations;

- Caspian tern
- Common Sandpiper
- Eastern osprey
- Glossy ibis
- Pectoral sandpiper
- White-winged black tern
- Wood sandpiper.

For this reason, these species have not been included in the Significant Impact Assessment.

7.5.4.2.1 Significant Impact Assessment

Based on the threshold criteria detailed in the *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Australian Government Department of Agriculture, Water and the Environment, 2015), taking into consideration the highly dynamic nature of wetlands within and in the vicinity of the Project Area, the broader Fitzroy River floodplain and associated wetland mosaic may constitute Important Habitat for the following species, for which a significant impact assessment has been undertaken (Table 7-24) against the Commonwealth's Significant Impact Guidelines 1.1 (Australian Government Department of the Environment, 2013):

- Black-tailed godwit
- Curlew sandpiper
- Little curlew
- Marsh sandpiper
- Red-necked stint
- Sharp-tailed sandpiper.

At the Project Area context, the impact footprint amounts to 2.1% of the total available wetland area provided by those wetlands that are traversed. While the wetlands within the Project Area contribute to what may constitute Important Habitat for these species in the broader Fitzroy River floodplain, given the acute impacts at the Project Area scale relative to the amount of wetland habitat that would be available in ideal conditions, it is **unlikely** that the Project will have a significant impact on these species.

Table 7-24 Significant Impact Assessment – Other Migratory–listed Birds

Criteria	Outcome of assessment and justification
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of Important Habitat for a migratory species	**Unlikely.** In isolation, currently the Project Area does not constitute Important Habitat for any other birds listed as migratory. No important populations of any other species were recorded during the survey program undertaken specifically for the Project, and based on records in available databases, there are no records of important populations of any other migratory-listed bird species. Wetlands traversed by the Project, and those present in the wider floodplain area, are all subject to variable hydroperiods. Based on their respective condition during the survey program that has been implemented for the Project, wetlands traversed by the Project were largely unsuitable for the species. In the March 2021 surveys, the majority of wetlands in the region were completely dry. Migratory birds, particularly migratory shorebirds, do not utilise or depend on dry wetland habitats as they generally do not provide adequate foraging resources or suitable vegetation structure

Criteria	Outcome of assessment and justification
	for roosting purposes. Following migration or large-scale movements, upon arrival to the region migratory bird species are expected to seek out wetlands which provide suitable foraging and roosting habitat. This requires them to demonstrate a high degree of adaptability in response to local site conditions. Based on the above, wetlands within the Project Area are only expected to provide suitable habitat conditions on an intermittent and unpredictable basis, driven by the incidence of rainfall, localised catchment flooding and subsequent wetland inundation leading up to August and September when migratory species are arriving in or travelling through the area each year. Given the highly ephemeral nature of wetland habitat resources, it is likely that existing resources within the Project Area would be utilised by migratory bird species infrequently and on a transitory, opportunistic basis only. Direct impacts (vegetation clearing, wetland loss) at wetlands are minimal given the inclusion of bridges in the design of the Project. The Project Area has been micro-sited to primarily overlap areas of low-value non-remnant grassland. No significant hydrological impacts (including water quality) to wetlands should occur as a result of the Project (Jacobs SMEC Design JV, 2021b; 2021d). As such, the Project is also considered unlikely to alter the nutrient or hydrological cycles of the wider floodplain environment, including wetlands areas that are offsite or downstream of the Project Area.
Result in an invasive species that is harmful to the migratory species becoming established in an area of Important Habitat for the migratory species	**Unlikely.** It is unlikely that the Project will exacerbate invasive species beyond current levels. Species-specific management will be undertaken for identified key weed and pest species at risk of spread through Project activities. Control efforts will be increased in areas particularly sensitive to invasion.
Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species	Each of the following species breeds outside of Australia, some in the far northern reaches of the East Asian-Australasian Flyway, and therefore only foraging, migratory and roosting behaviours are relevant in this context; ▪ Black-tailed godwit ▪ Curlew sandpiper ▪ Little curlew ▪ Marsh sandpiper ▪ Red-necked stint ▪ Sharp-tailed sandpiper. The occurrence and abundance of each of these migratory birds within the Project Area over successive years is likely to be highly variable, in response to rainfall, flooding and resultative wetland habitat conditions. There is currently no evidence to suggest that the Project Area or wetlands directly adjacent to the Project Area support an 'ecologically significant proportion of a population' of the following migratory birds recorded within the broader Project Area based on records held in available databases. While Important Habitat for each of these species may be present within the broader region, identified through their presence in abundances over their respective flyway population thresholds, based on the above considerations it is highly unlikely that the

Criteria	Outcome of assessment and justification
	Project will seriously disrupt the lifecycle (by altering foraging, roosting or migratory behaviours) of an ecologically significant proportion of any of these species.

[1] 'Support' is defined differently depending on whether the habitat is considered permanent or ephemeral. For permanent wetlands, 'support' is defined as: migratory shorebirds are recorded during surveys and/or known to have occurred within the area during the previous five years. For ephemeral wetlands, 'support' is defined as: habitat that migratory shorebirds have ever been recorded in, and where that habitat has not been lost permanently due to previous actions.

7.5.5 Summary of Significant Impact Assessment

MNES species and communities that have been recorded in the Project Area or are likely to be in the Project Area are unlikely to be significantly impacted by the Project.

7.6 Contingency Plan

Contingency measures and adjustments to the management strategies are outlined in the Environmental Management Plan (Appendix A) and relevant sub plans may need to be considered in the event a detrimental impact occurs, or the mitigation measures cannot be complied with, or are deemed to be ineffective. In this event, the current mitigation strategies will be reviewed in conjunction with a Suitably Qualified Person and any recommended changes implemented.

If a threatened species, other than that identified in this document, is identified during the course of the Project, works will stop in the area until suitable mitigation measures have been developed and/or the required permits/approvals have been obtained. However, if a threatened species with the same habitat requirements as the species covered by the Environmental Management Plan (Appendix A) and Construction MNES Flora and Fauna Sub Plan is identified (e.g. other MNES mammals, migratory birds and/or reptiles) the management measures identified in the Construction MNES Flora and Fauna Sub Plan shall be applied and considered sufficient.

TMR will notify the relevant departments including the DAWE of the inclusion of the additional threatened species in the management plans.

If MNES fauna or migratory birds are injured as a result of the clearing or site investigations, the following actions will be implemented:

- Injured fauna will be inspected by the fauna spotter catcher to assess the extent of the injury or sickness.
- Where the fauna spotter catcher considers the injury to be minor (e.g. minor abrasion) and the animal is otherwise alert and active, the animal may be released into suitable habitat outside the Project Area to reduce stress on the animal.
- Where the fauna spotter catcher considers the injury to be more than minor, the fauna spotter catcher will immediately take the species to a wildlife carer/vet/animal hospital.

Any instances of an animal emergency will be followed up with an incident report submitted by the construction contractor to TMR. If an animal emergency occurs to a State or Commonwealth listed fauna species, the fauna spotter catcher will remove the affected animal to a wildlife carer/vet/animal hospital. Contact is to be made with the relevant government departments (e.g. Queensland Department of Environment and Science and/or DAWE).

7.7 Monitoring

The effectiveness of management measures detailed in the Environmental Management Plan (Appendix A) and sub plans will be monitored through the compilation of incidental, weekly and monthly reporting in accordance with TMR's contractual documentation and the Environmental Management Plan (Construction) to be developed by the construction Contractor.

The Contractor will prepare a monthly report for TMR detailing any incidents of environmental nuisance and non-conformance in accordance with the requirement outlined in Clause 7.4 of Main Roads Technical Standard 51 – Environmental Management and Clause 8.2.3 of Main Roads Technical Standard 52 – Erosion and Sediment Control. TMR has a responsibility to report all major environmental incidents that risk causing environmental harm to the Queensland Department of Environment and Science under the Queensland *Environment Protection Act 1994*.

Pre-clearance and post-clearance Fauna Survey Reports by the fauna spotter catcher will be provided as part of the monthly environmental reports during vegetation clearing works. Where fauna/eggs/young are identified on site and taken to a wildlife carer/vet/animal hospital, the outcomes of the survival success rate will be documented in the Fauna Survey Reports. The date and location of the release point of the fauna will be recorded.

Any non-compliance with the requirements of the management plans will be documented, along with details of the corrective actions undertaken.

Water quality monitoring results will be detailed in monthly reporting required to be submitted by the Construction Contractor to TMR.

The Environmental Management Plan will be updated as required during the life of the Project to revise management measures to reflect any changes to the conservation status of species identified on site and to address the management of any previously unrecorded species identified within the Project Area.

8. Ecologically Sustainable Development

8.1 State

The Department of Transport and Main Roads (TMR) and other Queensland Government departments have publicly available and in-development strategies and guidelines that have informed the development of the Project. These documents helped to guide the setting of long-term project ambitions and include the following:

- Climate Change Risk Assessment and Adaptation Assessment Framework for Infrastructure Projects (Queensland Government Department of Transport and Main Roads, 2020a)
- Queensland Climate Adaptation Strategy 2017 – 2030 (Queensland Government Department of Environment and Heritage Protection, 2017)
- Queensland Transport Strategy (Queensland Government Department of Transport and Main Roads, 2020b)

The Queensland Government set an objective within the 2016 State Infrastructure Plan (Queensland Government Department of Infrastructure, Local Government and Planning, 2016), that all government infrastructure projects over $100 million will have a sustainability assessment completed, and that it is recommended for projects between $50-$100 million. The State Infrastructure Plan goes on to nominate that the Infrastructure Sustainability Council of Australia's Infrastructure Sustainability Rating Scheme is an acceptable method to achieve this objective. Infrastructure Sustainability Council of Australia (ISCA) is a non-for-profit industry body that has developed an infrastructure-specific sustainability assessment methodology and rating scheme. With this overarching Queensland Government objective and the sustainability objectives set by TMR, the Project is targeting an 'Excellent' Infrastructure Sustainability Rating for Design (Version 1.2).

An Infrastructure Sustainability Management Plan – Design has been developed to facilitate the integration of infrastructure sustainability into the design phase of the Project and identify the procedures, processes and management systems to be adopted. The Infrastructure Sustainability Management Plan –Design will be provided to the construction contractor to update to an Infrastructure Sustainability Management Plan – Construction to manage sustainability during construction and target an 'Excellent' Infrastructure Sustainability Rating for As Built (Version 1.2).

8.2 Commonwealth

An Infrastructure Sustainability Management Plan – Design (ISMP-D) has been developed to facilitate the integration of infrastructure sustainability into the design phase of the Project and identify the procedures, processes and management systems to be adopted. The ISMP-D has been developed in accordance with Section 3A of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), which specifies the principles of Ecologically Sustainable Development. The table below details how the proposed action meets the principles of ESD, as defined in section 3A of the EPBC Act.

Table 8-1 *Environmental Protection and Biodiversity Conservation Act 1999* Ecologically Sustainable Development Principles

EPBC Act ESD Principles	How the proposed action meets the ESD Principles
Decision-making processes should effectively integrate both long-term and short term economic, environmental, social and equitable considerations	Section 5.2 of the ISMP-D details sustainability management tools and systems, which includes decision making (Section 5.2.5). The ISMP-D states that decision making for significant decisions will incorporate sustainability aspects (environment, social and economic) to achieve sustainability outcomes for the Project. Where significant changes are required from the Business Case a comparative assessment of options (e.g. Multi-Criteria Analysis) should be used with input from the design team and TMR. The assessment criteria shall evaluate options based on the forecast useful life of the infrastructure asset and should consider the following: ▪ Environment (e.g. flooding, biodiversity, etc)

EPBC Act ESD Principles	How the proposed action meets the ESD Principles
	▪ Social (e.g. safety, active transport ▪ Constructability (e.g. productivity, safety) ▪ Economic/financial (capital and operational expenditure, etc). A comparative assessment of options using the above approach will be most valuable during the initial stages of design development to facilitate significant decisions that have the most material impact. For other key decisions sustainability elements shall be considered where possible.
If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation	The Project has undertaken a rigorous environmental assessment and monitoring program, which includes the following: ▪ surface water including a Surface Water Strategy and baseline monitoring ▪ groundwater including development of a conceptual model and baseline monitoring ▪ contaminated land ▪ protected flora including follow-up targeted surveys for brigalow TEC and black ironbox surveys ▪ wetlands ▪ terrestrial fauna ▪ migratory birds ▪ freshwater turtles ▪ fish passage. The outcomes of these assessments and monitoring are being used to prevent environmental degradation and inform adaptive management.
The principle of inter-generational equity – that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations	Section 4.1 of the ISMP-D details the Rockhampton Ring Road Sustainability Commitment, which states that throughout design, construction and operation of the Project, TMR has committed to: ▪ Respect and value the natural environment, enhance biodiversity and reduce pollution ▪ Reduce greenhouse gas emissions over the project lifecycle ▪ Reduce the Project's reliance on potable water by exploring alternatives ▪ Reduce waste to landfill by reducing, reusing, recycling and recovering. Section 4.2 of the ISMP-D details the Rockhampton Ring Road sustainability objectives and targets developed to drive consistent sustainable practices and outcomes. This includes objectives and targets for our environment which align with the Project sustainability commitments.

EPBC Act ESD Principles	How the proposed action meets the ESD Principles
The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making	Section 4.1 of the ISMP-D details the Rockhampton Ring Road Sustainability Commitment, which states that throughout design, construction and operation of The Project, TMR has committed to respect and value the natural environment, enhance biodiversity and reduce pollution. Section 4.2 of the ISMP-D details the Rockhampton Ring Road sustainability objectives and targets developed to drive consistent sustainable practices and outcomes. This includes objectives and targets for the conservation of biodiversity and ecological integrity. Section 5.2 of the ISMP-D details sustainability management tools and systems, which includes decision making (Section 5.2.5). The ISMP-D states that decision making for significant decisions will incorporate sustainability aspects (including environment) to achieve sustainability outcomes for the Project.
Improved valuation, pricing and incentive mechanisms should be promoted	TMR will incorporate its selection criteria around corporate sustainability credentials ISCA experience in the procurement process where contractors will be required to provide their response.

8.3 Infrastructure Sustainability Council of Australia

Infrastructure Sustainability Council of Australia (ISCA) is a non-for-profit industry body that has developed an infrastructure-specific sustainability assessment methodology and rating scheme. The Project is targeting an “Excellent” Infrastructure Sustainability Rating for Design (Version 1.2).

The achievement of an ‘Excellent’ ISCA rating is underpinned by the Rockhampton Ring Road Project Sustainability Commitment Statement (Queensland Government Department of Transport and Main Roads, 2021). These high-level commitments have been nominated by TMR to achieve net positive social, environmental and economic impacts throughout design, construction and operation of the Project and include the following:

- Implement sustainability during design, construction, and operation
- Strengthen the region’s growth
- Improve travel efficiency
- Improve flood immunity
- Pursue and reward innovation in design and construction
- Include strategies for adaptation to climate change into the project’s design
- Consider environmental, social, economic aspects in the procurement process
- Promote workforce development opportunities
- Work with industry partners to share project learnings
- Provide appropriate sustainability knowledge sharing and resources to the RRR project team and contractors
- Improve connectivity to key facilities, employment, services, and precincts within the Rockhampton region
- Support people’s health and wellbeing, ensuring they are prioritised
- Ensure user safety
- Work with the local communities to leave a positive legacy
- Respect, value and protect Indigenous, historical, shared, and natural heritage

- Respect and value the natural environment, enhance biodiversity and reduce pollution
- Reduce greenhouse gas emissions over the project lifecycle
- Reduce the project's reliance on potable water by exploring alternatives
- Reduce materials lifecycle impacts over the project lifecycle
- Reduce waste to landfill by reducing, reusing, recycling, and recovering

Ongoing initiatives for resource efficiency and material consumption will be considered throughout the detailed design and construction phase of the Project.

9. Environmental Record of Person Proposing to Take the Action

The Department of Transport and Main Roads (TMR) has not been subject to proceedings under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) any State environmental law. TMR, as the Project proponent, is highly experienced in the planning, delivery and operation of major transport infrastructure projects. TMR's core role is the planning, building and maintaining of Queensland's road, rail, freight, and maritime infrastructure.

TMR operates under the guiding principles of its Environmental Policy and Environmental Management System. The policy outlines how TMR will manage impacts on natural, human and cultural environments by:

- Meeting the statutory obligations or all relevant environmental and heritage legislation as a minimum standard
- Considering the effects of stakeholders and long-term relationships when carrying out statutory obligations, and seeking feedback on our performance
- Acting as a good government agency and adopting a proactive approach to environmental and heritage management
- Improving awareness of environmental and heritage management processes, standards and responsibilities among Main Road employees and contractors
- Ensuring the approach to the management of environmental and heritage impacts embrace the hierarchy of "avoid, minimise and mitigate" in a financially feasible manner.

TMR undertakes works in accordance with the Department's internal Environmental Processes Manual, available to view on the TMR website at https://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Environmental-processes-manual.aspx

TMR have an Environmental Management System consistent with the principles of the joint Australian/New Zealand Standards International Organization for Standardization (AS/NZS ISO) 14001:2016.

Further information about TMR's environmental management is available at https://www.tmr.qld.gov.au/Community-and-environment/Environmental-management

TMR Fitzroy District has an excellent track record in coordinating environmental assessments and delivery of environmentally sensitive transport solutions, evidenced through recent major infrastructure on the Bruce Highway upgrades such as the Yeppen Flood Plain Upgrade, Calliope Crossroad Upgrade and the Bruce Highway – Rockhampton Northern Access Upgrade (currently under construction).

Further information about TMR's achievements, performance and outlook is available at www.tmr.qld.gov.au.

10. Social and Economic Matters

10.1 Social Impact Evaluation

A social impact evaluation has been undertaken which considers the range of social and economic impacts arising from the Project during construction and operation. The social impact evaluation was developed in accordance with the Building Queensland Social Impact Evaluation Guide (2016) and involved the following:

- A gap analysis
- Identification of social impacts through stakeholder consultations
- Desktop analysis
- An impact risk assessment
- Analysis of results.

The social impact evaluation compared the Project to the social impact baseline, which described the social environment of the Greater Rockhampton area in the absence of the Project and recognised that the current alignment of the Bruce Highway to cross through the Rockhampton Central Business District results in a dual function of the road as both a major highway and an urban arterial road. The social impact baseline identified the following issued faced by road users, the local community, the Central Queensland community, freight carriers, local businesses, government (local, state and federal) and visitors/tourists:

- Inefficiency of freight movement in Rockhampton and subsequent travel time delay
- Congestion in Rockhampton Central Business District is expected to cause travel time delay to essential services and limit economic growth
- Adverse impacts on safety and amenity
- Rockhampton is difficult to access during flood events.

Population growth in the Greater Rockhampton area combined with an increased freight task, are expected to lead to increased congestion and travel time delays for freight carriers and other road users under the social impact baseline. For the local community, the current alignment of the Bruce Highway is also associated with negative issues relating to amenity and safety.

The majority of positive material impacts identified with the proposed Rockhampton Ring Road are economic, owing to the nature of the Project. However, the results of the social impact evaluation indicate that the Project will also have a positive net social impact across the key stakeholders identified, including:

- Improved personal safety for the local community
- Improved road user experience
- Improved regional connectivity between population areas, employment hubs, essential services and tourist destinations.

The construction of the Project on a greenfield site and diversion of traffic away from the Rockhampton Central Business District ‘drive’ several negative impacts experienced in the construction and operational phase. Stakeholders also raised concerns about changing the flood patterns of the Fitzroy River Floodplain as a result of the Rockhampton Ring Road. The key underlying drivers of these impacts were construction on a greenfield site and the diversion of traffic away from the Rockhampton Central Business District and onto the Project. In the absence of the Project, stakeholders perceived that congestion would continue to increase in the Central Business District and that other upgrades to the road network would be necessary.

The main economic negative impact raised by stakeholders in social impact interviews was a concern of reduced economic activity within the Rockhampton Central Business District due to reduced passing traffic. Identified examples of businesses which may experience a reduction in customers as a result of the Project included petrol stations, pubs, hotels and fast-food restaurants. However, a set of current issues and protective factors related to the concern of reduced economic activity were also noted by stakeholders, including:

- Limited access – the site of the Project is subject to flooding and therefore difficult to develop on. Thus, it is unlikely that economic activity would be transferred to the proposed alignment.
- Location – Rockhampton is located eight hours driving distance from Brisbane and Townsville, which makes it a natural rest point along the Bruce Highway. It was considered unlikely that visitors and through traffic would choose to continue driving for several hours to the next stop due to the construction of the Project.
- Current conditions – stakeholders expressed a belief that the retail sector was performing poorly at the moment, due to a lack of confidence, increased online competition and reduced through traffic. Thus, it would be difficult to accurately attribute any further worsening of conditions to the Project as opposed to a continuation of current trends.

As a result of the social impact stakeholder interviews, the following recommendations have been made:

- Proactive consultation with local government regarding strategies to minimise the economic impact of the Project to Rockhampton.
- Periodic consultation with local government regarding changes to traffic flow as a result of the Project which may require additional works to address.
- Consultation with the Dreamtime Cultural Centre regarding construction-related issues, as well as visitor flow issues resulting from the diversion of traffic to the Rockhampton Ring Road.

A stakeholder engagement plan has been prepared and is being implemented.

10.2 Economic Evaluation

10.2.1 Methodology

An economic evaluation of the Project was undertaken for the Detailed Business Case phase of the Project using a cost-benefit analysis framework. The economic evaluation was subsequently updated during the Preliminary and Detailed Design Phase based on the final Project scope and available information. Cost-benefit analysis is a method of examining expected costs and benefits of a proposed investment using discounted cashflow analysis where the costs and benefits of the ‘with’ project option (Project Case) are compared incrementally to the ‘without’ project option (Base Case). This enables a range of measures of net economic worth to be calculated including the net present value and the benefit cost ratio.

The Base Case and Project Case are defined as follows:

- Base Case: assumes that investment in the Project does not proceed and there is a ‘minimum level of service’ provided and maintained in the Rockhampton region.
- Project Case: assumes the investment is delivered in accordance with the Department of Transport and Main Roads (TMR) timeframes and assumptions.

The cost-benefit analysis methodology was underpinned by two traffic models which were used to forecast traffic demand associated with the Project infrastructure and changes to traffic flows in the modelled network. The cost-benefit analysis has been conducted in accordance with published guidelines/frameworks on transport project appraisal and economic evaluation, including:

- Australian Transport Assessment and Planning Guidelines – T2 Cost Benefit Analysis.
- Building Queensland Business Case Development Frameworks Cost Benefit Analysis Guide Release (December 2016).
- Infrastructure Australia’s Assessment Framework (IAAF) Detailed Technical Guidance (March 2018).
- Queensland Transport and Main Roads Cost Benefit Manual.
- Queensland Treasury Project Assessment Framework Cost Benefit Analysis (July 2015).

The cost-benefit analysis considered the value of the Project Case within the context of the Queensland and Australian community, specifically noting the Bruce Highway’s role as Queensland’s primary north-south inter-regional road route for passenger and freight movements and evaluated the broader costs and benefits associated with the proposed infrastructure. This allowed the Detailed Business Case to consider the key role the Bruce Highway plays in connecting regional centres and as a critical link (to other regional highways such as Capricorn Highway) to facilitate freight movements to/from inland production areas to ports that export commodities (e.g. agriculture) to overseas markets.

Improvements in the movement of freight in and around Rockhampton are significant to the Queensland economy, since several of the freight movements coming from the north of Rockhampton originate from the highly productive agricultural areas near Townsville and Cairns and from cattle producing regions in Central and Northern Queensland, used for processing in abattoirs in Rockhampton, South East Queensland and Townsville.

The economic evaluation is based on several key economic assumptions used to estimate benefits and costs of the Project. The estimation of key benefits and costs of the project, such as travel time savings and vehicle operating costs, are a function of traffic modelling outputs and as such are subject to the constraints and limitations of the traffic model used.

The traffic demand forecasts which underpin the economic analysis of the Project have been provided by AECOM. Traffic modelling outputs were developed by AECOM and region-specific traffic data from Transport and Main Roads (including traffic data for the Rockhampton region and data from the Queensland Freight Model). Detailed cost estimates are informed by the financial model. To ensure alignment between the traffic modelling and the economic analysis, detailed assumptions have been made to increase the specificity of the benefit and cost estimation.

10.2.2 Findings

The results of the economic appraisal, including the effect of discounting on each cost and benefit stream, of the Project are shown Table 10-1. At a discount rate of 7%, the benefit cost ratio is 0.57 and the net present value is -$303.2 million which indicates the benefits of the Project are lower than the costs. At a lower discount rate of 4 per cent the net present value is -$69.5 million and the benefit cost ratio increases to 0.87.

The benefit cost ratio of less than one across the 4%, 7% and 10% discount rates is driven by comparatively low traffic demand compared to the substantial cost of constructing the Project through a floodplain. While this benefit cost ratio is noted, the Project provides a range of benefits including quantitative and qualitative benefits that were incorporated into the economic analysis.

Further to this, an economic assessment of the wider road strategy program in the region (Fitzroy River Floodplain and Road Planning Study), which includes the Project, showed that the benefits of the Fitzroy River Floodplain and Road Planning Study outweighed the costs at a discount rate of 7%. A substantial economic benefit of the Fitzroy River Floodplain and Road Planning Study was the travel time savings, vehicle operating cost savings and flood immunity benefits.

Table 10-1 Economic benefits and costs of RRR at various real discount rates $M2020 (2020 to 2055)

Cost Benefit Analysis Results (P50)			
Item	**4% (REAL)**	**7% (REAL)**	**10% (REAL)**
Project Benefits ($million)			
Travel time savings	485.4	277.1	169.5
Travel time reliability	30.2	16.8	10
Vehicle operating costs savings	53.2	27.3	14.8
Safety (i.e. avoided accidents net of safety disbenefits)	30.1	18.6	12.3
Externalities (i.e. positive less negative)	54.2	33.6	22.2
Flood immunity benefits	38.0	23.3	15.3
Total benefits	**691.0**	**396.7**	**244.1**
Project Costs ($million)			
Initial capital costs	791.6	720.2	657.4
Life cycle capital costs	-7.6	-19.4	-24.3
Repairs and maintenance	30.1	18.9	12.7
Residual value (non-risk adjusted)	-53.6	-19.8	-7.5
Total Costs ($million)	**760.5**	**699.9**	**638.3**
Net Present Value ($million)	**-69.5**	**-303.2**	**-394.2**
Benefit Cost Ratio	**0.91**	**0.57**	**0.38**

10.2.2.1 Quantitative benefits

The investment in the Project is expected to generate almost $277 million in travel time savings discounted at a 7% real discount rate over the evaluation period (2025 to 2055). This is the most significant benefit stream – accounting for around 75% of the total project benefits (discounted) and this includes benefits associated with induced demand.

Travel time benefits for medium commercial vehicles and heavy commercial vehicles totals $64 million discounted and includes the value of both driver time and freight moved through the region. This emphasises the benefits associated with improved freight movements (value of freight time) with the Project. Over the period 2025 to 2055 the cumulative time savings through the Project is approximately 22 million vehicle hours.

Safety benefits (i.e. reduced crash costs net of safety dis-benefits) arise as a consequence of the reduced crash rate associated with use of the Project. The crash rate on the Bruce Highway through Rockhampton CBD is estimated at 17.9 casualty crashes per 100 million vehicle km travelled in the Base Case. With the Project, the crash rate is lowered to 8.59 casualty crashes per 100 million vehicle km travelled, this is considered a reasonable proxy for the additional safety associated with a modern new link.

The Project provides flexibility for road users and reduces the chance of unexpected delays (such as localised congestion) and the amount of time road users must factor in for a standard journey. The discounted value of travel time reliability benefits is approximately $17 million over the evaluation period. The bulk of these benefits accrue to car users. Fewer benefits accrue to users of medium commercial vehicles and heavy commercial vehicles as trip routes are likely to be more fixed and this allows less scope for reliability benefits.

The Project results in flood immunity benefit by reducing the average annual time of closure on the Capricorn Highway and Lower Dawson road, avoiding delays and reducing travel distance. This leads to a combined saving in travel time and vehicle operating costs of $23.3 million after discounting.

The Project results in vehicle operating costs savings of $27.3 million. The increase in average speed at which vehicles can travel lowers unit vehicle operating costs. This results in overall vehicle operating costs savings.

The Project also contributes to avoided externalities (net of negative externalities). The avoided externalities are primarily driven by reduced air pollution and noise. These avoided externalities, as a result of the Project, are around $33 million.

10.2.2.2 Qualitative Benefits

The Project is not considered to generate significant wider economic benefits and as such these benefits are discussed qualitatively.

Agglomeration economies arises from firms being in closer proximity to each other and having increased access to larger product markets, face to face contact and exchange of information. It is not considered that the Project would result in any material benefits due to agglomeration economies.

Output change in imperfectly competitive markets arises from relatively lower transport costs to business travellers and freight transport that provides firms with the opportunity to profitably increase their outputs of goods/services using transport as input. While the Project allows freight vehicles and business travellers to reduce the costs of travel, the portion of the journey through Rockhampton is considered to be a small portion of the overall freight journey and therefore unlikely to have a significant effect on output for these industries and the benefits associated with business travel are unlikely to be over and above the benefits which have already been captured in travel time savings.

The Project may lead to improved industry connectivity throughout the region, including:

- Agriculture: Rockhampton is often referred to as the ‘beef capital of Australia’, Rockhampton plays a central role in processing and supply chain support to regional beef producers. With two export focused abattoirs to service the region, it is one of the largest concentrations of beef processors in the country. The impact of the Project on the agricultural industry in Rockhampton is reviewed in detail in the Social Impact Evaluation (SIE).
- Public transport: the traffic modelling did not provide multi-modal outputs, hence the benefit to the Rockhampton public transport system as a result of the Project has not been estimated. However, it is likely that the associated benefit (primarily as a result of improved travel times) would be small due to the size of the Rockhampton public transport system.
- Rockhampton Airport Masterplan: It will benefit from improvements in the transport network because of the Project’s proximity to the airport for freight being moved to the airport. The proximity of the airport to the Project positions the airport to receive freight via heavy vehicle movements with potentially less disruption to the urban transport network.

The capital costs of the Project are estimated to be $903 million (undiscounted in $2020) over the period 2020 to 2025) at the P50 level. This increases to $973 million at the P90 level of confidence. The Project offers lifecycle capital cost savings, which includes pavement rehabilitation, bridge maintenance and bridge strengthening. These cost savings are $19.4 million discounted at a 7 per cent real discount rate. The residual value of these assets in the economic evaluation is estimated to be $19.8 million in present value terms. This is included as negative capital cost in the final year of the evaluation (2055) within the discounted cash flow analysis. Capital cost estimates have been informed by the financial model developed by Deloitte.

Sensitivity analysis has been undertaken to gauge the robustness of the economic evaluation and variation in the headline measures of net economic worth (net present value and benefit cost ratio) under various plausible changes to key assumptions such as:

- Capital costs varied by +/-20% with all benefits streams remaining unchanged

- All benefits varied by +/-20% with all capital costs remaining unchanged
- The implications of higher and lower traffic demand tested through increasing travel time savings for vehicles by 20% and then decreasing travel times savings by the same percentage
- The occupancy rate for cars (private and business) changed to 1.4 (weighted for cars and utility vehicles) in line with occupancy rates based on Transport for New South Wales Guidelines (that are lower than Australian Transport and Planning values) and to address Infrastructure Australia concerns that occupancy rates in Australian Transport and Planning may overstate true occupancy rates
- The evaluation period is extended to 50 years given the long economic life of capital assets involved e.g. road and bridge assets
- A best-case scenario where all project costs decline by 20% and all project benefits are assumed to be 20% greater
- A worst-case scenario where all project costs rise 20% and all project benefits reduce by 20%
- Excluding travel time savings benefits associated with the induced demand (i.e. generated trips and diverted trips)
- The annualisation factor varied on the upside and downside from its project specific value
- Lifecycle capital cost savings are set to zero
- Choice of vehicle operating costs methodology (i.e. using the Austroads 2008 parameter values) is tested by changing the parameter values to the Austroads 2012 parameter values
- Extrapolation of traffic volumes beyond the last modelled year.
- Lower population growth on road user benefits.

The results of the sensitivity analysis show that for the Project to result in a more favourable outcome, a material increase in project benefits (for example, travel time savings) or a significant reduction in project costs (for example capital costs) would be required.

The Project is estimated to have a positive impact on direct employment in the region. The total capital expenditure associated with the Project is estimated to support an average of 462 full-time equivalent jobs directly over the period from FY2020 to FY2025, peaking at 1,000 direct full-time equivalent jobs supported in FY2023.

It should be noted that the estimation of economic impacts (such as direct employment impacts) of the construction of Rockhampton Ring Road is based on different methodology to cost-benefit analysis. In a cost-benefit analysis, labour is treated as a cost, which reflects the opportunity cost of labour.

10.2.3 Summary

The Project seeks to address the key problems experienced by Rockhampton residents and business that operate in and around the region including:

- Freight movements through Rockhampton are impacted by the number of intersections and slower travel speeds
- Localised congestion in Rockhampton
- The current alignment of the Bruce Highway is impacting safety and amenity in Rockhampton
- Rockhampton is harder to access during flood events.

The Rockhampton region is a major service hub for the Central Queensland region and supports a diversified economic base. Rockhampton is an important centre for retail, education, health, airport and other facilities, and serves as an important transport hub and major service centre for the agricultural and mining industries.

There is a substantial rural base in the Rockhampton region, with beef cattle, cropping and horticulture being key activities. It is also a regional centre for many government and service sectors.

Economic activity requires transport to supply goods to markets and supplies to economic agents producing goods. There is also a need to supply workforce and services to businesses, and customers have to access retail and other outlets. These broad relationships mean that requirements for transport are an important derived demand from economic activity. The infrastructure solution required to address the Project's identified problems is complex, and as such has high associated construction costs that drive a low benefit cost ratio. While this benefit cost ratio is noted, the Project provides a range of benefits estimated quantitatively and qualitatively.

11. References

AECOM. (2019). *Cultural Heritage Risk Assessment Rockhampton Ring Road.*

AECOM. (2020a). *Rockhampton Ring Road EPBC Act referral .*

AECOM. (2020b). *Migratory shorebird survey report.*

AECOM. (2020c). *Review of Environmental Factors - Rockhampton Ring Road - Detailed Business Case.*

AECOM. (2020d). *Terrestrial fauna and migratory birds technical report Rockhampton Ring Road.*

AECOM. (2020e). *Threatened turtle and fish habitat assessment.*

AECOM. (2020f). *Flora and wetlands technical report Rockhampton Ring Road - business case.*

Ahern, C., Dear, S.-E., Dobos, S., McElnea, A., Moore, N., O'Brien, L., & Williams, K. (2014). *Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines.* Brisbane: Queensland Department of Science, Information Technology, Innovation and the Arts, Queensland Government.

Atlas of Living Australia. (2021). *Spatial Portal accessed 28 June 2021*. Retrieved from https://spatial.ala.org.au/?q=lsid:https:%2F%2Fid.biodiversity.org.au%2Fnode%2Fapni%2F2896993&qc=data_hub_uid:dh9#

Australian Government Bureau of Meteorology. (2019). *Climate Data Online*. Retrieved from http://www.bom.gov.au/climate/data/

Australian Government Bureau of Meteorology. (2021). *Bureau of Meteorology*. Retrieved from http://www.bom.gov.au/climate/data/?ref=ftr

Australia Government Department of Agriculture, Water and the Environment. (2021). *Eucalyptus raveretiana (black ironbox) .* Retrieved from https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=16344

Australian Government Department of Agriculture, Water and the Environment. (2021a). *Species Profile and Threats Database, Rostratula australis – Australian Painted Snipe. Department of the Environment*. Retrieved from: https://www.environment.gov.au/sprat

Australian Government Department of Agriculture, Water and the Environment. (2021b). *Species Profile and Threats Database, Calidris ruficollis — Red-necked Stint*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=860

Australian Government Department of Agriculture, Water and the Environment. (2021c). *Species Profile and Threats Database, Calidris melanotos — Pectoral Sandpiper*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=858

Australian Government Department of Agriculture, Water and the Environment. (2021d). *Species Profile and Threats Database, Chlidonias leucopterus — White-winged Tern, White-winged Black Tern accessed 22 June 2021*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59598

Australian Government Department of Agriculture, Water and the Environment. (2021e). *Species Profile and Threats Database, Denisonia maculata — Ornamental Snake accessed 21 June 2021*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1193

Australian Government Department of Agriculture, Water and Environment. (2021f). *Species Profile and Threats Database, Crocodylus porosus — Salt-water Crocodile, Estuarine Crocodile.* Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1774

Australian Government Department of Agriculture, Water and the Environment. (2021g). *Species Profile and Threats Database, Hydroprogne caspia — Caspian Tern accessed 22 June 2021*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=808

Australian Government Department of Agriculture, Water and the Environment. (2021h). *Species Profile and Threats Database, Geophaps scripta scripta — Squatter Pigeon (southern)*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=64440

Australian Government Department Agriculture, Water and the Environment. (2021i). *Species Profile and Threats Database, Hirundapus caudacutus — White-throated Needletail*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=682

Australian Government Department of Agriculture, Water and the Environment. (2021j). *Species Profile and Threats Database, Limosa limosa — Black-tailed Godwit accessed 22 June 2021*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=845

Australian Government Department of Agriculture, Water and the Environment. (2021k). *Species Profile and Threats Database, Numenius minutus — Little Curlew, Little Whimbrel*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=848

Australian Government Department of Agriculture, Water and the Environment. (2021l). *Species Profile and Threats Database, Rheodytes leukops — Fitzroy River Turtle, Fitzroy Tortoise, Fitzroy Turtle, White-eyed River Diver accessed 23 June 2021*. Retrieved from https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1761

Australian Government Department of Agriculture, Water and the Environment. (2021m). *Species Profile and Threats Database, Pandion haliaetus cristatus — Eastern Osprey, Australian Osprey*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=91198

Australian Government Department of Agriculture, Water and the Environment. (2021n). *Species Profile and Threats Database, Plegadis falcinellus — Glossy Ibis*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=991

Australia Government Department of Agriculture, Water and the Environment. (2021o). *Species Profile and Threats Database, Pteropus poliocephalus — Grey-headed Flying-fox accessed 18 June 2021.* Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186

Australian Department of Agriculture, Water and the Environment. (2021p). *National Flying-fox monitoring viewer*. Retrieved from https://www.environment.gov.au/webgis-framework/apps/ffc-wide/ffc-wide.jsf

Australian Government Department of Agriculture, Water and the Environment. (2021q). *Species Profile and Threats Database, Tringa glareola — Wood Sandpiper*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=829

Australian Government Department of Environment, Water and the Environment. (2021r). *Species Profile and Threats Database, Tringa nebularia — Common Greenshank, Greenshank*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=832

Australian Government Department of Environment, Water and the Environment. (2021s). *Species Profile and Threats Database, Actitis hypoleucos — Common Sandpiper accessed 18 June 2021*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59309

Australian Government Department of Agriculture, Water and Environment. (2021t). *Species Profile and Threats Database, Calidris acuminata — Sharp-tailed Sandpiper accessed 22 June 2021*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=874

Australian Government Department of Agriculture, Water and Environment. (2021u). *Species Profile and Threats Database - Cycas ophiolitica*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=55797

Australian Government Department of Agriculture, Water and the Environment. (2020a). *National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds.* Retrieved from https://www.environment.gov.au/biodiversity/publications/national-light-pollution-guidelines-wildlife

Australian Government Department of Agriculture, Water and the Environment. (2020b). *National Recovery Plan for the Whitethroated Snapping Turtle (Elseya albagula).* Commonwealth of Australia: Canberra.

Australian Government Department of Agriculture, Water and Environment. (2018). *Threat abatement plan for disease in natural ecosystems caused by Phytophthora cinnamomi*. Retrieved from https://www.awe.gov.au/sites/default/files/documents/tap-phytophthora-cinnamomi-2018.pdf accessed 27 October 2021

Australian Government Department of Agriculture, Water and the Environment. (2015). *EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species.* Retrieved from https://www.environment.gov.au/epbc/publications/shorebirds-guidelines

Australian Government Department of Environment, Water, Heritage and the Arts. (2009). *Weeping Myall Woodlands. A nationally threatened ecological community Environment Protection and Biodiversity Conservation Act 1999 Policy Statement 3.17*. Retrieved from http://www.environment.gov.au/system/files/resources/a887e6ec-f4db-4476-8e72-977085028dbd/files/weeping-myall-woodlands.pdf

Australian Government Department of Environment, Water, Heritage and the Arts. (2008). *Approved Conservation Advice for Rheodytes leukops (Fitzroy Tortoise)*. Retrieved from https://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1761: https://www.environment.gov.au/biodiversity/threatened/species/pubs/1761-conservation-advice.pdf

Australian Government Department of the Environment and Energy. (2018). *Guidelines for assessing the conservation status of native species according to the Environment Protection and Biodiversity Conservation Act 1999 and Environment Protection and Biodiversity Conservation Regulations 2000*. Retrieved from https://www.environment.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2018.pdf

Australian Government Department of Environment and Energy. (2018a). *What are the ecological impacts of groundwater drawdown?* Retrieved from https://www.environment.gov.au/system/files/resources/1f3ca8af-a881-4c3a-b6bb-07d7ebaef0ca/files/what-are-the-ecological-impacts-of-groundwater-drawdown.pdf accessed 11 October 2021

Australian Government Department of the Environment and Energy. (2017). *The National Recovery Plan for the White-throated Snapping Turtle (Elseya albagula).* Canberra: Comonwealth of Australia.

Australian Government Department of Environment and Energy. (2017a). *EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species.*

Australian Government Department of the Enviornment, Water, Heritage and the Arts. (2010). *Survey guidelines for Australia's threatened birds - Guidelines for detecting birds listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.*

Australian Government Department of the Enviornment, Water, Heritage and the Arts. (2010a). *Survey guidelines for Australia's threatened bats.*

Australian Government Department of the Environment, Water, Heritage and the Arts. (2008). *Approved Conservation Advice for Weeping Myall Woodlands ecological community*. Retrieved from http://www.environment.gov.au/biodiversity/threatened/communities/pubs/98-conservation-advice.pdf

Australian Government Department of the Environment. (2015a). *Referral guideline for 14 birds listed as migratory species under the EPBC Act.* Retrieved from http://environment.gov.au/system/files/resources/c05f5b87-0a99-4998-897e-7072c236cf83/files/migratory-birds-draft-referral-guideline.pdf

Australian Government Department of the Environment. (2015b). *Conservation Advice Calidris ferruginea curlew sandpiper.* Retrieved from http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf

Australian Government Department of the Environment. (2014a). *Conservation Advice Elseya albagula White-throated snapping turtle.* Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=81648

Australian Government Department of the Environment. (2014b). *EPBC Act referral guidelines for the vulnerable koala.* Retrieved from http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala

Australian Government Department of the Environment. (2014c). *Environmental Management Plan Guidelines.* Retrieved from https://www.environment.gov.au/epbc/publications/environmental-management-plan-guidelines

Australian Government Department of the Environment. (2013). *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance.* Retrieved from https://www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance

Australian Government Department of Sustainability Environment, Water, Population and Communities. (2011a). *EPBC Act - Draft Referral guidelines for the nationally listed Brigalow Belt reptiles.* Retrieved from https://www.environment.gov.au/resource/epbc-act-draft-referral-guidelines-nationally-listed-brigalow-belt-reptiles

Australian Government Department of Sustainability , Environment, Water, Population and Communities. (2011b). *Survey guidelines for Australia's threatened reptiles. Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999.*

Austroads Inc. . (2000). *Road Runoff and Drainage: Environmental Impacts and Management Options.*

Bamford, M., Watkins, D., Bancroft, W., Tischler, G., & Wahl, J. (2008). *Migratory Shorebirds of the East Asian–Australasian Flyway: Population Estimates and Internationally Important Sites.* Canberra: Wetlands International – Oceania.

Baudains, T., & Lloyd, P. (2007). Habituation and habitat changes can moderate the impacts of human disturbance on shorebird breeding performance. *Animal Conservation*, 10: 400-407.

Birdlife Australia. (2009). *Australia's Important Bird Areas.* Birdlife Australia.

Birdlife Australia. (2021). *Birdlife Australia, Birdata database accessed June 2021*. Retrieved from https://birdata.birdlife.org.au/

BirdLife International. (2021). *Important Bird Areas factsheet: Fitzroy Floodplain and Delta.* . Retrieved from http://www.birdlife.org/

Blakers, M., Davies, S., & Reilly, P. (1984). *The Atlas of Australian Birds.* Melbourne: Melbourne University Press.

Butler, D. (2007). *Recovery plan for the "Brigalow (Acacia harpophylla dominant and co-dominant" endangered ecological community .* Brisbane: Queensland National Parks and Wildlife Service.

C&R Consulting. (2020). *Wetland Impact Assessment Rockhampton Ring Road Project.*

Cameron, R. & M. Hinchey (1981). *An apparently immature White-throated Needletail in Australia.* Australian Bird Watcher. 9:68.

Campbell, H. A., Dwyer, R. G., Irwin, T. R., & Franklin, C. E. (2013). Home Range Utilisation and Long-Range Movement of Estuarine Crocodiles during the Breeding and Nesting Season. *PLoS ONE*, 1.

Campbell, A.G. (1930). *Notes on swifts.* Emu. 29:308.

Cann, J. (1998). *Australian Freshwater Turtles.* Singapore: Beaumont Publishing.

Clemens, R., Weston, M., Haslem, A., Silcocks, A., & Ferris, J. (2010). Identification of Significant Shorebird Areas. *Diversity and Distributions*, 16:229-242.

Cogger, H., Cameron, E., Sadlier, R., & Eggler, P. (1993). *The Action Plan for Australian Reptiles.* Australian Nature Conservation Agency.

CSIRO Land and Water. (2021). *Australian Soil Resource Information System*. Retrieved from https://www.asris.csiro.au/index.html

Deniz, O., Lorenzo, J., & Hernandez, M. (2003). A computational mechanism for habituation in perceptual user interfaces. *CIMCA 2003 Proceedings*, (pp. 846-856). Vienna.

Draffan, R.D.W., S.T. Garnett & G.J. Malone (1983). *Birds of the Torres Strait: an annotated list and biogeographic analysis*. Emu. 83:207-234.

Duffield, G. (2019). *Representative Values of Hydraulic Properties.* Retrieved from http://www.aqtesolv.com/aquifer-tests/aquifer_properties.htm accessed 14 October 2021

eBird. (2021). *eBird: An online database of bird distribution and abundance accessed June 2021*. Retrieved from https://ebird.org/home

Ecosure. (2021a). *Technical Note - Turtle Habitat Survey.*

Ecosure. (2021b). *Ecosure data of Eucalyptus raveretiana and Brigalow Threatened Ecological Community (TEC).*

Etcheverry, B. (1915). *Irrigation Practice and Engineering: Conveyance of water.* New York: McGraw-Hill.

Eyre, T J; Ferguson, D J; Smith, G C; Mathieson, M T; Kelly, A L; Venz, M F; Hogan, D L; Rowland, J;. (2018). *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland.* Brisbane: Department of Enviornment and Science.

Garnett, S. (1989). Wading Bird Abundance and Distribution - South-eastern Coast of the Gulf of Carpentaria. *RAOU Report Series*, 58:1-39.

Garnett, S., & Crowley, G. (2000). *The action plan for Australian birds.* Canberra: Environment Australia.

GHD. (2015). *Lower Fitzroy River Infrastructure Project, Fitzroy River turtle (Rheodytes leukops) technical report.*

GHD. (2016). *Gladstone Area Water Board and SunWater, Lower Fitzroy River Infrastructure Project; additional information to the draft environmental impact statement Fitzroy River turtle and white-throated snapping turtle species management program.* Brisbane: GHD.

Gochfeld, M., & Burger, J. (1996). Family Sternidae (Terns). In J. del Hoyo, & J. Sargatal, *Handbook of the Birds of the World. Volume 3: Hoatzin to Auks* (pp. 624-667). Barcelona: Lynx Edicions.

Gordos, M. A. (2007). Diving behaviour of Elseya albagula from a naturally flowing and hydrologically altered habitat. *Journal of Zoology*, 458-469.

Goss-Custard, J., Triplet, P., Sueur, F., & West, A. (2006). Critical thresholds of disturbance by people and raptors in foraging wading birds. *Biological Conservation*, 127:88-97.

Government of Western Australia. (2001). *Living Wetlands: An Introduction to Wetlands*. Retrieved from https://www.water.wa.gov.au/__data/assets/pdf_file/0016/5380/11420.pdf

Government of Western Australia Department of Primary Industries and Regional Development. (2021). *Waterlogging – the science*. Retrieved from https://www.agric.wa.gov.au/waterlogging/waterlogging-%E2%80%93-science

Great Barrier Reef Marine Park Authority . (2013). *Fitzroy basin assessment: Fitzroy Basin Association Natural Regional Management Region.*

Halford, D. (1997). *Eucalyptus raveretiana Species Management Profile.* Brisbane: Department of Natural Resources.

Hamann, M. (2007). *Management plan for the conservation of Elseya sp. [Burnett River] in the Burnett River catchment.* Brisbane: Queensland Government EPA QPWS.

Hansen, B. F., Rogers, D., Clemens, R., Newman, M., Woehler, E., & Weller, D. (2016). *Revision of the East Asian–Australasian Flyway Population Estimates for 37 listed Migratory Shorebird Species. Unpublished report for the Department of Environment.* Melbourne: BirdLife Australia.

Higgins, P., & Davies, S. (1996). *Handbook of Australian, New Zealand & Antarctic birds. Volume 3, Snipe to Pigeon.* Melbourne: Oxford University Press.

Higgins, P.J. (1999). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 4, Parrots to Dollarbird.* Melbourne: Oxford University Press

Hull, C.L., Stark, E.M., Peruzzo, S. & Sims, C.C. (2013). *Avian collisions at two wind farms in Tasmania, Australia: taxonomic and ecological characteristics of colliders versus noncolliders.* New Zealand Journal of Zoology 40, 47-62.

Jacobs SMEC Design Joint Venture. (2021a). *Migratory Bird Survey.*

Jacobs SMEC Design Joint Venture. (2021b). *Technical Note - Hydraulics of Wetland Connectivity.*

Jacobs SMEC Design Joint Venture. (2021c). *Rockhampton Ring Road Contamianted Land Gap Analysis.*

Jacobs SMEC Design Joint Venture. (2021d). *Hydraulic Analysis Design Report.*

Jacobs SMEC Design Joint Venture. (2021e). *Technical Note - Water Quality Strategy.*

Jacobs SMEC Design Joint Venture. (2021f). *Technical Note - Eucalyptus ravertiana Population Survey.*

Jacobs SMEC Design Joint Venture. (2021g). *Water Quality Report.*

JASCO Applied Sciences. (2017). *Underwater Noise Modelling of Impact Pile Driving.* Retrieved from https://thirdcrossing.cityofkingston.ca/documents/26467239/38278041/Appendix%20G%20-%20Underwater%20Noise%20Modelling%20of%20Impact%20Pile%20Driving%20-%20Final.pdf accessed 15 October 2021

Lane, B., & Rogers, D. (2000). The Australian painted snipe Rostratula (benghalensis) australis: An endangered species? *Stilt* , 36: 26–34.

Limpus, C. (2011). *The biology and management strategies for freshwater turtles in the Fitzroy Catchment, with particular emphasis on Elseya albagula and Rheodytes leukops.* Brisbane: Department of Environment and Resource Management.

Lindgren, E. (1956). Irruption of the White-winged Black-Tern in the south-west. *Western Australian Naturalist*, 5:124.

McDonald, K., Covacevich, J., Ingram, G., & Couper, P. (1991). The Status of Frogs and Reptiles. In G. &. Ingram, *An Atlas of Queensland's Frogs, Reptiles, Birds and Mammals* (pp. 338-345). Queensland Museum: Brisbane.

Neldner, A. J., Dillewaard, B. A., Butler, D. W., 'Ryan, T. S., & Wilson, B. A. (2017). *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland.* Brisbane: Queensland Herbarium.

New South Wales Government Department of Planning, Industry and Environment. (2018). *Freshwater mussels*. Retrieved from https://www.environment.nsw.gov.au/topics/animals-and-plants/native-animals/native-animal-facts/freshwater-mussels

New South Wales Government Office of Environment & Heritage. (2011). *Freshwater mussels in coastal streams of New South Wales*. Retrieved from https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Animals-and-plants/Native-animals/freshwater-mussels-coastal-streams-nsw-110307.pdf

Pearce, B., & Hansen, J. (2006). *Hydrogeological Investigation of the Fitzroy River sub-catchment, Central Queensland, Australia.* Brisbane: Water Assessment Group, Department of Natural Resources, Mines and Water.

Peeters, P., & Butler, D. (2014). *Brigalow: regrowth benefits management guideline.* Brisbane: Department of Science, Information Technology, Innovation and the Arts.

Philips, S., & Callaghan, J. (2011). The Spot Assessment Technique: a tool for determining localised levels of habitat use by Koalas Phascolarctos cinereus. *Australian Zoologist*.

Queensland Department of Environment and Science. (2021b). *WildNet database*. Retrieved from https://www.qld.gov.au/environment/plants-animals/species-information/wildnet

Queensland Government. (2021). Queensland Government Queensland Spatial Catalogue - QSpatial.

Queensland Government. (2019). *Impacts of acid sulfate soils.* Retrieved from https://www.qld.gov.au/environment/land/management/soil/acid-sulfate/impacts accessed 14 October 2021

Queensland Government Department of Agriculture and Fisheries. (2021). *Invasive plants and animals, accessed 6 July 2021*. Retrieved from https://www.daf.qld.gov.au/business-priorities/biosecurity/invasive-plants-animals

Queensland Government Department of Agriculture and Fisheries. (2018). *Guidelines for Fish Salvage, accessed 6 July 2021*. Retrieved from https://www.daf.qld.gov.au/business-priorities/fisheries/habitats/policies-guidelines/factsheets/guidelines-for-fish-salvage

Queensland Government Department of Environment and Heritage Protection. (2011). *Environmental Protection (Water) Policy 2009 Environmental Protection (Water) Policy Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Fitzroy River Sub-basin 2009.*

Queensland Government Department of Environment and Heritage Protection. (2017). *Pathways to a Climate Resilient Queensland.*

Queensland Government Department of Environment and Heritage Protection. (2014). *Flora Survey Guideline – Protected Plants.*

Queensland Government Department of Environment and Resource Management. (2011). *Queensland wetland definition and delineation guideline.*

Queensland Government Department of Environment and Resource Management. (2011a). *Salinity management handbook.* Brisbane: Queensland Government.

Queensland Government Department of Environment and Science. (2018). *Monitoring and Sampling Manual - Environmental Protection (Water) Policy 2009 .* Brisbane: Queensland Government.

Queensland Government Department of Environment and Science. (2020a). *Flora survey guideline – Protected plants.*

Queensland Government Department of Environment and Science. (2020b). *Guide to determining terrestrial habitat quality, Methods for assessing habitat quality under the Queensland Environmental Offsets Policy, Version 1.3 February 2020*. Retrieved from https://environment.des.qld.gov.au/__data/assets/pdf_file/0017/102833/habitat-quality-assessment-guide-v1-3.pdf

Queensland Government Department of Environment and Science. (2020c). Hydrogeology of the Great Artesian Basin. Retrieved from: https://wetlandinfo.des.qld.gov.au/wetlands/ecology/processes-systems/water/catchment-stories/transcript-gab.html

Queensland Government Department of Environment and Science. (2021a). *WetlandInfo, Riverine ecology accessed 24 June 2021*. Retrieved from https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/riverine/

Queensland Government Department of Environment and Science, Queensland. (2021b). *WetlandInfo, Palustrine ecology accessed 24 June 2021*. Retrieved from https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/palustrine/

Queensland Government Department of Environment and Science. (2021c). *WetlandInfo, Lacustrine ecology accessed 24 June 2021*. Retrieved from https://wetlandinfo.des.qld.gov.au/wetlands/ecology/aquatic-ecosystems-natural/lacustrine/

Queensland Government Department of Environment and Science. (2021d). *Regional ecosystem descriptions*. Retrieved from https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions

Queensland Government Department of Environment and Science. (2021e). *Species profile—Numenius minutus (little curlew)*. Retrieved from https://apps.des.qld.gov.au/species-search/details/?id=1844

Queensland Government Department of Environment and Science. (2021f). *WetlandInfo - Lower Fitzroy Catchment Story accessed 24 June 2021*. Retrieved from https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/

Queensland Government Department of Infrastructure, Local Government and Planning. (2016). *State Infrastructure Plan 2016.*

Queensland Government Department of Natural Resources and Mines . (2018). *Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual* . Rocklea: Queensland Government.

Queensland Government Department of Transport and Main Roads. (2021). Rockhampton Ring Road Project Sustainability Committment Statement. *2021*.

Queensland Government Department of Transport and Main Roads. (2020a). *Climate Change Risk Assessment and Adaptation Assessment Framework for Infrastructure Projects.*

Queensland Government Department of Transport and Main Roads. (2020b). *Queensland Transport Strategy.*

Queensland Government Department of Transport and Main Roads. (2020c). *Rockhampton Ring Road Preliminary and Detailed Design Functional Specification.*

Queensland Herbarium. (2008). *Specimen label information*.

Queensland Herbarium. (2007). *National Multi-species Recovery Plan for the cycads, Cycas* . Brisbane: Queensland Parks and Wildlife Service.

Read, M. A., Miller, J. D., Bell, I. P., & Felton, A. (2004). The distribution and abundance of the estuarine crocodile, Crocodylus porosus, in Queensland. *Wildlife Research*, 527-534.

Richardson, R. (2006). *Draft Queensland Brigalow Belt Reptile Recovery Plan 2008 - 2012. Report to the Department of the Environment, Water, Heritage and the Arts, Canberra.* Brisbane: WWF-Australia.

Robert, M., & McNeil, R. (1989). Comparative day and night feeding strategies of shorebird species in a tropical environment. *Ibis*, 131: 69-79.

Rockhampton Regional Council. (2017). *Rockhampton Regional Council Biosecurity Plan for Pest Management.*

Rogers, D., Hnace, I., Paton, S., Tzaros, C., Griffioen, P., Herring, M., Weston, M. (2005). The breeding bottleneck: Breeding habitat and population decline in the Australian painted snipe. *Status and Conservation of Shorebirds in the East Asian-Australasian.* Canberra.

Santos, C., Miranda, A., Granadeiro, J., Lourenço, P., Saraiva, S., & Palmeirim, J. (2009). Effects of artificial illumination on the nocturnal foraging of waders. *Acta Oecologica* , 36: 166-172.

Slater, K.R. (1964). *Spine-tailed Swift in central Australia*. Emu. 64:72.

Smit, C., & Visser, G. (1993). Effects of disturbance on shorebirds: a summary of existing knowledge from the Dutch Wadden Sea and Delta area. *Wader Study Group Bulletin*, 68: 6-19.

Standards Australia. (2020). *AS/NZS IEC 31010:2020 Risk management - Risk assessment techniques.* Homebush and Wellington: Standards Australia and Standards New Zealand.

Standards Australia. (2018). *Australian Standard ISO 31000:2018 Risk Management Guidelines.* Homebush and Wellington: Standards Australia and Standards New Zealand.

Standards Australia. (1998). *AS/NZS 5667.1:1998 Water quality – Sampling: Guidance on the design of sampling programs, sampling techniques and preservation and handling of samples.* Homebush and Wellington: Standards Australia and Standards New Zealand.

Standards Australia. (1981). *Australian Standard 2436-1981, Guide to noise control on construction, maintenance and demolition sites .* Homebush: Standards Australia.

Stokes, T. (1983). *Bird casualties in 1975-76 at the Booby Island Lightstation*, Torres Strait. Sunbird. 13:53-58

Sundaram, B., Feitz, A., de Caritat, P., Plazinska, A., Brodie, R., Coram, J., & Ransley, T. (2009). *Groundwater Sampling and Analysis – A Field Guide.* Canberra: Geoscience Australia.

Tarburton, M.K. (2014). *Status of the White-throated Needletail Hirundapus caudacutus in Australia: Evidence for a marked decline.* Australian Field Ornithology 31, 122-140

Threatened Species Scientific Committee. (2019). *Conservation Advice Hirundapus caudacutus White-throated Needletail.* http://environment.gov.au/biodiversity/threatened/species/pubs/682-conservation-advice-04072019.pdf

Threatened Species Scientific Committee. (2014). *Conservation Advice - Elseya albagula (White-throated snapping turtle).* Retrieved from Species Profile and Threats Database: http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Threatened Species Scientific Committe. (2013). *Approved Conservation Advice for the Brigalow (Acacia harpophylla dominant and co-dominant) ecological community.* Retrieved from http://www.environment.gov.au/biodiversity/threatened/communities/pubs/028-conservation-advice.pdf

Threatened Species Scientific Committee. (2009). *Commonwealth Listing Advice on Weeping Myall Woodlands*. Retrieved from http://www.environment.gov.au/biodiversity/threatened/communities/pubs/98-listing-advice.pdf

Tucker, A. D., Limpus, C. J., Priest, T. E., Cay, J., Glen, C., & Guarino, E. (2001). Home ranges of Fitzroy River turtles (Rheodytes leukops) overlap riffle zones: potential concerns related to river regulation. *Biological Conservation*, 102:171-181.

Water Quality Australia. (2018). *Australian and New Zealand guidelines for fresh and marine water quality, accessed 6 July 2021*. Retrieved from https://www.waterquality.gov.au/guidelines/anz-fresh-marine

Watkins, D. (1993). *A National Plan for Shorebird Conservation in Australia. Royal Australasian Ornithologists Union Report No. 90.* Melbourne: RAOU.

Weller, D., Kidd, L., Lee, C., Klose, S., Jaensch, R., & Driessen, J. (2020). *Directory of Important Habitat for Migratory Shorebirds in Australia. Prepared for Australian Government Department of Agriculture, Water and the Environment.* Melbourne: BirdLife Australia.

West, A., Goss-Custard, J., Stillman, R., Caldow, R., Durell, S., & McGrorty, S. (2002). Predicting the impacts of disturbance on shorebird mortality using a behaviour-based model. *Biological Conservation* , 106:319-328.

WSP. (2018). *Mordialloc Bypass (Freeway) Environment Effects Statement - Chapter 17 Groundwater.* Retrieved from https://roadprojects.vic.gov.au/__data/assets/pdf_file/0005/334652/Chapter-17-Groundwater.pdf accessed 21st October 2021