MacIntyre Wind Farm Project Environmental Offsets Strategy

Prepared for:
ACCIONA Energy Australia Global Pty Ltd

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Environmental Offsets Strategy

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1.0 Introduction

1.1 Background

ACCIONA Energy Australia Global Pty Ltd (ACCIONA) proposes to develop and operate the MacIntyre Wind Farm Project (the Project) with up to 169 wind turbines that are anticipated to generate approximately 963 MW of renewable energy to contribute to the national electrical grid, together with associated ancillary infrastructure.

The Project is located approximately 40 km southwest of the township of Warwick and 70 km southwest of Toowoomba, Queensland. The Project is located within Southern Downs Regional Council and Goondiwindi Regional Council Local Government Areas and is proposed over 16 subject lots as well as road reserves and easements.

The Project will be connected into Powerlink's transmission network via a proposed 64 km 330 kV overhead transmission line (OHTL). The OHTL will be shared with the proposed neighbouring Karara Wind Farm (KWF). Approximately 27 km of the OHTL traverses the KWF and MIWF project areas. The three projects (MIWF, KWF and the OHTL) are being progressed as separate projects due to current or likely future ownership arrangements.

The Project will require a Development Approval under the Queensland *Planning Act 2016* (the Planning Act) and an approval under the Federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). A referral was submitted to the Commonwealth Department of Agriculture, Water and the Environment (DAWE), assessing the Project's potential to have a significant impact on matters of national environmental significance (MNES). Detailed ecology studies have been completed to identify and assess the type and extent of MNES potentially impacted by the Project and these formed the basis of the EPBC referral. Significant impact assessments were presented in the EPBC referral alongside initial quantification of potential impacts to MNES where impacts have been assessed as significant.

The Project was subsequently declared a controlled action by DAWE for its potential to have a significant impact on listed threatened species and communities and listed migratory species. A request for information was received from DAWE and some additional ecological studies have been undertaken since the referral was submitted. The results of these additional surveys are presented elsewhere in the Preliminary Documentation package of which this Offsets Strategy forms a part. The Preliminary Documentation package also includes updated significant impact assessments and revised quantification of potential impacts to MNES.

1.2 Purpose and Scope

The purpose of this Environmental Offsets Strategy is to demonstrate the feasibility of securing a scientifically robust offset program for the Project in support of securing approval under the EPBC Act.

This Environmental Offset Strategy has been prepared to present:

- An outline of relevant approvals and environmental offset regulatory framework at Federal and State level for the Project;
- A summary of the significant residual impacts to MNES and identification of the Project's environmental offset requirements – noting that a more detailed discussion on the extent of residual impacts is presented elsewhere in the Additional Information Response Report as part of Preliminary Documentation package;
- The proposed offset delivery approach and timeframes for future stages in the offset program;
- Results of the offset availability analysis;

- Information on the proposed offset sites currently undergoing investigation in relation to their suitability to provide the necessary offsets for the Project;
- Proposed habitat scoring methodologies for MNES values to be offset;
- For each MNES value to be offset, a description of the final conservation outcomes being sought, progressive milestones to be achieved to demonstrate progress towards these final outcomes and high-level management measures considered likely to be required to achieve the progressive milestones and final conservation outcomes.

This Environmental Offset Strategy relates only to the MacIntyre Wind Farm Project; separate strategies are being prepared for the OHTL and KWF.

2.0 Approvals and Regulatory Framework

Environmental offset requirements for the Project occur at the Federal and State level. Relevant legislation and policies are described in the following sections.

2.1 Federal Government Approval

2.1.1 Environment Protection and Biodiversity Act 1999

The EPBC Act is the Australian Government's central piece of environmental legislation that provides a legal framework to manage proposed actions that will or are likely to have an impact on MNES, which includes nationally and internationally important flora, fauna, ecological communities and heritage places.

The Project was determined as a 'controlled action' due to the potential for significant impacts to occur to listed migratory species, threatened species and communities. It therefore requires approval under the EPBC Act. Due to the likelihood of a significant residual impact on MNES an environmental offset is required to compensate for that impact. Environmental offsets are required to comply with the EPBC Act Environmental Offsets Policy (DSEWPC 2012). This policy outlines the Australian Government's approach to the use of environmental offsets ('offsets') under the EPBC Act. Offsets are defined as measures that compensate for the residual adverse impacts of an action on the environment.

Avoidance and mitigation measures are the primary strategies for managing the potential significant impact of a proposed action. Offsets do not reduce the likely impacts of a proposed action, but instead compensate for any residual significant impact. Where environmental offsets are required for MNES an offsets package should be provided. An offsets package is a suite of actions that a proponent undertakes to compensate for the residual significant impacts to the identified MNES. The EPBC Act requires offsets to be comprised largely of direct (land-based) offsets and other compensatory measures. Offsets should align with conservation priorities for the impacted protected matter and be tailored specifically to the attribute of the protected matter that is impacted in order to deliver a conservation gain (DSEWPC 2012).

2.1.1.1 Direct Offsets

Direct offsets are those actions that provide a measurable conservation gain for an impacted protected matter. Direct offsets are an essential component of a suitable offsets package. A minimum of 90% of the offset requirements for any given impact must be met through direct offset (DSEWPC 2012). Deviation from the 90% direct offset requirement will only be considered where:

- It can be demonstrated that a greater benefit to the protected matter is likely to be achieved through increasing the proportion of other compensatory measures in an offsets package; or
- Scientific uncertainty is so high that it is not possible to determine a direct offset that is likely to benefit the protected matter.

Conservation gain is the benefit that a direct offset delivers to the protected matter, which maintains or increases its viability or reduces any threats of damage, destruction or extinction. A conservation gain may be achieved by:

- Improving existing habitat for the protected matter; or
- Creating new habitat for the protected matter; or

- Reducing threats to the protected matter; or
- Increasing the values of a heritage place; or
- Averting the loss of a protected matter or its habitat that is under threat.

2.1.1.2 Compensatory Offsets

Other compensatory measures are those actions that do not directly offset the impacts on the protected matter but are anticipated to lead to benefits for the impacted protected matter, for example funding for research, implementing priority actions outlined in applicable recovery plans or educational programs. Other compensatory measures should relate to the impacted aspect of the protected matter. For example, research into effective re-vegetation techniques for a particular ecological community may be an appropriate component of an offsets package for an action that involves clearing of that ecological community (DSEWPC 2012).

2.2 State Approval

2.2.1 Planning Act 2016

Under the *Planning Act 2016,* wind farm development is assessable development (a material change of use for a wind farm). In accordance with Part 21, Division 2, Table 1 of the *Planning Regulation 2017*, the Project requires assessment and decision by the Department of State Development, Infrastructure, Local Government and Planning (DSDILGP), represented by the State Assessment and Referral Agency (SARA), as assessment manager. The Project will be assessed against State Code 23: Wind farm development (State Code 23).

The purpose of State Code 23 is to protect individuals, communities and the environment from adverse impacts resulting from the construction, operation and decommissioning of wind farm development. Table 23.2.1 of State Code 23 lists the relevant performance outcomes and acceptable outcomes (as applicable) with which the Project must demonstrate compliance. Offsets must be provided where there is an unavoidable residual impact on Matters of State Environmental Significance (MSES). Offsets must be provided in accordance with the *Environmental Offsets Act 2014*.

2.2.2 Queensland Environmental Offset Framework

Environmental offsets are required when a *prescribed activity* causes *significant residual impacts* on *prescribed matters* of national, state or local significance despite all reasonable avoidance and mitigation measures. This framework provides structure for delivering, monitoring and assessing environmental offsets and is comprised of the *Environmental Offsets Act 2014*, *Environmental Offsets Regulation 2014* and Queensland Environmental Offsets Policy (v.1.9).

Under the Queensland Environmental Offset Framework, an environmental offset may be required when:

- An activity has been identified as a *prescribed activity*;
- An activity will have an impact on a *prescribed environmental matter*;
- The activity will have a *significant residual impact* on a *prescribed environmental matter,* despite all reasonable avoidance and mitigation measures; and
- An environmental offset is an appropriate solution.

The above points must be considered when identifying if a prescribed activity requires environmental offsets and conditions to be imposed.

2.2.2.1 Environmental Offsets Act 2014

The main purpose of the *Environmental Offsets Act 2014* (EO Act) is to counterbalance *significant residual impacts* of an activity on *prescribed environmental matters* at the Commonwealth, State and local level using environmental offsets. This Act states environmental offsets must achieve a *conservation outcome* for the impacted matter. A *conservation outcome* is achieved if, selected and delivered correctly, an offset can maintain the status quo of the *prescribed environmental matter* as if the development and offset had not occurred. The Act defines a *prescribed environmental matter* as:

1. *A prescribed environmental matter is any of the following matters prescribed under a regulation to be a prescribed environmental matter –*
    a) *A matter of national environmental significance*
    b) *A matter of State environmental significance*
    c) *A matter of local environmental significance*

Section 14(1) outlines that an administering agency can impose an offset condition on an authority if:

a) *the prescribed activity will, or is likely to, have a significant residual impact on a prescribed environmental matter; and*
b) *all reasonable on-site mitigation measures for the prescribed activity have been, or will be, undertaken.*

The offset conditions imposed by administering agencies have limitations and are outlined in Section 15(1-4):

1. *An administering agency may impose an offset condition on an authority only if:*

    a) *The same, or substantially the same, impact has not been assessed under a relevant Commonwealth Act; and*

    b) *The same, or substantially the same, prescribed environmental matter has not been assessed under a relevant Commonwealth Act*

2. *Subsection (1) applies whether or not the assessment resulted in the imposition of an offset condition*

3. *However, Subsection (1) does not apply if the prescribed environmental matter to which the condition relates is a protected area*

4. *An administering agency that is a local government may impose an offset condition on an authority only for the following:*

    a) *A matter of local environmental significance*

    b) *Another prescribed environmental matter that is further prescribed by regulation as relevant for this subsection*

The EO Act in accordance with the Policy provides three approaches in which an offset can be delivered and requirements per the delivery. These include a proponent-driven offset, a financial settlement offset or a combination of both. For a proponent-driven offset, an offset delivery plan and an agreed delivery arrangement is required before starting an activity. For a financial settlement offset, the amount payable must be in accordance with this Act and the Policy, and in the way stated in the agreed delivery arrangement. A detailed description of a proponent-driven,

financial settlement or combination offset is provided in Division 4&5 of the EO Act and **Section 2.2.2.3** of this document.

Part 6A of the Act outlines that offset conditions cease to apply when a duplicate condition is imposed at another level of jurisdiction.

2.2.2.2 Environmental Offsets Regulation 2014

The Project can be considered a *prescribed activity* under Schedule 1 Section 4 of the *Environmental Offsets Regulation 2014* as defined by the following points:

1. *Taking a protected plant within the meaning of the Nature Conservation Act 1992 under a protected plant clearing permit granted under the Nature Conservation (Administration) Regulation 2006, section 15 in an area outside a protected area*
2. *Development for which an environmental offset may be required under any of the following State Development Assessment Provisions –*
   a) *module 8 (native vegetation clearing)*
3. *Development for which an environmental offset may be required under any of the following –*
   a) *a local planning instrument;*
   b) *State planning regulatory provision within the meaning of the Sustainable Planning Act 2009*

Schedule 2 Section 5 of the *Environmental Offset Regulation 2014* provides a list of *prescribed environmental matters* of State environmental significance (MSES) some of which the Project may potentially impact. These MSES are listed below:

2. *Regulated Vegetation*
   1) *the prescribed regional ecosystems that are endangered regional ecosystems comprise a matter of State environmental significance.*
   2) *the prescribed regional ecosystems that are of concern regional ecosystems comprise a matter of State environmental significance.*
   3) *a prescribed regional ecosystem is a matter of State environmental significance if it is –*
      a) *a regional ecosystem that intersects with an area shown as a wetland on the vegetation management wetlands map*
      b) *an area of essential habitat on the essential habitat map for an animal that is endangered wildlife or vulnerable wildlife or a plant that is endangered wildlife or vulnerable wildlife*
   4) *a prescribed regional ecosystem is a matter of State environmental significance to the extent the ecosystem is located within a defined distance from the defining banks of a relevant watercourse*
3. *Connectivity areas*
   2) *the prescribed regional ecosystem is a matter of State environmental significance if the administering agency is satisfied, having had regard to criteria in the environmental offsets policy about connectivity areas, that –*
      a) *The connectivity area is of sufficient size or configured in a way that maintains ecosystem functioning; and*
      b) *The prescribed regional ecosystem will remain despite a threatening process within the meaning of the Nature Conservation Act 1992*
6. *Protected wildlife habitat*
   1) *An area that is shown as a high-risk area on the flora survey trigger map and that contains plants that are endangered wildlife or vulnerable wildlife is a matter of State environmental significance*
   2) *An area that is not shown as a high-risk area on the flora survey trigger map, to the extent the area contains plants that are endangered wildlife or vulnerable wildlife, is a matter of State environmental significance*

3) *(only applicable to South East Queensland)*
4) *A habitat for an animal that is endangered wildlife or vulnerable wildlife or a special least concern animal is a matter of State environmental significance*

Under the Policy, an environmental offset for an impact on regulated vegetation can be provided in an ecosystem in the same broad vegetation group. A conservation outcome therefore can be achieved by offsetting an impact on a regional ecosystem, at a site with a similar ecosystem. Furthermore, the offset will have the same regional ecosystem status, occur in the same bioregion and be listed in the same broad vegetation group. The financial settlement formula should use the broad vegetation group scales, depending upon the ecosystem types within the groups, whilst a land-based offset should use the 1:1,000,000 scale.

2.2.2.3 Queensland Environmental Offset Policy v.1.9.

The Queensland Environmental Offset Policy is a decision-support tool used to assess offset proposals and ensure requirements of the EO Act are met. This Policy is relevant to this Project as it provides guidance on offset requirements for impacts on *prescribed matters* at commonwealth, State and local level. Offsets delivered under this policy must achieve a *conservation outcome* for the impacted *prescribed matters*. The Policy proposes three offset delivery options:

- Proponent-driven offset, comprising:
  - A land-based offset;
  - Actions in a Direct Benefit Management Plan (DBMP); or
  - Both; or
- Financial settlement offset; or
- Combination of a proponent-driven offset and a financial settlement offset.

Land-based offset can be an individual or multiple parcels of land being managed to achieve a *conservation outcome* for any impacted *prescribed environmental matters*. To achieve a *conservation outcome,* a land-based offset site must have the following characteristics:

- In relation to endangered and of concern regional ecosystems:
  - Of the same broad vegetation group as the impacted regional ecosystem;
  - Of the same regional ecosystem status; and
  - Within the same bioregion;
- In relation to a plant or animal that is critically endangered, endangered, vulnerable, near threatened and special least concern wildlife under the *Nature Conservation Act 1992*:
  - The offset site must contain, or be capable of containing, a self-sustaining population of that same impacted species;
- For vegetation intersecting a wetland:
  - Of the same broad vegetation group as the impacted regional ecosystem;
  - Within the same bioregion; and

- Associated with a wetland
- For connectivity:
  - A non-remnant ecosystem; and
  - In the same subregion; however, if the subregion is intact, the offset should be in the nearest fragmented subregion
- Maximum four times the area of impact on each MSES
- Provide a gain in 'habitat quality' suitable to compensate the loss of 'habitat quality' at the impact site (habitat quality assessment with The Guide to Determining Terrestrial Habitat Quality)

DBMP offsets is a packaged investment that provides priority actions that address threats and benefits for *prescribed environmental matters*. The Policy requires a DBMP is pre-approved by the Department of Environment and Science (DES) before being considered as part of an offset delivery approach. Pre-approval of a DBMP for MSES can be done by DES, or relevant local government under local government's jurisdiction. DES will only approve a DBMP with endorsement of the plan from the administering agency responsible for the management of MSES.

Financial settlement offsets allow a proponent to provide a payment in accordance with this Policy and meet offset requirements. For financial settlement offsets required by the State, payment amount must be calculated in accordance with the Financial Settlement Offset Calculation Methodology. This methodology must be used when determining a suitable offset payment for impacts on MSES.

Proponent-driven offsets require an offset delivery plan which is subject to further requirements under the EO Act and EO Regulation and finally agreed upon with the administering agency. The Policy articulates these requirements and are summarised below:

- Describe the prescribed environmental matter to which the offset condition relates;
- State whether the offset condition will be delivered wholly or partly on the land where the offset will be delivered;
- Describe how the offset will be conducted and the conservation outcome achieved;
- Description of the land where the offset will be delivered;
- Include information on persons with interest in the land subject to the offset;
- Describe the existing land use of the land subject to the offset, and if this land use will have an impact on the offset;
- Account for and manage the risk of failing to achieve a conservation outcome;
- Ensure the offset provides benefits to the prescribed environmental matter in addition to other benefits provided under a requirement of an Act;
- Transparent government arrangements – offsets are easily measured, monitored and assessed across all jurisdictions;
- Scale and size of offset is proportionate to the significant residual impact on the prescribed environmental matter;
- Statement provided by the authority holder listing:
  - Measures undertaken to secure land subject to offset as a legally secured offset area;

- Measures taken are reasonable and practical;
- The period in which measures will be taken and why this is a reasonable period to secure the land.

A combination of proponent-driven and financial settlement is also an offset option. The Policy's suggested process for delivering this type of offset to achieve offset obligations focusses primarily on proponent-driven offsets, with the outstanding balance being provided as financial settlement.

The Policy outlines additional offset tools including Strategic Offset Investment Corridors (SOICs) and Advanced Offsets. SOICs are pre-defined areas of land that contain MNES and MSES that are not subject to high development pressure or zoned for urban activities. Advanced offsets are parcels of land reserved for the future potential use as an offset site for impacted matters. Proponents are encouraged to seek SOIC opportunities with landholders because of the landscape-scale benefits to prescribed matters.

2.2.3 Nature Conservation Act 1992

The purpose of the *Nature Conservation Act 1992* is to provide for the conservation of nature whilst enabling indigenous people to be involved in the management of protected areas. This Act is triggered under Schedule 1 s[4](5) of the *Environmental Offset Regulation 2014* in that '*taking a protected plant within the meaning of the Nature Conservation Act 1992 outside a protected area'* is a *prescribed activity* and will *'require a protected plant clearing permit granted under the Nature Conservation (Administration) Regulation 2006*'.

2.2.4 Vegetation Management Act 1999

The purpose of the *Vegetation Management Act 1999* is to regulate the clearing of vegetation whilst managing for environmental effects caused by clearing. The Project involves operation works, that is clearing native vegetation, which is otherwise prohibited if not for a relevant purpose (*Planning Regulation 2017*). However, under Section 22A(2)(d) of the *Vegetation Management Act 1999*, the Project is considered a relevant purpose; '*for relevant infrastructure activities and clearing for the development cannot reasonably be avoided or minimised*'. The clearing of native vegetation will require an environmental offset under State Code 16: Native vegetation clearing (State Code 16) of the SDAP under the Planning Act.

2.3 Environmental Offset Hierarchy

Until the Queensland Environmental Offsets Framework has been recognised by the Australian Government, for the purposes of the EPBC Act, the framework is not applicable to impacts on MNES and jurisdiction responsibility remains with the relevant Federal agency (QOEP Guidelines v.1.2). For MSES, the Queensland Government has jurisdiction over offset requirements. Local Government has jurisdiction over MLES which must be specified in a local government planning scheme and be approved by the state in accordance with the Minister's Guidelines and Rules under the *Planning Act 2016*.

To avoid duplication of offset conditions across jurisdictions, the EO Act requires agencies to consider existing offset conditions that have been applied to the activity. The EO Act requires that the State cannot impose an offset condition that is the same or substantially the same impact, if DAWE has assessed an activity as a controlled action and decided that an offset is, or is not required. In addition, the EO Act requires that a MLES cannot be the same or substantially the same as an MNES or MSES, therefore duplication of MLES offset conditions with MNES or MSES offset conditions should not occur.

3.0 Project Environmental Offset Requirements

3.1 Ecological Values of the Project Area

The Project is located on agricultural land that has been extensively cleared and fragmented over generations of intensive sheep grazing. Despite this, the Project footprint retains areas of remnant vegetation with high ecological value for native flora and fauna. The Project area is immediately adjacent to the Durikai State Forest and MacIntyre State Forest, both of which retain large stands of Eucalypt woodland that provide habitat for a range of flora and fauna including conservation significant species.

Desktop analysis and ecological field assessments have been completed for the Project between 2011 and 2021 to support an understanding of the environmental values that are present. These studies informed a likelihood of occurrence assessment that returned the following EPBC Act listed species and communities:

- Confirmed present:
  - One threatened ecological community (TEC) – white box-yellow box-Blakely's red gum grassy woodland and derived native grassland (critically endangered);
  - One flora species – *Macrozamia conferta* (vulnerable);
  - Two bird species – squatter pigeon (southern) (*Geophaps scripta scripta*) (vulnerable) and white-throated needletail (*Hirundapus caudacutus*) (vulnerable, migratory);
  - Two mammals – koala (*Phascolarctos cinereus*) (vulnerable) and central greater glider (*Petauroides armillatus*) (vulnerable);
- Likely to occur:
  - Two flora species – *Eucalyptus infera* (Durikai mallee) (vulnerable) and *Tylophora linearis (syn Vicetoxicum forsteri)* (endangered);
  - Five bird species – regent honeyeater (*Anthochaera phrygia*) (critically endangered), painted honeyeater (*Grantiella picta*) (vulnerable), swift parrot (*Lathamus discolor*) (critically endangered), fork-tailed swift (*Apus pacificus*) (migratory) and rufous fantail (*Rhipidura rufifrons*) (migratory);
  - One mammal species – grey-headed flying-fox (*Pteropus poliocephalus*) (vulnerable).

Additional detailed information is available in the MIWF MNES Assessment Report (GHD 2021).

3.2 Assessment of Significant Impacts

The design and layout of the Project has been refined through the iterative application of the mitigation hierarchy to minimise potential impacts as far as practicable. Nevertheless, the construction and operation of the Project will result in the removal of vegetation and the disturbance of existing ground conditions on either a temporary or permanent basis. The assessment of impacts to MNES determined that the following impacting processes are those most likely to result in a significant impact to one or more MNES:

- Loss of habitat;
- Injury or mortality;

- Fragmentation of habitat and loss of connectivity;
- Disturbance to habitat from noise, light and vibration;
- Habitat degradation and increased erosion;
- Spread of invasive species.

As part of the impact assessment process, a significance of impacts assessment was undertaken of the Project's potential impacts on MNES that were confirmed present or considered likely to occur within the Project area. The assessment determined that the Project is likely to result in significant residual impacts on the following listed species:

- *Macrozamia conferta* (vulnerable) – due to direct impacts on the species;
- Koala (*Phascolarctos cinereus*) (vulnerable) – due to the impact on habitat critical to the survival of the species and potential for injury or mortality during construction;
- Grey-headed flying-fox (*Pteropus poliocephalus*) (vulnerable) – due to the magnitude of impact on winter foraging habitat that represents habitat critical to the survival of the species;
- Regent honeyeater (*Anthochaera phrygia*) (critically endangered) – due to a localised loss of habitat critical to the survival of the species;
- Central greater glider (*Petauroides armillatus*) (vulnerable) – due to the impact on habitat critical to the survival of the species;
- Squatter pigeon (southern) (*Geophaps scripta scripta*) (vulnerable) – due to the impact on habitat critical to the survival of the species.

3.3 MNES Offset Requirements

A summary of the MNES required to be offset under the EPBC Act is provided in **Table 3.1**.

Table 3.1 Offset requirements

MNES	Threat Status	Impacted Habitat Proposed to be Offset (ha)
Threatened Flora		
Macrozamia conferta	Vulnerable	2,578 individuals
Threatened Fauna		
Koala (*Phascolarctos cinereus*)	Vulnerable	498.10
Grey-headed flying-fox (*Pteropus poliocephalus*)	Vulnerable	498.10
Regent honeyeater (*Anthochaera phrygia*)	Critically Endangered	8.06
Central greater glider (*Petauroides armillatus*)	Vulnerable	156.65
Squatter pigeon (southern) (*Geophaps scripta scripta*)	Vulnerable	136.69

The Project is proposed to be delivered in stages, owing primarily to the long construction period across a large area. The proponent seeks the ability to deliver offset solutions for the Project in a way that allows flexibility in offset site securement according to the timeframe over which the impacts are realised. Four discrete stages have been defined for the Project and their spatial extent has been used to calculate offset obligations for each individual stage. No stage of the Project will be allowed to commence until such time that an offset solution is identified to address all significant residual impacts on MNES attributable to that specific stage of the Project. In the interests of transparency, this Environmental Offset Strategy includes reference to the significant residual impacts associated with each Project stage as presented in **Table 3.2**.

Table 3.2 Offset staging breakdown

MNES	Stage 1	Stage 2	Stage 3	Stage 4	Total (ha)
Koala (*Phascolarctos cinereus*)	131.67	144.99	88.86	132.58	498.10
Grey-headed flying-fox (*Pteropus poliocephalus*)	137.55	143.33	87.26	129.96	498.10
Regent honeyeater (*Anthochaera phrygia*)	0	0.98	2.43	4.65	8.06
Central greater glider (*Petauroides armillatus*)	27.47	48.66	38.45	42.07	156.65
Squatter pigeon (southern) (*Geophaps scripta scripta*)	29.01	30.69	34.94	42.05	136.69
Macrozamia conferta – number of individual plants	*0*	*126*	*1,654*	*798*	*2,578*

4.0 Offset Delivery Strategy

Direct land-based offsets are proposed for all MNES assessed as having significant residual impacts associated with development of the Project. This section provides detail on how the proposed offset package will be delivered.

It is intended that the offset package detailed in this report will deliver 100% of the MNES and MSES offset requirements for the Project. Offsets for impacts to fauna habitat values will use the EPBC Act offsets calculator to determine the total area required for each value using data obtained from habitat quality assessments as outlined in the following sections. Data from impact areas will be compared against offset areas to determine the areas required for each value.

For impacts to *Macrozamia conferta*, offsets will be developed using the *Threatened Species* field of the EPBC Act calculator and impacts to *Number of individuals*. The proposed approach for *Macrozamia conferta* is to translocate all individuals potentially impacted to a recipient translocation site. The number of plants established at the recipient translocation site will be supplemented with additional plants propagated from seed, and grown in a commercial nursery. Assumptions and justifications of inputs are described in relevant sections of the Plan provided in **Appendix B**.

4.1 Habitat Quality Assessments

Field-based habitat quality assessments have been undertaken at impact sites and several potential offset sites. Additional surveys are planned for further potential offset sites. A range of site-based habitat quality data has been collected, principally based on the Queensland *BioCondition Assessment Manual Version 2.2* (Eyre et al 2015) and the *Guide to Determining Terrestrial Habitat Quality Version 1.2* (DES 2017). Additionally, the approach has incorporated draft guidance provided by DAWE on using modified habitat quality assessment (MHQA) to better reflect the requirements of the EPBC Act Environmental Offsets Policy.

This method is aimed at defining the appropriate field data to be collected during field habitat assessments to allow comparative analysis between sites and subsequently support area calculations for the purposes of acquitting offset requirements for the six MNES identified as being impacted by the Project.

BioCondition Assessment requires a condition benchmark for each regional ecosystem (RE) represented to allow scoring of the assessment. Although the Government has only published BioCondition benchmarks for a subset of REs affected by the project, the Queensland Herbarium has provided the project with benchmark information for all affected REs. In order to do this, the Queensland Herbarium utilised data provided by the project from nine local reference sites established by the project within the adjoining Durikai State Forest. These reference sites were established as per the *Method for the Establishment and Survey of Reference Sites for BioCondition, Queensland Herbarium Version 3* (Eyre et al 2017).

The following sections describe the data collection approach for each of the MNES requiring offsets. The habitat quality scoring is then discussed further in **Section 4.2**.

4.1.1 Desktop

It is first necessary to assign assessment units and survey zero points for each plot for each MNES at a desktop level, as prescribed in the BioCondition Assessment Manual. This allows navigation and the ability to ground-truth the desktop information for accuracy and relevance to the MNES to be assessed prior to progressing with the collection of more detailed field data. The following steps were undertaken at a desktop level, prior to mobilising for field surveys:

- Spatially locate suitable candidate sites including both remnant and non-remnant vegetation based on pre-clear mapping of REs (where there are known associations between REs and the MNES in question), with reference to historical records, soil types, protected areas, bioregional habitat corridors and/or any other landscape features that might provide additional habitat value to an area.
- Where possible, conduct aerial interpretation of vegetation health and cover, and the accuracy of mapping.
- Assign assessment units based on vegetation, health, cover and any other influences such as weediness, erosion, fire, grazing, clearing etc., that can be inferred from imagery.
- Assign sufficient survey plot locations based on initial assessment units according to Section 3.2 of the BioCondition Assessment Manual, noting that these may require fine tuning in the field.

4.1.2 Field

Before undertaking BioCondition assessment consideration needs to be given to the optimal timing of the field survey, as explained broadly in Section 3.3 of the BioCondition Assessment Manual and in the recommended survey guidelines for specific MNES. Field assessment steps are described below, specific to each MNES.

4.1.2.1 Koala

- Navigate to the plot survey locations;
- Rapid vegetation assessment to be conducted using Quaternary plot assessment as per Nelder et al (2019). Reference the number of koala preferred canopy species and condition at site.
- Initial site verification of habitat suitability:
  - Are koalas present?
  - Is there evidence of habitation?
  - Conduct a koala SAT.
  - If no evidence, assess whether the site can be managed such that koala will ultimately use the site?
  - If no koalas are using the site and it is agreed that management will increase the likelihood of koala use, there will be a need to provide evidence that koalas use habitat nearby (within the species' documented home range) and that management of the site will increase the inhabited size or provide connectivity between known koala habitats.
- If it is not likely that koala will use the site with management, look for another site;
- Where necessary, modify assessment unit boundaries based on field interpretation;
- Develop habitat quality scores for the relevant assessment units as per the MHQA;
- As per the guide, habitat notes at each site should be made to address direct threats and developing threats.

4.1.2.2 Grey-headed Flying-fox

- Navigate to the plot survey locations;

- Rapid vegetation assessment to be conducted using Quaternary plot assessment as per Neldner et al 2019. Reference the number of preferred canopy feed species and their condition at site.
- Initial site verification of habitat suitability:
  - Are grey-headed flying-fox feed trees present?
  - Is there evidence of habitation?
  - Where are the closest roosts?
  - What is the likelihood of ongoing grey-headed flying-fox utilisation given that they are mobile feeders with seasonally nomadic roosting depending on food availability (i.e. the site may be significant even though there is no current activity)?
- Where necessary, modify assessment unit boundaries based on field interpretation;
- Calculate habitat quality scores for the relevant assessment units as per the MHQA.

4.1.2.3 Regent Honeyeater

- Navigate to plot locations using GPS;
- Rapid vegetation assessment to be conducted using Quaternary plot assessment as per Neldner et al (2019). Reference the number of preferred canopy feed species and condition at site;
- Initial site verification of habitat suitability:
  - Are regent honeyeater food sources present?
  - Regent honeyeaters preference larger trees at wetter, more fertile locations. Those trees tend to grow larger and provide more nectar. Key tree and mistletoe species for the regent honeyeater include:
    - Mugga (or red) ironbark, *Eucalyptus sideroxylon*
    - Yellow box, *E. melliodora*
    - White box, *E. albens*
    - Yellow gum, *E. leucoxylon*
    - Spotted gum, *Corymbia maculata*
    - Swamp mahogany, *E. robusta*
    - Needle-leaf mistletoe, *Amyema cambagei* on River Sheoak, *Casuarina cunninghamiana*
    - Box mistletoe, *A. miquelii*
    - Long-flower mistletoe, *Dendropthoe vitellina*
    - Flowering of associated species such as thin-leaved stringybark (*E. eugenioides*) and other stringybark species, and broad-leaved ironbark (*E. fibrosa*) can also contribute important nectar flows at times
- If the site isn't suitable regent honeyeater habitat move to the next site. Note: that while the site may not suit regent honeyeater it may be suitable for offsetting other matters;

- Where necessary, modify assessment unit boundaries based on field interpretation;
- Collect site data at sufficient number of plots and calculate habitat quality scores for the relevant assessment units as per the MHQA.

4.1.2.4 Central Greater Glider

- Navigate to the plot survey locations;
- Rapid vegetation assessment to be conducted using Quaternary plot assessment as per Neldner et al 2019. Reference the number of preferred canopy feed species and their condition at site;
- Initial site verification of habitat suitability:
  - Is there evidence of moderate to high abundance of large, live hollow-bearing trees?
- If the site is not suitable greater glider habitat move to the next site. Note: that while the site may not suit greater gliders it may be suitable for offsetting other matters;
- Where necessary, modify assessment unit boundaries based on field interpretation;
- Collect site data at sufficient number of plots and calculate habitat quality scores for the relevant assessment units as per the MHQA.

4.1.2.5 Squatter Pigeon

- Navigate to plot locations using GPS;
- Rapid vegetation assessment to be conducted using Quaternary plot assessment as per Neldner et al. (2019). Reference the number of preferred dominant canopy species and condition at site;
- Initial site verification of habitat suitability:
  - Are preferred dominant canopy species of *Eucalyptus*, *Corymbia*, *Acacia*, or *Callitris*, remnant and/ or regrowth present?
  - Is there permanent water in the area and is the distance to nearest permanent water body within 3 km of survey site?
- If the site is not suitable squatter pigeon habitat move to the next site. Note: that while the site may not suit the squatter pigeon it may be suitable for offsetting other matters;
- Where necessary, modify assessment unit boundaries based on field interpretation;
- Collect site data at sufficient number of plots and calculate habitat quality scores for the relevant assessment units as per the MHQA.

4.2 Habitat Quality Scoring

DAWE's modified habitat quality assessment (MHQA) is an adaptation of the Queensland Government's *Guide to determining terrestrial habitat quality v1.2* (EHP 2017). The MHQA better reflects the requirements of the *EPBC Act*

Environmental Offsets Policy (DSEWPC 2012) for determining habitat quality, including consideration of **site condition, site context** and **species stocking rate**.

The MHQA can be used to value the quality of habitat at the impact and offset sites. Scores from the MHQA can be transferred into the quality score fields of the EPBC calculator. As a general rule, proposed offset areas in very good condition are unlikely to be useful as offsets as there is little scope for a gain in habitat quality. For this reason, properties with large areas of regulated vegetation (as defined in **Section 2.2.2.2**) and little regrowth have generally not been proposed as prospective offset areas. Equally, proposed offset areas in very poor condition may require too much time and active management to be able to confidently demonstrate the necessary conservation gains within the maximum time horizon of 20 years. Therefore, if it is expected that a field site scores close to 8 or less than 3 for habitat quality or BioCondition, the site will not be prioritised as a potential offset.

The proposed data inputs for the habitat quality scoring of the impact and offset sites for the Project area are listed in **Table 4.1**.

Table 4.1 Data input for scoring

Attribute	Methodology	Notes
Site Condition		
Site-based attributes: • Recruitment of woody perennial species in the ecologically dominant layer (EDL) • Native plant species richness – trees, shrubs, grasses and forbes • Tree canopy height • Tree canopy cover • Shrub canopy cover • Native grass cover • Organic litter • Large native trees • Coarse woody debris • Non-native plant cover	Raw data column: *Guide to determining terrestrial habitat quality* • Section 5.1.1 How to measure field based attributes *BioCondition Assessment Manual* (Eyre et al 2015) • Chapter 3 The assessment unit and site selection • Chapter 5 Assessment of site-based attributes Benchmarks column: *Guide to determining terrestrial habitat quality* • Section 5.1.1 How to measure field based attributes, Table 2 Guide for site condition scoring sheet *BioCondition benchmarks* (DES 2019) Each attribute scores 0, 3 or 5 according to the *Guide to determining terrestrial habitat quality*	Benchmarks are specific to the Regional Ecosystem present in the assessment unit (AU).
Species habitat attributes: • Quality and availability of food and foraging habitat • Quality and availability of shelter	*Guide to determining terrestrial habitat quality* – Section 7.2 Undertaking a species habitat index assessment, Table 4 Species habitat index scoring guide	These attributes are scored by determining species-specific indicators and developing a rating scale for each indicator.

Attribute	Methodology	Notes
	Each attribute scores 1, 5 or 10 according to the *Guide to determining terrestrial habitat quality*	
Site Context		
Landscape-scale attributes: • Size of patch • Connectedness • Context	*Guide to determining terrestrial habitat quality* • Section 6.2 Undertaking a site context assessment, Table 3 Site context scoring sheet guide • Patch size scores 0, 2, 5, 7 or 15 • Connectedness scores 0, 2, 4 or 5 • Context scores 0, 2, 4 or 5 *BioCondition Assessment Manual* (Eyre et al 2015) • Chapter 6 Assessment of landscape-scale attributes (Section 6.1 Fragmented landscapes)	**Apply procedure for fragmented landscapes:** The *Guide to determining terrestrial habitat quality* includes instructions for intact and fragmented landscapes. To score these for the MHQA, apply the procedure for fragmented landscapes. **Include all habitat:** The *Guide to determining terrestrial habitat quality* includes only remnant or regrowth vegetation in these measurements. To score these for the MHQA, measurements must include *all* habitat for the protected matter. E.g. koala habitat includes any forest or woodland containing species that are known koala food trees, or shrubland with emergent food trees as defined in the *EPBC Act referral guidelines for the vulnerable koala* (DoE 2014). **Assess at AU scale:** The *Guide to determining terrestrial habitat quality* states that measurements should be conducted at the overall site level. To score these for the MHQA, measurements should be conducted at the Assessment Unit (AU) level. **Connectivity and absence of barriers to movement:** The *Guide to determining terrestrial habitat quality* measures connectivity based on adjacency to vegetation. To score this for MHQA, connectivity includes any boundaries where the protected matter can move into adjacent habitat (e.g. a boundary adjacent to a narrow strip of cleared land/track which koalas would use to move into adjacent habitat would be considered to be 'connected' to adjacent habitat). **Context buffer:**

Attribute	Methodology	Notes
		The *BioCondition Assessment Manual* measures context using a 1 km buffer. To score this for MHQA, the following buffers should be used: • TECs, plants, Collared Delma – 1 km • koala, Greater Glider, Squatter Pigeon – 20 km • South-eastern Long-eared Bat – 10 km • Painted Honeyeater, Australian Painted Snipe – 30 km • Dunmall's Snake, Yakka Skink, Ornamental Snake – 5 km
Landscape-scale attributes: • Ecological Corridors	*Guide to determining terrestrial habitat quality* • Section 6.2 Undertaking a site context assessment, Table 3 – Site context scoring sheet guide • Scores 0, 4 or 6	**Shared boundary and absence of barriers to movement:** Similar to Connectivity above, to score this for MHQA, 'sharing a common boundary with' an ecological corridor includes any boundaries where the protected matter can move into adjacent corridors (e.g. a boundary adjacent to a narrow strip of cleared land/track which koalas would use to move into adjacent corridors would be considered to be a shared common boundary).
Species habitat attributes: • Threats to the species	*Guide to determining terrestrial habitat quality* • Section 6.2 Undertaking a site context assessment, Table 4 Species habitat index scoring guide • Scores 1, 7 or 15	This attribute is scored by identifying and scoring species-specific and site-specific threat factors. *Proposed threat factors and scoring must be provided, supported by peer reviewed literature, with references provided, or expert opinion.*
Species habitat attributes: • Species mobility capacity	*Guide to determining terrestrial habitat quality* • Section 6.2 Undertaking a site context assessment, Table 4 Species habitat index scoring guide • Scores 1, 4, 7 or 10	This attribute is not relevant to plants or TECs. This attribute is scored by determining species-specific indicators and developing a rating scale for each indicator. *Proposed scoring and species-specific indicators must be supported by peer reviewed literature, with references provided, or expert opinion.*
Species habitat attributes: • Role of site location to overall population	*Guide to determining terrestrial habitat quality* • Section 7.2 Undertaking a species habitat index assessment, Table 4 Species habitat index scoring guide	This attribute relates to the likelihood that the site contains habitat critical to the survival of the species or community.

Attribute	Methodology	Notes
	• Scores 1, 4 or 5	
Species Stocking Rate (SSR)		
Species presence and usage attributes: • Presence detected on or adjacent to site (neighbouring property with connecting habitat) • Species usage of the site (habitat type & evidenced usage) • Approximate density (per ha)	MHQA spreadsheet provides a suggested scoring matrix	**Species usage:** To score this attribute, consider whether there are different definitions for habitat used for dispersal, foraging and/or breeding – refer to SPRAT profiles, conservation advices, recovery plans or other relevant EPBC policy documents. **Approximate density:** For species with sufficient population data, density ranges can be calculated based on local survey records/ sightings; or if comprehensive targeted surveys have been done on the impact and offset sites, ranges could be devised based on the results. Needs to consider species abundance in the same habitat type and carrying capacity. For cryptic species and data-deficient species, calculating density may not be possible, which would also mean that an increase in stocking rate is not feasible.
Role/importance of species population on site*	Score derived from SSR supplementary table (see below)	This attribute is not relevant to TECs.
***SSR Supplementary Table**		
Attribute	Methodology	Notes
Key source population for breeding	Refer to available literature on the species (including SPRAT profiles, conservation advices, recovery plans or other relevant EPBC policy documents).	Scoring for these attributes must be supported by scientific evidence, surveys or studies, and species distribution mapping.
Key source population for dispersal		
Necessary for maintaining genetic diversity		
Near the limit of the species range		

Instructions on scoring are provided in Section 8 of the *Queensland Government Guide to Determining Terrestrial Habitat Quality v1.2*, Steps 2-6. These are listed in **Table 4.2**.

Table 4.2 Scoring calculations

Score	Methodology	Notes
Site Condition		
MAX Site Condition Score	Total the maximum scores for each attribute for Site Condition	For site-based attributes, maximum scores are provided in the relevant scoring tables in the: • *Guide to determining terrestrial habitat quality* (Step 2) and/or • *BioCondition Assessment Manual*
Score for sampling site	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score, Step 3	For each sampling site: • Total all site condition attribute scores • Divide by *MAX Site Condition Score*
Score for assessment unit	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score, Step 4	For each assessment unit: • Total all *scores for sampling sites* • Divide by number of sampling sites in the assessment unit
Area-weighted score for assessment unit	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score, Step 5	For each assessment unit: • Multiply *Score for assessment unit* by area (ha) of assessment unit • Divide by total site area (ha)
Score for the site	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score, Step 6	For the total site (matter area): • Add the *area-weighted scores for the assessment units*
Site Condition Score - out of 3	Convert the score for the site to a score out of 3	To convert the score for the site to a score out of 3: • Multiply *score for the site* by 3
Site Context		
Score	Methodology	Notes
MAX Site Context Score	Total the maximum scores for each attribute for Site Context	• For Size of patch, Connectedness and Context, maximum scores are provided in the relevant scoring tables in the *BioCondition Assessment Manual* • For Ecological corridors, maximum score is provided in Table 3 of the *Guide to determining terrestrial habitat quality* • For Role of site location to species overall population in the state, Threats to the species and Species mobility capacity, maximum scores are provided in Table 4 of the *Guide to determining terrestrial habitat quality*
Score for sampling site	*Guide to determining terrestrial habitat quality*	For each sampling site: • Total all site context scores

Score	Methodology	Notes
	– Section 8 Determine the final habitat quality score	• Divide by *MAX Site Context Score*
Score for assessment unit	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score	For each assessment unit: • Total all *scores for sampling sites* • Divide by number of sampling sites in the assessment unit
Area-weighted score for the assessment unit	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score	For each assessment unit: • Multiply *Score for assessment unit* by area (ha) of assessment unit • Divide by total site area (ha)
Score for the site	*Guide to determining terrestrial habitat quality* – Section 8 Determine the final habitat quality score	For the total site (matter area): • Add the *area-weighted scores for the assessment units*
Site Context Score – out of 3	Convert the score for the site to a score out of 3	To convert the score for the site to a score out of 3: • Multiply *score for the site* by 3
Species Stocking Rate		
Score	Methodology	Notes
Score assigned	Scored using scoring table in MHQA spreadsheet	
Total SRR score – out of 70	Total *Score assigned* column	
Total SRR score – out of 4	Convert to score out of 4	To convert the score to a score out of 4: • Divide score by 70 • Multiply score by 4
Final Habitat Quality Score (weighted)		
Score	Methodology	Notes
Average/Final	Transfer scores for Site Condition, Site Context and Species Stocking Rate	
Habitat Quality score - out of 10	Total *Average/Final* column	This score can be transferred into the Quality score fields of the *Offsets Assessment Guide* (DAWE) spreadsheet

If any of the attributes are not applicable for the species, remove the row from the spreadsheet (ensuring that the value for MAX Site Condition/Context Score updates accordingly).

Proposed habitat scoring indicators for each of the five MNES are presented in **Appendix A**. Habitat quality scoring is not relevant to the *Macrozamia conferta* offset as the offset calculator relies on the total number of individual plants impacted.

4.3 Threat Assessment

Threat assessment (absence of threats) for impact and offset sites is based on the Queensland Habitat Assessment Guide Ver 1.2. Threats for each of the relevant MNES were derived from the relevant conservation advice:

- Approved Conservation Advice for *Macrozamia conferta* (DEWHA 2008);
- Approved Conservation Advice: *Phascolarctos cinereus* (combined populations of Queensland, New South Wales and the Australian Capital Territory) (Koala Northern Design Table Unit), (DSEWPC 2012);
- South East Queensland Koala Conservation Strategy 2020–2025 (DES 2020);
- *Nature Conservation (Koala) Conservation Plan 2006* and Management Program 2006 – 2016 (EPA 2006);
- Ranking the feeding habitats of Grey-headed flying foxes for conservation management (Ebby & Law 2008);
- Flying-fox Heat Event Response Guidelines (Bishop et al. 2018);
- National Recovery Plan for the Grey-headed Flying-fox (*Pteropus poliocephalus*) (DAWE 2021);
- National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*) (DoE 2016);
- Approved Conservation Advice for Greater Glider (*Petauroides volans*) via The Action Plan for Australian Mammals 2012 (TSSC 2016; Woinarski et al. 2014);
- Approved Conservation Advice for Squatter Pigeon (southern) (*Geophaps scripta scripta*) (TSSC 2015).

A range of potential key threats were identified for each of the MNES and the relevant threats (to the Project) on which the threat assessments were based are provided in the following sections.

4.3.1 Macrozamia conferta

Key threats to *M. conferta* are provided in **Table 4.3**.

Table 4.3 Key threats to *Macrozamia conferta*

Threat	Description
Loss of and damage to habitat	Clearing of habitat for timber harvesting Trampling by livestock
Fire	Inappropriate fire regimes kill surface seed and young seedlings
Loss of fecundity	Failure of insect pollination mutualism Genetic inbreeding due to fragmentation of populations
Harvest	Illegal collection of seed and whole plants for retail

4.3.2 Koala

Several of the threats to koala are interactive. For example, invasion of habitat by non-native plant species has the capacity to increase fire fuel loads, reduce species mobility and limit the establishment of koala forage species whilst fragmentation by urban development is associated with increased predation by domestic dogs and potentially

disease prevalence with increased environmental stress. The threatening processes described in **Table 4.4** are intended to address the major known threats in a format that relates to the habitat assessment method and the management practices proposed for offset sites.

Table 4.4 Key threats to Koala

Threat	Description
Loss of habitat	Clearing of habitat associated with anthropogenic disturbance such as urban development and agriculture particularly in areas of high fertility
Fragmentation of habitat	Fragmentation of habitat associated with anthropogenic disturbance, urban development
Weed invasion	Reduction in species mobility and contributing to reduced habitat quality and altered fire regimes.
Bushfire	A direct threat to related to fire related mortality and potentially causing habitat degradation.
Vehicle strike	Mortality caused by the intersection with traffic where koalas are drawn into remnant areas that occur in association with roads.
Disease	Infection of populations by Chlamydia, Koala Retrovirus and other diseases leading to reduced fecundity.
Predation by dogs	Domestic and/or feral dogs constitute a key threatening process

4.3.3 Grey-headed Flying-fox

The processes that threaten grey-headed flying foxes are most prevalent in coastal areas north from Sydney, coinciding with areas that support the greatest natural diversity of food plants and the most consistent presence of the species outside metropolitan areas (DAWE 2021). Key threats are described in **Table 4.5**.

Table 4.5 Key threats to Grey-headed Flying-fox

Threat	Description
Loss of foraging habitat is considered the primary threat to the species	Loss of diet plants that provide winter and spring foraging resources: *Eucalyptus tereticornis, E. albens, E. crebra, E. fibrosa, E. melliodora, E. paniculate, E. pilularis, E. robusta, E. seeana, E. sideroxylon, E. siderophloia, Banksia integrifolia, Castanospermum austral, Corymbia citriodora citriodora, C. eximia, C. maculate, Grevillea robusta, Melaleuca quinquenervia*
Habitat fragmentation	Fragmentation of habitat affecting species mobility
Camp disturbance	Direct and indirect impacts to known camps
Heat stress	Mortality to individuals caused by daytime temperatures >40C and impacted by habitat condition, proximity to water, camp conditions, population demographics, timing and human conditions.
Entanglement	Mortality of animals due to entanglement in netting, barbed wire fences (especially associated with water sources) and other anthropogenic structures.

Threat	Description
Climate change	Climate change has the potential to affect food availability and head-related mortality in grey-headed flying foxes. Climate change may put further pressure on alternative food sources, commercial food crops, and urban and botanical gardens.
Bushfire	The 2019/2020 bushfires across southern and eastern Australia affected large areas of foraging habitat for the grey-headed flying fox and the species has been included in DAWE's provisional list of 119 animal species requiring urgent management intervention as a result of the bushfires.
Electrocution	Grey-headed flying fox are prone to electrocution on power lines in urban areas.

4.3.4 Regent Honeyeater

Based on the literature review, key threats to regent honeyeater have been defined as per **Table 4.6**.

Table 4.6 Key threats to Regent Honeyeater

Threat	Description
Increased competition	Larger aggressive honeyeaters including noisy miners *Manorina melanocephala*, noisy friarbird *Philemon corniculatus*, and red wattlebird *Anthochaera carunculate* exclude regent honeyeater from food sources especially in degraded open habitat adjoining eucalypt woodland as this is suitable habitat for these species – negatively impacting breeding success. Increased competition results in lower reproductive output (Ford et al. 1993).
Loss of foraging and nesting habitat	Historical clearing for residential, agricultural, and industrial developments has resulted in severe fragmentation and degradation of foraging and nesting habitat. Remaining habitat is subject to further decline of mature trees through senescence, dieback, use as fenceposts, timber and firewood, and inappropriate fire regimes. Fragmentation and degradation expose species to increased competition and predation and hinders dispersal (Webster and Menkhorst 1992).
Eggs and nestling predation	Sugar glider (*Petaurus breviceps*), squirrel glider (*P. norfolcensis*), noisy miner (*Manorina melanocephala*), Australian ravens (*Corvus coronoides*), pied butcherbird, magpie (*Cracticus tibicen*) and pied currawong (*Strepera craculina*) have been recorded attempting to prey on adults and/or successfully preying on eggs, and the impacts of this may be significant (Szabo 2016; Crates et al. 2017; Fulton and Ford 2001).
Inappropriate fire regimes	Frequent fire reduces flowering events and maturation of nectar rich species hence reduced foraging habitat (Woinarski and Cullen 1984).
Disease and reduced genetic diversity	Small, fragmented populations can bottleneck and be subject to Allee effects (Crates et al. 2017) whilst captive-bred birds can carry internal and external parasites which could impact wild populations.
Climate Change	Species habitat is susceptible to increased risk of fire and drought which can suppress flowering events, potentially exacerbating habitat loss (DoE 2016; Birdlife International 2018).

4.3.5 Central Greater Glider

Cumulative effects of land clearing and logging activities, current burning regimes and the impacts of climate change are a major threat to large hollow-bearing trees on which the greater glider relies. The species is particularly susceptible to threats because of its slow life history characteristics, specialist habitat requirements (and hence mature

forests), and relatively specialised dietary requirements (Woinarski et al. 2014). The key threatening processes are defined as per **Table 4.7**.

Table 4.7 Key threats to Central Greater Glider

Threat	Description
Habitat loss and fragmentation	The species is highly dependent on forest connectivity and large mature (myrtaceous) trees and is particularly sensitive to forest clearance as prime habitat coincides with areas suitable for land clearance. Habitat loss and fragmentation limits dispersal of the species between smaller isolated fragments and subsequently reduces reproductive outputs and population viability. Limited dispersal ability constrains genetic diversity and weakens resilience thus increasing susceptibility to disturbance. The species is slow to recover from major disturbance (Kavanagh 2004).
Timber production	There is a progressive decline in numbers of hollow-bearing trees in production forests as logging rotations become shorter and as dead stags collapse (Lindenmayer et al. 2011).
Inappropriate fire regimes	Inappropriate and too frequent fire regimes cause population declines in and after high intensity fires (Lindenmayer et al. 2013). The species is sensitive to repeated prescribed burning and abundance is significantly greater in forests that are infrequently burnt (Andrews et al. 1994).
Climate change	The species is florivorous that favours forests with a diversity of eucalypt species and such forest types are susceptible to the effects of climate change that affects fruiting and flowering events, thus exacerbating key threatening processes of the species. Biophysical modelling indicates that the degree of site occupancy is associated with vegetation moisture and water stress from drought affects growth of eucalypt forest and woodlands, therefore limiting the species' food source and causing heat stress and mortality (Lumsden et al. 2013; Matusick et al. 2013). Literature predicts a 3C temperature increase will cause a severe decline in the population, nationally (Kearney et al. 2010).
Increased competition	Sulphur-crested cockatoos (*Cacatua galerita*) have been observed taking over nesting hollows of powerful owls and along with other hollow-bearing wildlife are likely to be competing with the species for hollows (Lumsden et al. 2013).
Predation by owls	The species forms a significant part of both the powerful owl (*Ninox strenua*) and sooty owl (*Tyto tenebricosa*) dietary requirements and have been recorded utilising the same habitat (Bilney et al. 2006). Reduction in the density of hollow-bearing trees increases the threat of predation whilst the species is moving between hollows and localised population declines due to owls have been observed (Lindenmayer et al. 2011).

4.3.6 Squatter Pigeon (Southern)

Based on the literature review, the key threats to the squatter pigeon have been defined as per below **Table 4.8**.

Table 4.8 Key threats to Squatter Pigeon (Southern)

Threat	Description
Habitat loss and fragmentation, increased competition	The subspecies inhabits and relies upon the short, grassy understorey of well-drained sandy or loamy soils that support open-forests to sparse, open-woodlands and scrub that are dominated by *Eucalyptus*, *Corymbia*, *Acacia*, or *Callitris* species, remnant and regrowth within 3 km of permanent water (DAWE 2019; Squatter Pigeon Workshop 2011). The combined effect of habitat loss and fragmentation for agricultural purposes and the degradation of habitat by overgrazing domesticated livestock (sheep, cow) and feral herbivores such as rabbits (*Oryctolagus cuniculus*), have impacted the subspecies' dispersal and breeding success. However, the effect this has upon the subspecies' long-term persistence and recovery in the region is unknown (Garnett & Crowley 2000).
Predation by cat and fox	Predation by feral cats (*Felis catus*) and foxes (*Vulpes vulpes*) are likely to be having the greatest impact upon the subspecies as population declines have been associated with areas where cats and foxes are highly abundant (Ayers et al. 1996; EPA 2006; Garnett & Crowley 2000).
Inappropriate fire regimes	Inappropriate, frequent and high intensity fire regimes reduce foraging and nesting habitat of low vegetation and understorey cover hindering reliable food sources and exposing the subspecies to population declines (Woinarski & Cullen 1984).
Climate change	Literature suggests the subspecies is highly sensitive to the effects of climate change as extreme weather events such as drought and bushfires are likely to exacerbate the key threatening processes and contribute to, or accelerate, population declines of the subspecies (Frith 1982; Garnett & Franklin 2014).

4.4 Offset Calculator

Impact area habitat quality scores, along with habitat quality scores for offset sites (existing, without the offset, and with the implementation of the OMP) were entered into the DAWE Offsets Assessment Guide (v1.04) calculator to assess how much of the impact each offset would acquit for each value being offset. Inputs to the calculator included the following:

- Risk of Loss – numbers applied as per *Guidance for deriving 'Risk of Loss' estimates when evaluating biodiversity offset proposals under the EPBC Act* (DoEE 2017) (Goondiwindi = 7.02%, Southern Downs 2.28%);
- Time Horizon – 20 years for all values;
- Confidence – 90% where there was a 1 point improvement in habitat quality score (and for *Macrozamia conferta*), 85% for a 2 point improvement, and 70% for a 3 point improvement.

For each offset site, the habitat quality score 'start value' is the same as the 'future value without offset'. The same values have been applied because there are no legislative requirements for landholders to undertake conservation management actions at the offset sites. Specifically:

- Management of a pests is not required under the Queensland *Biosecurity Act 2014*;
- The *Vegetation Management Act 1999* in conjunction with the *Planning Act 2016* and subordinate legislation jointly forms the vegetation management framework and regulates the clearing of vegetation in Queensland. Under this framework clearing of non-remnant vegetation is permissible for agricultural purposes.

5.0 Impact Area Habitat Quality Assessment Results

Habitat quality assessment and BioCondition surveys were undertaken in January 2021. Surveys included a total of 41 survey sites within relevant assessment units. The results of the weighted habitat quality assessment scores for each of the relevant values are presented in **Table 5.1**.

Table 5.1 Impact Area Weighted Habitat Quality Scores

MNES	Impact Area (ha)	Weighted Habitat Quality Score
Koala	498.11	5.78
Grey-headed Flying-fox	498.11	5.79
Regent Honeyeater	8.06	7.44
Greater Glider	156.65	6.10
Squatter Pigeon	136.69	7.64
Macrozamia conferta	NA	NA – impacts to individuals proposed to be offset

6.0 Bioregional Offset Availability Analysis

6.1 Methodology

A regional scale desktop analysis has been completed to assess the availability of potential offset sites that could be used as a direct offset for the predicted Project offset requirements. This analysis was intended to establish the total area of forest and regrowth vegetation (associated with each MNES) and potential offset areas available based on tailored ecological criteria within a defined area of the New England Tableland Bioregion. This information provides greater certainty to regulators in assessing the Project that suitable offset areas, in sufficient quantities, are available to acquit the Project's MNES offset requirements.

6.1.1 Area of Investigation

The Project area is situated within the Nandewar Northern Complex sub-bioregion of the New England Tablelands bioregion and is located within the local government areas of Goondiwindi Regional Council and Southern Downs Regional Council. Due to the limited size of the sub-bioregion, ~6,000 km^2, it was considered impractical to limit the Area of Investigation (AOI) for assessing offset availability to the local government area and sub-bioregion. As such the AOI was defined as the outer limit of properties within the Nandewar Northern Complex sub-bioregion, excluding small protuberance in the localities of Brush Creek and Stonehenge, illustrated in **Figure 6-1**.

Attexo

MacIntyre Wind Farm

Offset Investigation Area

Figure 6.1

- MacIntyre Wind Farm
- Karara Wind Farm
- Overhead Transmission Line
- Area of Investigation
- Major Road
- Local Government Area Boundary
- Biogeographic Subregion
- Protected Area

Date: 2020-12-18
Author: TOD
Reviewed: NOD
Project: ACC-005

0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service

6.1.2 Data Acquisition

Offset availability analysis was undertaken using the most recent geospatial data available to the public within a desktop GIS environment including:

- Vegetation management pre-clear regional ecosystem map - version 11 (DNRME 2019);
- Vegetation management regional ecosystem map - version 11 (DNRME 2020);
- Vegetation management regulated vegetation management map - version 4.06 (DNRME 2020);
- National Forest and Sparse Woody Vegetation Data – version 4 (DoEE 2019);
- Digital Cadastral Database (DNRME 2020);
- Local government area boundaries (DNRME 2020); and
- Queensland mines permits current web map service (DNRME 2020).

6.1.3 Offsetable Vegetation

The National Forest and Sparse Woody Vegetation Data from the National Inventory Reporting derives vegetation mapping using remote sensing analysis techniques from Landsat satellite imagery. Whilst these data are generated primarily for carbon accounting, they provide a robust, consistent, and freely available resource for identifying any remnant or regrowth vegetation across Australia.

Forest woody vegetation is defined as any vegetation with a minimum canopy cover of 20 %, a height of at least 2 m, and minimum patch size of 0.2 ha. Sparse woody vegetation is defined as any vegetation with a canopy cover of 5-19 %, a height of at least 2 m, and minimum patch size of 0.2 ha.

The occurrence of established woody vegetation on a prospective offset site is expected to be in better ecological condition and of an older age, therefore more likely to contain good vegetation community structure and presence of microhabitats such as hollows, leaf litter and woody debris. This in turn reduces the timeframe for the site to provide ecological benefit. Regrowth (sparse woody) vegetation is likely to be in poorer ecological condition (higher level of weeds due to more open canopy) and less likely to have the structural integrity, height, and cover of remnant vegetation. However, over time the sparse vegetation can be enhanced in condition and structure to achieve higher net gains than forest woody vegetation.

A combination of forest and sparse woody vegetation is preferred to achieve a balance between reducing the time to ecological benefit and maximising opportunities to achieve net gains, respectively.

The geospatial intersection of each MNES value's specific search criteria with mapped forest woody and sparse vegetation and cadastral boundaries provides a robust desktop assessment of the abundance and distribution of prospective offset properties that meet the criteria of each value as well as a framework for assessing the opportunities for the co-location of offsets for multiple values within the same property. The total number of properties that satisfy the search criteria for each MNES value is presented in **Section 6.3**.

For each MNES value, a number of specific desktop search criteria were then applied to the vegetation mapping to identify the total availability of offsetable vegetation in the investigation area and the number of individual properties which contain adequate vegetation to acquit an offset liability.

6.2 Limitations

The offset availability analysis has conducted on a DCDB parcel level. It is not practical to aggregate adjacent land parcels owned by the same landholder into a property holding. As such the potential offset sites may over-estimate the number of landholdings available for establishing an offset site. Conversely, additional sites may also be missed if a number of individual lots do not pass the search criteria but aggregated into a single land holding, they do.

The number of potential offset sites is based on the best available desktop criteria. For several MNES values, the criteria are primarily driven by regional ecosystem associations known to contain floristic elements relevant to the MNES value. Additional survey is essential to confirm the suitability of any site to be used as an offset.

6.3 Offset Availability Results

The results of the desktop availability analysis are presented in **Table 6.1** along with the number of land parcels which meet the criteria and the total extent of forest and sparse woody vegetation within these offset sites.

Table 6.1 Offset availability criteria and results

MNES	Search Criteria	Forest Woody Vegetation (ha)	Sparse Woody Vegetation (ha)	Number of Potential Offset Sites
Listed flora				
Macrozamia conferta	• Freehold or Lands Lease property within Nandewar Northern Complex sub-bioregion • Preclearing RE containing 13.11.3, 13.11.5, 13.11.6, 13.11.8 • At least 500 ha of Forest or Sparse woody vegetation present on site mapped as Cat X on DNRME regulated vegetation map (incl. minimum of 250 ha of sparse woody vegetation) • Property situated above 550 m AHD	13,780	9,265	29
Listed fauna				
Koala (*Phascolarctos cinereus*)	• Freehold or Lands Lease property within Nandewar Northern Complex sub-bioregion • Preclearing RE containing 11.3.2, 11.3.4, 11.5.1, 11.5.4, 11.7.7, 13.3.4, 13.3.5, 13.11.3, 13.11.5, 13.11.6, 13.11.8 • At least 500 ha of Forest or Sparse woody vegetation present on site mapped as Cat X on DNRME regulated vegetation map (incl. minimum of 200 ha of sparse woody vegetation)	11,450	9,775	28
Grey-headed flying-fox (*Pteropus poliocephalus*)	• Freehold or Lands Lease property within Nandewar Northern Complex sub-bioregion (New England Tablelands) • Preclearing RE containing 11.3.2, 11.3.4, 11.5.1, 11.5.4, 11.7.7, 13.3.4, 13.3.5, 13.11.3, 13.11.5, 13.11.6, 13.11.8	10,965	8,975	26

MNES	Search Criteria	Forest Woody Vegetation (ha)	Sparse Woody Vegetation (ha)	Number of Potential Offset Sites
	• At least 500 ha of Forest or Sparse woody vegetation present on site mapped as Cat X on DNRME regulated vegetation map (incl. minimum of 200 ha of sparse woody vegetation) • Within 50 km of known roosting camp			
Regent honeyeater (*Anthochaera phrygia*)	• Freehold or Lands Lease property within Nandewar Northern Complex sub-bioregion • Preclearing RE containing 11.3.2, 11.3.4, 11.5.1, 11.5.4, 13.11.3, 13.11.5, 13.11.8 • At least 100 ha of Forest or Sparse woody vegetation present on site mapped as Cat X on DNRME regulated vegetation map (incl. minimum of 50 ha of sparse woody vegetation) • Preference for higher soil water levels, i.e. creek flats, river valleys and lower slopes (land-zone 3) • Preference for within 5 km of a confirmed record	17,700	16,145	115
Central greater glider (*Petauroides armillatus*)	• Freehold or Lands Lease property within Nandewar Northern Complex sub-bioregion • Preclearing RE containing 11.3.2, 11.5.1, 11.5.4, 11.7.7, 13.3.4, 13.3.5, 13.11.3, 13.11.5, 13.11.6, 13.11.8 • At least 700 ha of Forest or Sparse woody vegetation present, including remnant and regrowth vegetation • Within patch of continuous remnant or regrowth vegetation greater than 156 km^2	84,180	13,061	78
Squatter pigeon (*Geophaps scripta scripta*)	• Freehold or Lands Lease property within Nandewar Northern Complex sub-bioregion • Preclearing RE containing 13.11.3, 13.11.8 within 1km of permanent water (Steam order > 4); OR Preclearing RE containing 11.3.2, 11.3.4, 13.11.3, 13.11.8. • At least 450 ha of Forest or Sparse woody vegetation present, including remnant and regrowth vegetation	13,462	2,120	18

Figures illustrating the overall availability of potential habitat for each MNES value within the AOI as well as identifying potential offset sites which satisfy the search criteria listed in **Table 6.1** are shown in the following maps.

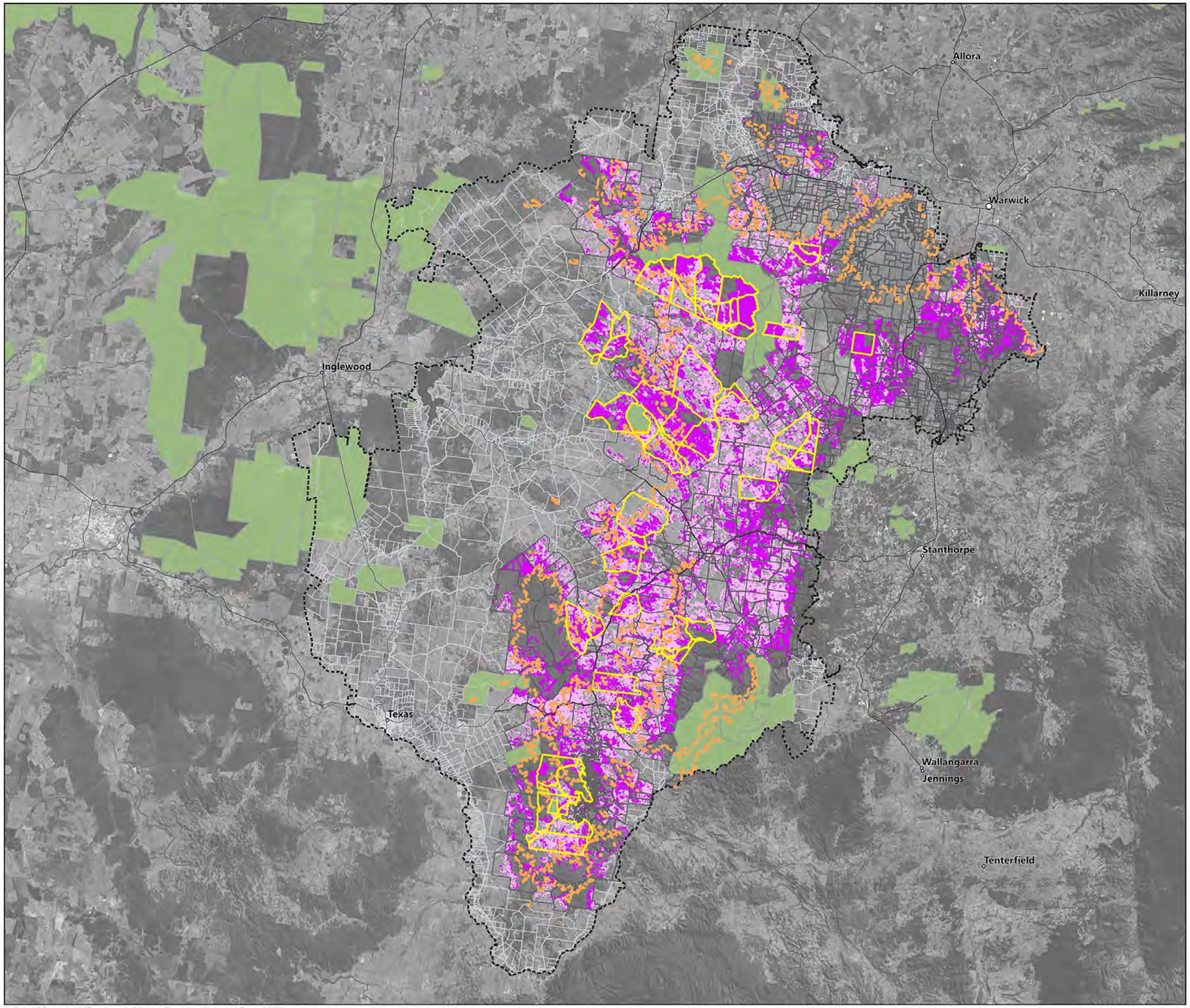
Attexo

MacIntyre Wind Farm

Macrozamia conferta

Offset Availability

Figure 6.2



- Potential Offset Site
- 550 Contour (AHD)
- Property >550m AHD
- Woody Vegetation
- Sparse Vegetation
- Offset Investigation Area
- Major Road
- Protected Area
- Lot Boundary

Date: 2020-12-18
Author: TOD
Reviewed: NOD
Project: ACC-005

0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State
Satellite Public Basemap Service

Attexo

MacIntyre Wind Farm
Koala
Offset Availability

Figure 6.3

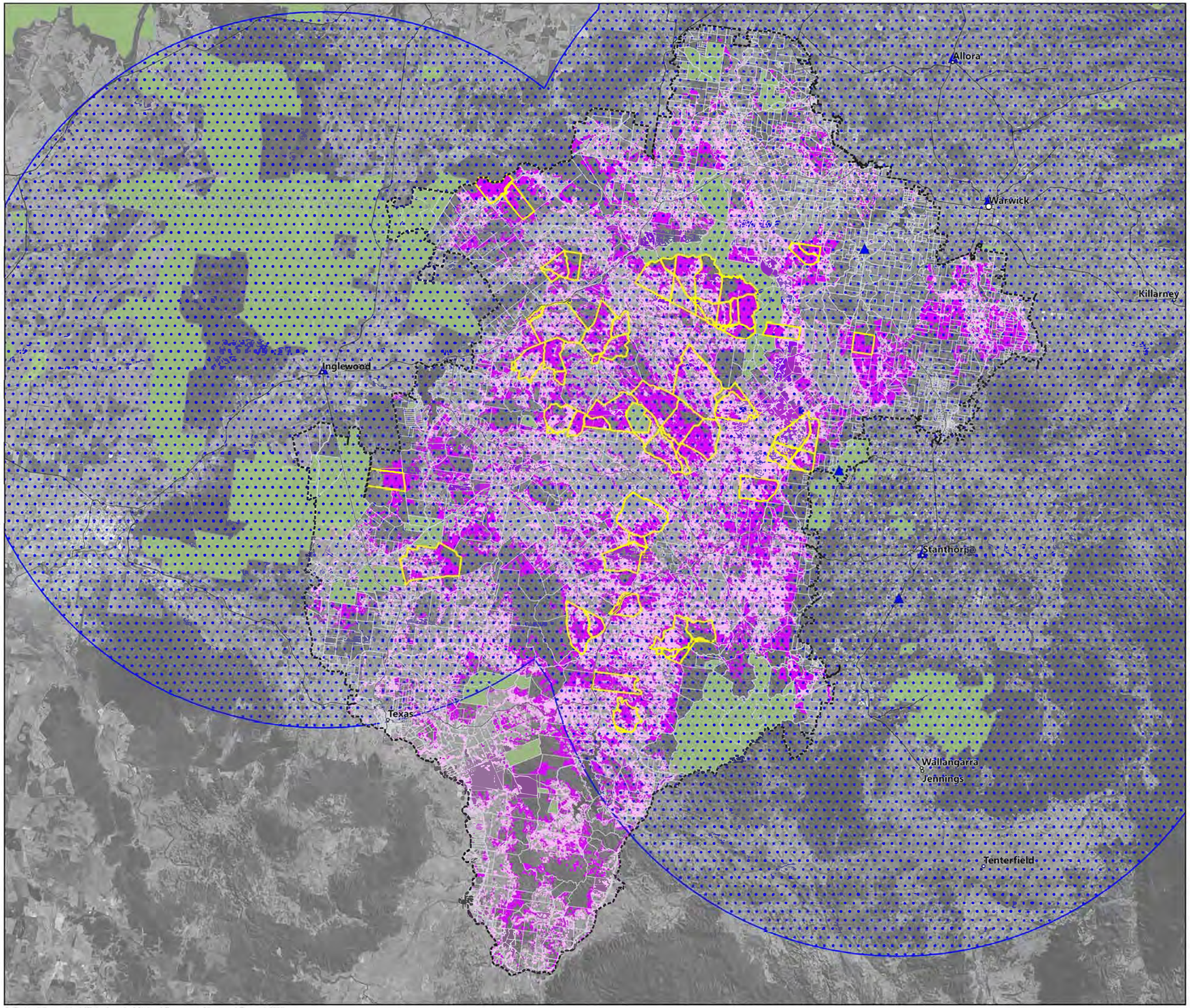
Potential Offset Site
Woody Vegetation
Sparse Vegetation
Offset Investigation Area
Major Road
Protected Area
Lot Boundary

Date: 2020-12-10
Author: TOD
Reviewed: NOD
Project: ACC-005

0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service



Attexo

MacIntyre Wind Farm

Grey-headed flying-fox
Offset Availability

Figure 6.4

- Potential Offset Site
- Flying-fox camp
- Foraging Range (50km Buffer)
- Woody Vegetation
- Sparse Vegetation
- Offset Investigation Area
- Major Road
- Protected Area
- Lot Boundary

Date: 2020-12-18
Author: TOD
Reviewed: NOD
Project: ACC-005

0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service

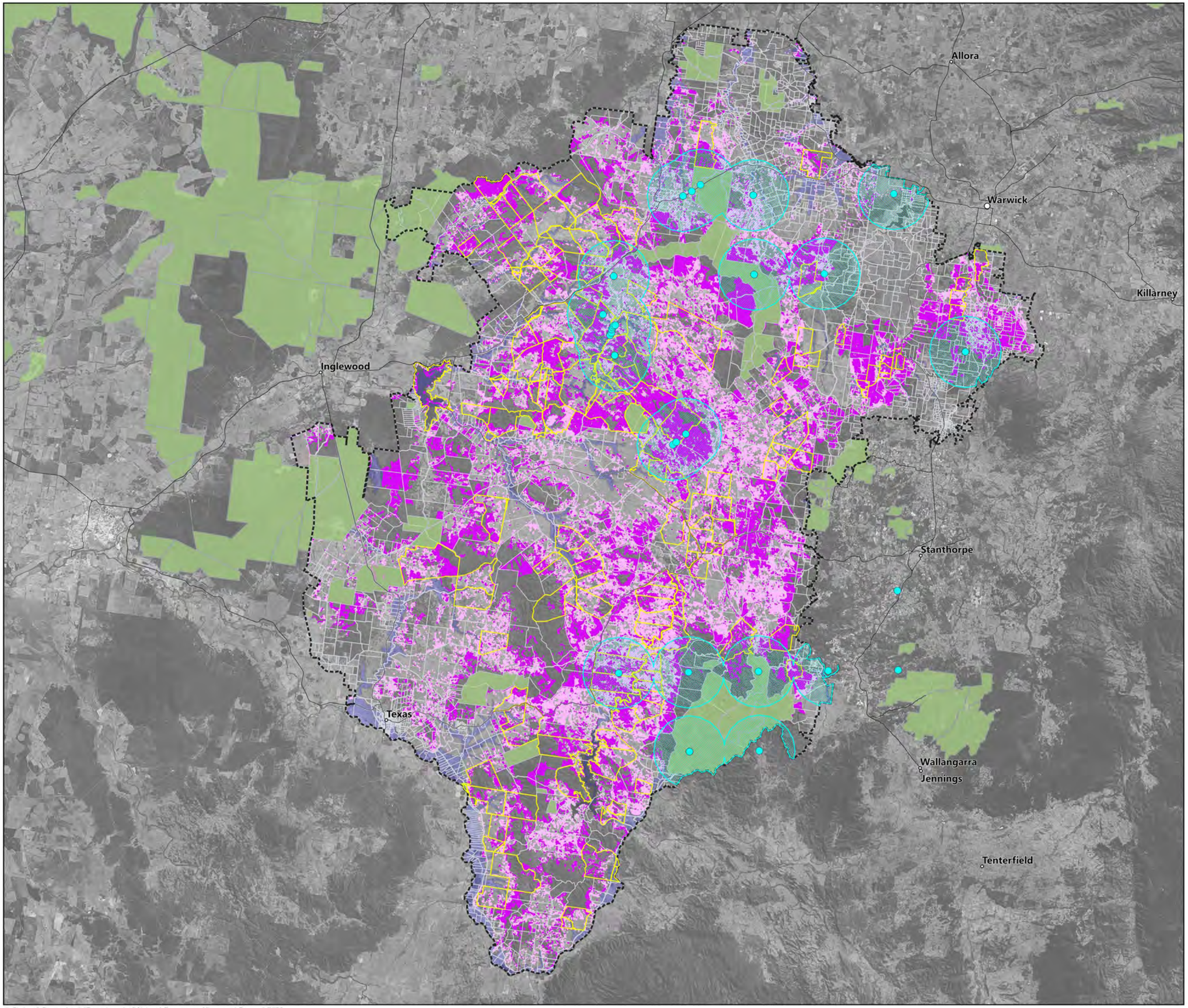
Attexo

MacIntyre Wind Farm

Regent honeyeater

Offset Availability

Figure 6.5



- Potential Offset Site
- Confirmed Record
- 5km Buffer of Confirmed Record
- Alluvial river and creek flats (Landzone 3)
- Woody Vegetation
- Sparse Vegetation
- Offset Investigation Area
- Major Road
- Protected Area
- Lot Boundary

Date: 2020-12-18
Author: TOD
Reviewed: NOD
Project: ACC-005

0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service

Attexo

MacIntyre Wind Farm

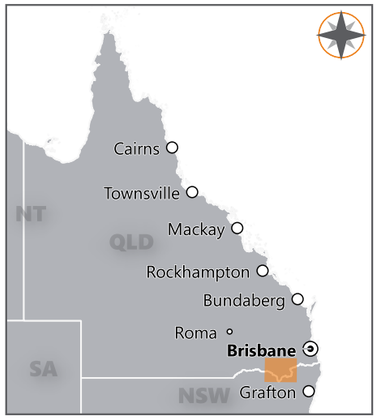
Greater glider

Offset Availability

Figure 6.6

- Potential Offset Site
- Woody Vegetation
- Sparse Vegetation
- Offset Investigation Area
- Major Road
- Protected Area
- Lot Boundary

Date: 2021-08-06
Author: TOD
Reviewed: NOD
Project: ACC-005



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Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service

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Attexo

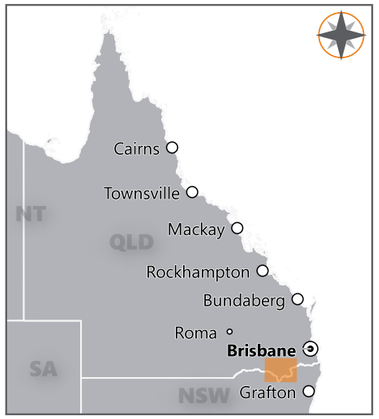
MacIntyre Wind Farm

Squatter pigeon
Offset Availability

Figure 6.7

- Potential Offset Site
- Woody Vegetation
- Sparse Vegetation
- Offset Investigation Area
- Major Road
- Protected Area
- Lot Boundary

Date: 2021-08-06
Author: TOD
Reviewed: NOD
Project: ACC-005



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Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service

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7.0 Offset Site Selection

The results presented in the offset availability analysis suggest there is a high availability of prospective sites which may contain habitat for the MNES values requiring an offset. However, for several of the affected values the desktop search criteria, such as regional ecosystem associations, are too broad to be relied upon for selecting a prospective offset site. To refine this list down to a more manageable number of sites that can be verified in the field, additional analysis has been conducted to prioritise the sites to be ground-truthed.

7.1 Strategic Offset Investment Corridors

Strategic Offset Investment Corridors (SOICs) are areas of largely intact remnant vegetation, generally linking or associated with protected areas, that have been identified by DES as strategic opportunities for environmental offsets. Under the Queensland Environmental Offsets Policy, proponents are recommended to preferentially seek offset opportunities within a SOIC, which can comprise conservation hubs (generally land adjacent to protected areas or otherwise of high conservation value) and corridors based on the Biodiversity Planning Assessment wildlife corridors.

A SOIC has been described for the Southern Brigalow Belt and New England Tableland, and publicly available mapping and the corresponding report (EHP 2015) have been reviewed to determine whether there are potential offset opportunities for the Project within the SOIC. There are two conservation hubs within the New England Tableland component of the SOIC as described below.

7.1.1 Traprock Hub

The Traprock Hub is located to the southwest of the Project area and covers 55,591 ha. The Traprock Hub provides the following ecological features that provide potential opportunity for environmental offsets:

- 8,334 ha of high value regrowth that has been identified as having a viable opportunity for regeneration and restoration of ecological function;
- Representation of sixteen regional ecosystems of which ten have low and four have no representation on the protected area estate;
- Habitat for ten threatened[1] fauna species: common death adder (NT), spotted-tailed quoll (V), squatter pigeon (V), brush-tailed rock wallaby (V), koala (SL), border thick-tailed gecko (LC), yakka skink (V), collared delma (V), eastern long-eared bat (V), swift parrot (E) and large-eared pied bat (V);
- Habitat for twelve threatened flora species: *Astrotricha roddii* (E), *Leucopogon sp*. (E). *Macrozamia cranei* (E), *Macrozamia machinii* (V), *Pterostylis setifera* (NT), *Thesium australe* (V), *Bertya opponens* (LC), *Lepidium pergrinum*, *Anthochaera phyrgia*, *Eucalyptus virens* (V), *Arthraxon hispidus* (V) and *Paspalidium grandispiculatum* (V).

Although the Traprock Hub provides offset opportunity for the koala and squatter pigeon, it does not appear to provide opportunities for the remaining MNES that the Project is required to offset, particularly the regent honeyeater and *Macrozamia conferta*.

7.1.2 Sundown Hub

The Sundown Hub Covers is located south of the Project area and covers 13,623 ha. The Sundown Hub provides the following ecological features that provide potential opportunity for environmental offsets:

[1] Note, the threat status listed here is that of the State

- 1,490 ha of high value regrowth has been identified as having a viable opportunity for regeneration and restoration of ecological function;
- Representation of seven regional ecosystems of which three have of concern Vegetation Management status, and one has low and one has no representation on the protected area estate;
- Habitat for eight threatened fauna species: glossy black-cockatoo (V), spotted-tailed quoll (V), squatter pigeon (V), Murray cod (V), eastern long-eared bat (V), brush-tailed rock-wallaby (V), koala (SL) and border thick-tailed gecko (LC);
- Habitat for eight threatened flora species: *Cadellia pentastylis* (V), *Diuris parvipetala* (V), *Homoranthus montanus* (V), *Kardomia granitica* (E), *Lepidium peregrinum* (LC), *Macrozamia occidua* (V), *Macrozamia viridis* (E) and *Melaleuca flavovirens* (NT).

Although the Sundown Hub provides offset opportunity for koala and squatter pigeon, it does not appear to provide opportunities for the remaining MNES that the Project is required to offset, particularly the regent honeyeater and *Macrozamia conferta*.

7.2 Co-location Assessment

To ensure direct offsets are delivered in the most cost-effective manner possible, it is necessary to undertake an assessment of the co-location potential of each value requiring an offset to determine the degree of overlap between habitat requirements and the likelihood of being able to utilise the same offset site to acquit a number of values simultaneously. In particular, minimising the number of landholders to negotiate with can improve the likelihood of securing an offset in a timely manner and allow the proponent to focus resources more towards on-the-ground work.

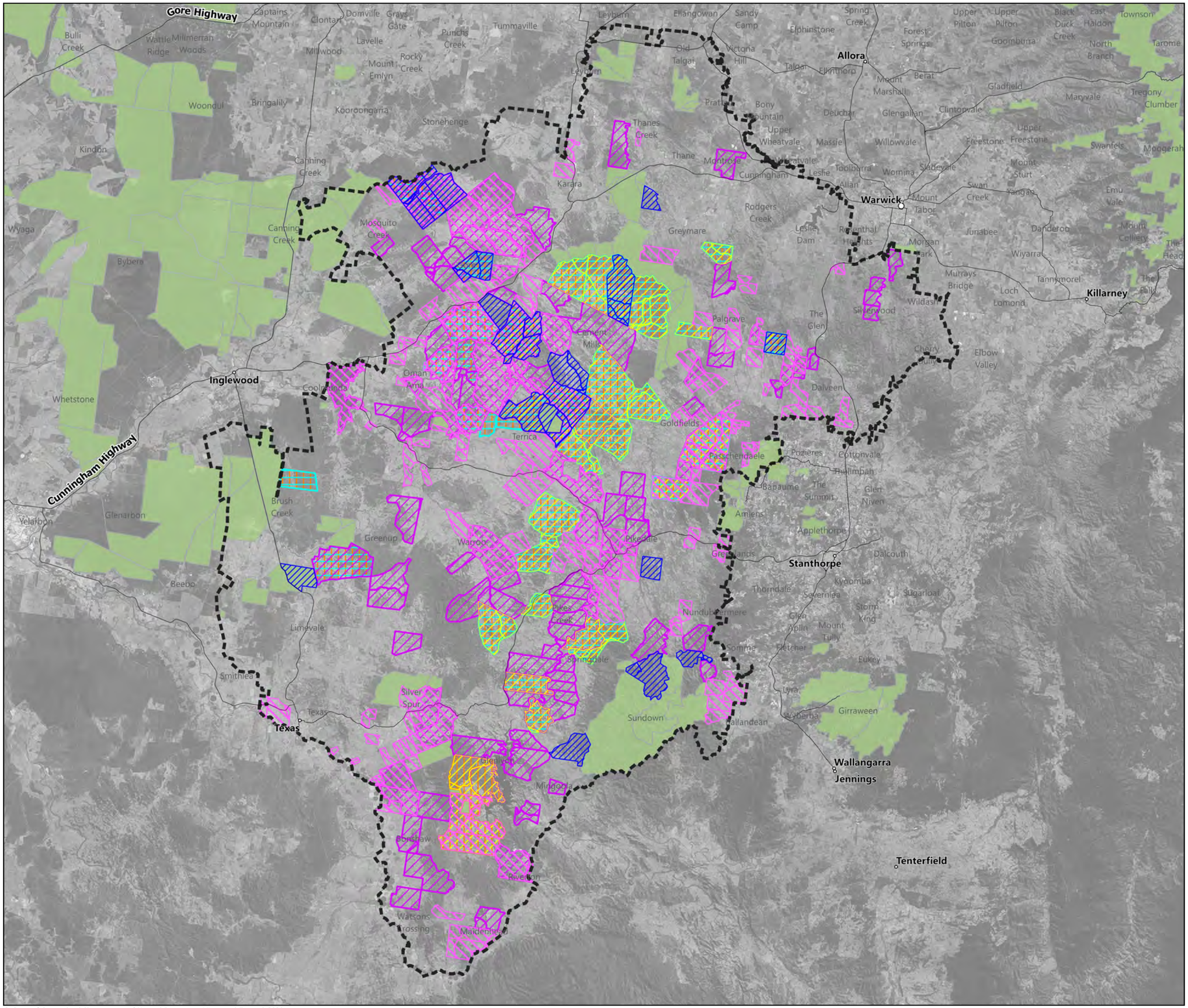
In the case of the regent honeyeater and *Macrozamia conferta*, the limited known distribution of habitat for the species in conjunction with poorly understood habitat requirements made it challenging to identify possible offset sites with any level of certainty. Due to the diverse range of habitat requirements, there were no single properties which contained adequate volumes of offsetable vegetation for all six of the MNES values. **Figure 7-1** illustrates the distribution of potential offset sites for the six MNES values.

7.3 Preliminary Offset Sites

To increase the likelihood of identifying preliminary offset sites the following additional selection criteria were applied to the potential offset sites to make the best use of previous surveys that have been conducted in the locality of the Project site over the last nine years:

- Proximity to known records of MNES;
- Existing relationship between proponent and landholder; and
- Existing survey data confirming presence of threatened species.

On this basis a total of 19 properties were identified that could be used in combination to acquit the Project offset liability, as illustrated in **Figure 7-2.** A number of these properties have been visited to undertake preliminary discussions with the landholder to establish their interest in MIWF securing a portion of their property for an offset, as well as to verify the suitability of the site and confirm the occurrence of niche habitat requirements. Several potential offset properties have had detailed BioCondition and habitat quality scoring undertaken.



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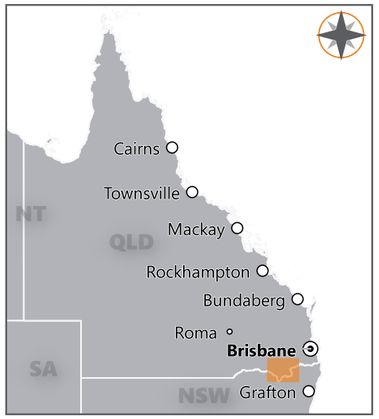
MacIntyre Wind Farm Co-location of Potential Offset Sites

Figure 7.1

Potential Offset Site
- Regent honeyeater
- Box-Gum TEC
- Macrozamia conferta
- Grey-headed flying fox
- Koala
- Squatter pigeon
- Major Road
- Area of Investigation
- Protected Area

Date: 2021-08-06
Author: TOD
Reviewed: NOD
Project: ACC-005



0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2020)
Queensland Imagery Whole Of State Satellite Public Basemap Service

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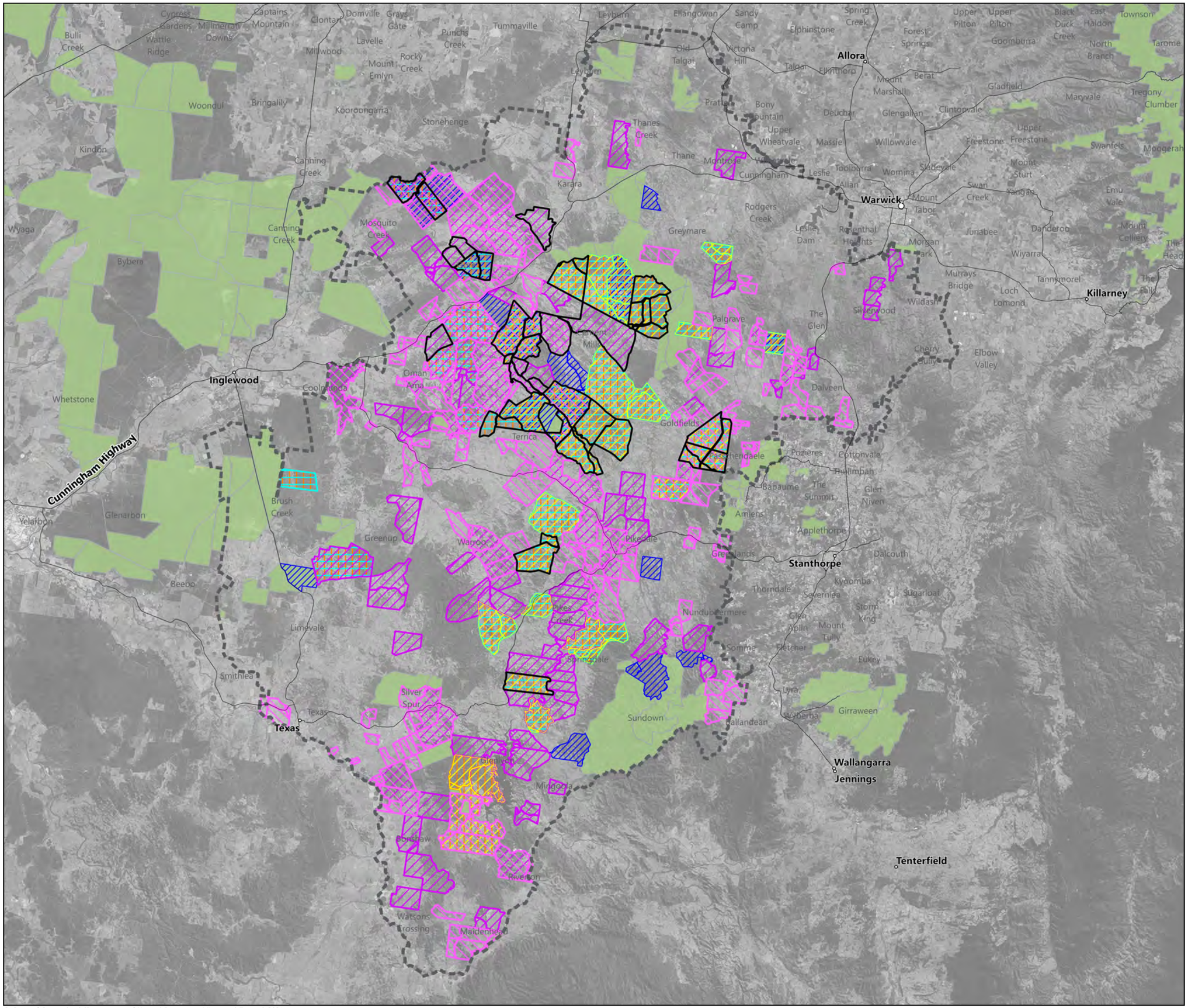
Attexo

MacIntyre Wind Farm

Preliminary Offset Sites

Figure 7.2

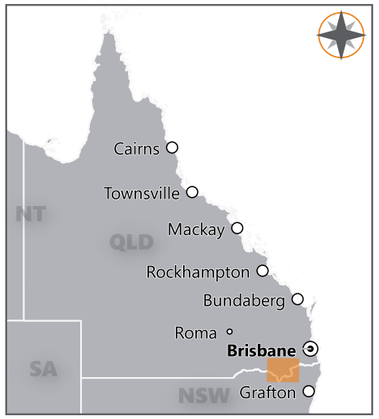


Preliminary Offset Site

Potential Offset Site

- Regent honeyeater
- Box-Gum TEC
- Macrozamia conferta
- Grey-headed flying fox
- Koala
- Squatter pigeon
- Major Road
- Area of Investigation
- Protected Area

Date: 2021-08-06
Author: TOD
Reviewed: NOD
Project: ACC-005



0 5 10 15 20 25 km

1:500000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2021)
Queensland Imagery Whole Of State Satellite Public Basemap Service

7.4 Proposed Offset Sites

It is anticipated that the Project's residual impacts can be offset using the four properties described below.

7.4.1 Property One

Property One is located in the east of Goondiwindi Regional Council local government area, in the locality of Gore. It is partly affected by the MIWF Project footprint and the landholder has expressed a willingness to enter into discussions regarding the use of areas on the property for the purposes of a land-based offset.

The proposed offset management area includes the majority of the property (not within the Project footprint). The property is situated on hills and lowlands (land zone 11) and dominated by remnant and regrowth of dry woodlands and open woodlands dominated by *Eucalyptus dealbata, Eucalyptus melliodora, E. microcarpa, E. moluccana, E. fibrosa, E. tereticornis and E. crebra* (REs 13.11.3, 13.11.8, 13.11.5).

A preliminary site visit has confirmed suitable habitat for all MNES values. Existing records of *Macrozamia conferta* occur at several separate locations. There is approximately 1,920 ha of regrowth and category X vegetation (primarily young regrowth) proposed for use as an offset. Areas of young regrowth are of variable age, but in most locations exhibit reasonable diversity and densities. Some bare areas occur on ridge tops that may cover approximately 50 ha that may have more limited regrowth interspersed with mature ironbarks.

The property includes two Stream Order 3 watercourses that may provide suitable habitat for regent honeyeater, though this is likely to be limited to approximately 5 ha.

Evidence of the presence of or usage by the relevant MNES is as follows:

- There are historical records of koala approximately 5.5 km to the east of the proposed offset area, dating from 2000 (Atlas of Living Australia 2021). Project surveys recorded a koala and koala scat in the neighbouring property, less than 2.5 km from the proposed offset management area.
- Project surveys recorded central greater glider scat approximately 1 km from the proposed offset management area.
- Project surveys recorded squatter pigeon in the neighbouring property to the east, within approximately 500 m of the offset management area.
- As with the impact areas, there are no recent or historical records of grey-headed flying-fox within 20 km of Property One.
- Approximately 450 *Macrozamia conferta* have been recoded on the property.

The property includes 1,515 ha of remnant vegetation which will be managed to improve habitat values for relevant MNES. Two Stream Order 3 watercourses within the property may provide suitable habitat for regent honeyeater, though this is likely to be limited to approximately 5 ha.

Strategically, Property One provides a large offset which builds on existing remnant vegetation within the property. It also links to existing remnant within the neighbouring property to the east and from there into Durikai State Forest.

It is anticipated that the offset area will be managed for 20 years. Key management actions are likely to include:

- The installation of stock-exclusion fencing and its ongoing maintenance;
- Weed control and thinning of dense regrowth vegetation;
- Active revegetation such as seeding;

- Feral animal control (wild dogs are a known problem in the area);
- Establishment and maintenance of fire breaks;
- Fire management and controlled burns;
- Monitoring, evaluation and reporting.

Proposed management actions will be updated following detailed site inspections and habitat quality assessments and will be described in more detail in an Offset Management Plan.

Using information from the initial offset site inspections, likely habitat quality scores have been estimated. **Table 7.1** presents habitat quality assessment Property One for each MNES. This table presents estimated existing scores for the offset site, along with estimated scores for the offset site following the implementation of the Offset Management Plan, and the total percentage of impact offset using the offsets calculator. Additionally, habitat quality scores for the offset site without the implementation of the Offset Management Plan are included. As set out in Section 4.4, there are no legislative obligations for landholders to implement that would lead to an increase in the habitat quality score of the offset site over time.

Table 7.1 Property One Estimated Habitat Quality Scores

MNES	Offset Area (ha)	Habitat Quality Score – Start Value	Habitat Quality Score – Future Value without Offset	Habitat Quality Score – Future Value with Offset	% of Impact Offset
Koala	3,329	6	6	7	103%
Grey-headed Flying-fox	3,329	6	6	7	103%
Regent Honeyeater	5	5	5	8	5%
Greater Glider	3,329	6	6	7	308%
Squatter Pigeon	3,327	6	6	8	563%
Macrozamia conferta	150	NA	NA	NA	100%[2]

7.4.2 Property Two

Property Two is located northwest of Gore and is not affected by the MIWF Project footprint. The landholder has expressed a willingness to enter into discussions regarding the use of parts of the property for the purposes of a land-based offset.

The proposed offset management area is situated on hills and lowlands (land zone 11) dominated by remnant and young regrowth of dry woodlands and open woodlands dominated by *Eucalyptus dealbata*, *E. moluccana*, *E. fibrosa*, and *E. crebra* (REs 13.11.3, 13.11.8, 13.11.5). A preliminary site visit has confirmed suitable habitat for all MNES, with the exception of Regent Honeyeater and *Macrozamia conferta*.

[2] Translocation area required is <15 ha

Evidence of the presence of or usage by the relevant MNES is as follows:

- There is a record of koala within approximately 2.2 km of the property dating from 2007 (Atlas of Living Australia 2021).
- Project surveys recorded evidence of central greater glider (scat) approximately 23 km to the east of the offset management area.
- A squatter pigeon was recorded at the same location as the koala record, at the same time (Atlas of Living Australia 2021). Project surveys recorded squatter pigeon approximately 6.5 km northeast of the offset management area.
- There is an historical record of regent honeyeater approximately 4.6 km to the east of the offset management area (Atlas of Living Australia 2021).
- As with the impact areas, there are no recent or historical records of grey-headed flying-fox within 20 km of Property Two.

Strategically, Property Two connects to existing remnant vegetation to the north and west, within neighbouring private property.

It is anticipated that the offset area will be managed for 20 years. Key management actions are likely to include:

- The installation of stock-exclusion fencing and its ongoing maintenance;
- The removal of stock to allow regeneration of canopy species;
- Weed control and thinning of dense regrowth vegetation;
- Active revegetation such as seeding;
- Feral animal control;
- Establishment and maintenance of fire breaks;
- Fire management and controlled burns;
- Monitoring, evaluation and reporting.

Proposed management actions will be updated following detailed site inspections and habitat quality assessments and will be described in more detail in an Offset Management Plan.

Using information from the initial offset site inspections, likely habitat quality scores have been estimated. **Table 7.2** presents habitat quality assessment Property Two for each MNES. This table presents estimated existing scores for the offset site, along with estimated scores for the offset site following the implementation of the Offset Management Plan, and the total percentage of impact offset using the offsets calculator. Additionally, habitat quality scores for the offset site without the implementation of the Offset Management Plan are included. As set out in Section 4.4, there are no legislative obligations for landholders to implement that would lead to an increase in the habitat quality score of the offset site over time.

Table 7.2 Property Two Estimated Habitat Quality Scores

MNES	Offset Area (ha)	Habitat Quality Score – Start Value	Habitat Quality Score – Future Value without Offset	Habitat Quality Score – Future Value with Offset	% of Impact Offset
Koala	3,657	5	5	7	214%
Grey-headed Flying-fox	3,657	5	5	7	214%
Regent Honeyeater	-	-	-	-	-
Greater Glider	3,657	5	5	7	351%
Squatter Pigeon	3,363	6	6	8	569%
Macrozamia conferta	-	-	-	-	-

7.4.3 Property Three

Property Three is located in the east of Goondiwindi Regional Council local government area, in the locality of Terrica. It does not support any MIWF Project infrastructure, but the landholder has expressed an interest regarding the securing of part of the property for the purposes of a land-based offset.

The proposed offset management area occurs in two discrete patches. The easternmost patch adjoins MacIntyre State Forest, occurs on lowland hills. The vegetation is a combination of small patches of remnant vegetation linked by larger areas of regrowth, dominated by woodlands to open woodlands of *Eucalyptus crebra, E. dealbata, E. albans* and woodlands of *E melliodora*, *E. microcarpa* and *E. moluccana* (RE 13.11.3/13.11.8). The westernmost patch occurs in the southwest of the property and is dominated by a mosaic of woodlands to open forests of *Eucalyptus caleyi subsp. caleyi, E. crebra* and *E. sideroxylon.*

The offset property contains habitat for all MNES values with the exception of *Macrozamia conferta*.

Evidence of the presence of or usage by the relevant MNES is as follows:

- There is an historical record of koala approximately 11 km to the east, dating from 1995 (Atlas of Living Australia 2021). Project surveys recorded evidence of koala (scat) approximately 12 km to the northeast.
- There is an undated squatter pigeon record from this or the neighbouring property to the south (Atlas of Living Australia 2021; record location generalised due to sensitivity issues). Project surveys recorded squatter pigeon within 1 km of the north-eastern boundary of the offset management area.
- Project surveys recorded evidence of greater glider (scat) approximately 14 km to the northeast of the offset management area.
- There is an historical record of regent honeyeater approximately 6 km to the east of the offset management area (Atlas of Living Australia 2021).
- As with the impact areas, there are no recent or historical records of grey-headed flying-fox within 20 km of Property Three.

The proposed offset area provides an opportunity to improve connectivity between large areas of remnant and regrowth vegetation to the south and west of the property and Macintyre State Forest which is located to the east.

It is anticipated that the offset area will be managed for 20 years. Key management actions are likely to include:

- The installation of stock-exclusion fencing and its ongoing maintenance;
- Weed control and thinning of dense regrowth vegetation;
- Active revegetation such as seeding;
- Feral animal control (wild dogs are a known problem in the area);
- Establishment and maintenance of fire breaks;
- Fire management and controlled burns;
- Monitoring, evaluation and reporting.

Proposed management actions will be updated following detailed site inspections and habitat quality assessments, and will be described in more detail in an Offset Management Plan.

Using information from the initial offset site inspections, likely habitat quality scores have been estimated. **Table 7.3** presents habitat quality assessment Property One for each MNES. This table presents estimated existing scores for the offset site, along with estimated scores for the offset site following the implementation of the Offset Management Plan, and the total percentage of impact offset using the offsets calculator. Additionally, habitat quality scores for the offset site without the implementation of the Offset Management Plan are included. As set out in Section 4.4, there are no legislative obligations for landholders to implement that would lead to an increase in the habitat quality score of the offset site over time.

Table 7.3 Property Three Estimated Habitat Quality Scores

MNES	Offset Area (ha)	Habitat Quality Score – Start Value	Habitat Quality Score – Future Value without Offset	Habitat Quality Score – Future Value with Offset	% of Impact Offset
Koala	491	5	5	7	29%
Grey-headed Flying-fox	491	5	5	7	29%
Regent Honeyeater	183	6	6	8	242%
Greater Glider	491	6	6	7	49%
Squatter Pigeon	491	6	6	8	78%
Macrozamia conferta	-	-	-	-	-

7.4.4 Property Four

The proposed offset management area excludes the patch of remnant vegetation on the western side of the property. Regrowth areas generally comprise vegetation 13.11.3 and 13.11.5. A preliminary site visit has confirmed suitable

habitat for koala and grey-headed flying fox. It is possible that the site could support regent honeyeater habitat. The property may also contain *Macrozamia conferta* in remnant areas in the west, but this has not been confirmed. The proposed management area contains regrowth vegetation that includes advanced regrowth areas that are close to remnant, with other areas containing sparse and young regrowth.

Evidence of the presence of or usage by the relevant MNES is as follows:

- Project surveys recorded evidence of koala (scat) approximately 3 km to the northeast of the offset management area.
- There is a squatter pigeon record dating from 2011 approximately 2.7 km to the south of this property (Atlas of Living Australia, 2021). Project surveys recorded squatter pigeon within 1 km of the northern boundary of the offset management area.
- Project surveys recorded evidence of greater glider (scat) approximately 8.6 km to the east of the offset management area.
- There is an historical record of regent honeyeater from the neighbouring property to the west, less than 1 km from the offset management area (Atlas of Living Australia 2021).
- As with the impact areas, there are no recent or historical records of grey-headed flying-fox within 20 km of Property Four.

Strategically, this property connections to large areas of remnant vegetation to the west.

It is anticipated that the offset area will be managed for 20 years. Key management actions are likely to include:

- The installation of stock-exclusion fencing and its ongoing maintenance;
- Weed control and thinning of dense regrowth vegetation;
- Active revegetation such as seeding;
- Feral animal control (wild dogs are a known problem in the area);
- Establishment and maintenance of fire breaks;
- Fire management and controlled burns;
- Monitoring, evaluation and reporting.

Proposed management actions will be updated following detailed site inspections and habitat quality assessments and will be described in more detail in an Offset Management Plan.

Using information from the initial offset site inspections, likely habitat quality scores have been estimated. Table 7.4 presents habitat quality assessment Property One for each MNES. This table presents estimated existing scores for the offset site, along with estimated scores for the offset site following the implementation of the Offset Management Plan, and the total percentage of impact offset using the offsets calculator. Additionally, habitat quality scores for the offset site without the implementation of the Offset Management Plan are included. As set out in Section 4.4, there are no legislative obligations for landholders to implement that would lead to an increase in the habitat quality score of the offset site over time.

Table 7.4 Property Four Estimated Habitat Quality Scores

MNES	Offset Area (ha)	Habitat Quality Score – Start Value	Habitat Quality Score – Future Value without Offset	Habitat Quality Score – Future Value with Offset	% of Impact Offset
Koala	2,023	5	5	7	118%
Grey-headed Flying-fox	2,023	5	5	7	118%
Regent Honeyeater	200	6	6	8	173%
Greater Glider	2,023	5	5	7	376%
Squatter Pigeon	2,023	6	6	8	323%
Macrozamia conferta	-	-	-	-	-

7.5 Offset Acquittal Strategy

The proposed offset management areas on the four properties described above contain more than adequate vegetation to acquit 100% of the Project's residual impacts to the six MNES. The final areas to be used will be confirmed in the Offset Management Plans following negotiations with the landholders. The EPBC offset calculator will be re-run for each value using site-based habitat quality scores to demonstrate how offset liabilities have been acquitted.

8.0 Desired Conservation Outcomes

8.1 Final Outcomes

The majority of the proposed offset areas are regrowth. These regrowth areas will be managed so that they return to 'remnant vegetation' status as specified under the Queensland *Vegetation Management Act 1999*. This will require the predominant canopy of the vegetation to:

- Cover more than 50% of the undisturbed predominant canopy;
- Average more than 70% of the vegetation's undisturbed height;
- Be composed of species characteristic of the vegetation's undisturbed canopy.

Once these characteristics have been achieved the vegetation is considered to be generally resilient and self-sustaining. The time period that the regrowth will take to reach 'remnant vegetation' status will vary between assessment units, depending on the age and structure of the regrowth but is expected to be achieved for all areas within 20 years. Throughout this period these areas will also be managed to improve their suitability as habitat for the relevant MNES where these are fauna or flora species are achieved.

A relatively small portion of the proposed offset management areas already have the characteristics of remnant vegetation (and are mapped as such on the Queensland Government regional ecosystem mapping). These areas have either never been cleared or are vegetation communities which have regrown over several decades. These areas will be managed to improve their suitability as habitat for the relevant MNES where these are fauna or flora species. These habitat improvements will be achieved within 20 years.

A portion of the proposed offset areas for MNES fauna species are currently predominantly cleared. These are areas in which regrowth has been actively managed over many years. Generally, these areas are the most suitable for grazing pasture production and are often associated with lower slopes in proximity to ephemeral watercourses or, less commonly, broad hill crests. These areas will be managed to improve their suitability for koala, grey-headed flying fox, greater glider, squatter pigeon and regent honeyeater to move between adjoining regrowth and remnant vegetation patches, protect and enhance feed trees, and minimise edge effect impacts upon and threats to relevant MNES within the adjoining patches (e.g. weeds, fire, predation). These habitat improvements will be achieved within 20 years.

The overall habitat quality across each offset site will be improved through enhancing site condition attributes such as increasing woody perennial species recruitment, native plant species richness, tree canopy height and cover, shrub and native grass cover, organic litter and coarse woody debris and reducing weed cover. The quality and availability of food and foraging habitat and shelter, and species mobility capacity for regent honeyeater, koala, grey-headed flying fox, squatter pigeon and greater glider will be enhanced in their respective offsets. The 'Habitat Indicator Tables' in Appendix A provide details of each of the habitat characteristics that will be improved or considered for improvement for each MNES over the 20 year period. The offset site field assessments will enable the improvements in each of these characteristics for each MNES to be estimated.

The offsets will result in the following threats being reduced for each MNES:

- *Macrozamia conferta* – timber harvesting, trampling by livestock, fire and illegal collection;
- Koala – clearing, fragmentation, weeds, fire (impacts upon habitat as well as direct mortality) and dogs;
- Grey-headed flying fox – loss of foraging habitat and entanglement;
- Regent honeyeater – loss of foraging and nesting habitat including through fire;

- Greater glider – habitat fragmentation and loss of hollow-bearing trees from logging activities, inappropriate fire regimes, increased susceptibility to predation and competition;
- Squatter pigeon (southern) – habitat degradation and fragmentation from trampling and overgrazing by livestock, inappropriate fire regimes, increased competition and exposure to predation.

The offsets are over 40 km from the nearest known grey-headed flying fox roosting site. Therefore, it is not proposed that the offsets will aim to provide breeding habitat for this species.

Regent honeyeater and grey-headed flying fox have not been detected in the impact area during any of the Project's ecological surveys to date. There are some historical records (the most recent dating from 2004) of the regent honeyeater in the impact area and within or in proximity to proposed offset areas. It has been conservatively assumed that these two species may temporarily utilise the impact area on a seasonal basis. Similarly, utilisation of the offset areas is likely to be on a temporary and seasonal basis. Due to the paucity of data on these two species, it is not proposed that the offsets will aim to provide an increase in stocking rate for either the regent honeyeater or grey-headed flying fox.

There have been a small number of sightings of koala in the impact area during the Project's ecological surveys and greater glider were identified at several locations from scats. The impact and offset area field assessments will include koala SAT scat surveys to determine the feasibility of aiming for improvements in species stocking rates for koala and greater glider.

8.2 Interim Milestones

In order to track progress towards the desired final conservation outcomes, interim milestones have been defined. These provisional milestones are currently presented in relation to the baseline condition and will be refined once the detailed habitat quality field assessments have been completed.

- Pest and weed management;
  - Demonstrate the extent of weed cover across the offset management areas is < 25% by the end of year 5 and < 5% by the end of year 10, and then maintained at or below this level;
- Stock management;
  - Install fauna friendly stock exclusion fencing around the offset management areas as required, by the end of year 1;
  - Only permit grazing for the purposes of bushfire hazard reduction, to extent required to meet the habitat quality improvement milestones listed below, by the end of year 1;
  - Ensure all livestock are excluded from the offset management area for a minimum of 5 years, or until a suitably qualified independent expert has determined that any significant cohorts of koala and grey-headed flying-fox feed trees are a sufficient size to withstand grazing by sheep and cattle;
  - Ensure any grazing is managed so as to prevent the risk of injury or mortality of koalas, by the end of year 1;
- Habitat quality improvement;
  - Undertake ecology work which contributes to improvement of the condition of REs and facilitates natural regeneration within the offset management area, such that the following outcomes are achieved:
    - Average recruitment of woody perennial species in the EDL is > 75% of the benchmark for the relevant RE by the end of year 5 and maintain that level or greater;

- Maintain average tree canopy height at > 50% of the benchmark for the relevant RE by the end of year 10;
- Maintain average tree canopy cover at > 25% of the relevant benchmark for the relevant RE by the end of year 10.

As outlined in Section 4.4, proposed offset management actions are all additional to those required under existing legislation.

9.0 Future Steps

9.1 Offset Management Plans

Following field surveys to assess vegetation type, habitat attributes and condition, management plans will be prepared for each offset site. The management plans will provide details on the performance outcomes to be achieved, specific management actions required on each offset site, an estimate of the costs of management and details regarding the reporting and monitoring of offset actions and outcomes. Offsets include a mix of remnant vegetation and non-remnant areas. The management plans will therefore include details on where active management is required to restore ecosystem function whilst identifying appropriate management actions for remnant areas that require a different mix of management actions. The final management actions recommended will be dependent on the condition of vegetation and habitat, and the nature and type of threatening processes.

Detailed offset management plans will be developed that provide specific information on the following:

- Specific weed mapping across the offset sites;
- Pest animal mapping;
- Detailed assessment / mapping of species composition across all planted and regrowth areas to guide supplementary and enrichment planting;
- Fully quantify tree planting and maintenance requirements;
- Inspect and quantify changes to livestock grazing and pest exclusion fencing;
- Mosaic fire regimes (based on fuel load assessment and time since previous fire events).

Management plans will include cost estimates for all proposed management actions, monitoring and reporting, and detailed logistical program of works to guide implementation of conservation measures. Timing of works to maximise the return from resource and financial investment is considered critical for achieving conservation outcomes.

Management plans will set out an active management period of 20 years; however, all management actions will be guided through monitoring and subsequent reporting. It is anticipated that management efforts will be greatest in the first five years, particularly to establish revegetation areas, new fencing and getting weed populations under control.

9.2 Legal Mechanisms for Securing Offsets

Once the final offset package has been agreed, offset sites would be legally secured for offset purposes following Section 29 of the Offsets Act, through either of:

- An environmental offset protection area under Section 30 of the *Environmental Offsets Act 2014*; or
- An area declared as an area of high nature conservation value under Section 19F of the *Vegetation Management Act 1999* where it is secured for the purposes of an environmental offset

The mechanisms adopted to secure offsets will ultimately depend on the approval of relevant government departments, and landholders or parties with interests over the offset property.

The legal mechanism would remain on title for the offset area in perpetuity, ensuring that conservation gains are protected for the long term.

9.3 Offset Monitoring and Reporting

Offset management plans will include a monitoring program. It is proposed that monitoring be conducted annually for the first five years, with subsequent monitoring events being conducted bi-annually for a maximum of 20 years or until it can be demonstrated that the objectives of the management plans have been met. Monitoring plans will be developed in conjunction with the detailed management plans and will reflect the management actions at the site.

Vegetation / habitat condition monitoring will be based around the Queensland Government Guide to Determine Terrestrial Habitat Quality, following the baseline assessment used in determining the area of offset required at each of the sites. Other monitoring would include:

- Weed population and extent;
- Pest animal occurrence / abundance;
- Fire fuel load monitoring, fire impact monitoring and associated habitat change;
- Supplementary / enrichment planting monitoring for growth and survival rates; and
- Targeted fauna surveys and fauna utilisation monitoring (against the target species for the sites).

Monitoring reports will be used to inform ongoing management actions and be supplied to regulators as they are completed, to demonstrate progress towards the target conservation gains. Active management and associated monitoring would continue until all conservation gains at the offset sites have been achieved.

10.0 Compliance with EPBC Act Environmental Offsets Policy

Table 10.1 lists the principles of the EPBC Act Environmental Offsets Policy and describes how the Project Offset Strategy has been developed to adhere to these principles.

Table 10.1 EPBC Act Environmental Offsets Policy Principles

Principle	Offset Strategy Compliance
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environmental law and affected by the proposed action	Based on the outcomes of a desktop offset availability analysis, a number of potential offset sites have been identified for the Project as described in **Section 6.3**. The offset site selection and preliminary site inspections have assessed the suitability of each potential offset site to deliver conservations gains for each matter being offset. The next stage of the Project's offset program will involve undertaking habitat quality assessments for the offset areas and uses of the EPBC Calculator to more fully demonstrate that the offset will improve or maintain the viability of relevant MNES.
Suitable offsets must be built around direct offsets but may include other compensatory measures	Direct offsets will provide 100% of the Project's offset requirements for MNES. The offset availability analysis presented in **Section 6.3** demonstrates that there are a large number of properties within the Nandewar Northern Complex sub-bioregion that provide potentially suitable vegetation to meet the Project's offset requirements.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter	In the absence of habitat quality measurements for the offset areas, it is not yet possible to fully assess the suitability of the proposed offset sites using the EPBC Calculator. This will be completed during the next stage of the offsets program.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter	Offset availability assessment has incorporated consideration for how the proposed offset will be proportionate to the residual impacts on each of the MNES.
Suitable offsets must effectively account for and manage the risks of the offset not succeeding	It is not yet possible to estimate the risk of the offset not succeeding based on current information; this will be assessed during the next stage of the offset program and presented in the Offset Management Plan, which will also provide further detail on proposed monitoring, reporting and adaptive management.
Suitable offsets must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action)	As described in **Section 2.3**, the EPBC Act Environmental Offsets Policy takes precedence in relation to MNES and the State cannot impose an offset condition in relation to the same or substantially the same impact, if DAWE has assessed an activity as a controlled action and decided that an offset is, or is not, required. The Project has the potential to result in significant residual impacts to MSES that are not also MNES and it is intended that the proposed offset sites will also fully acquit the State offset requirements for these MSES.
Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable	It is the proponent's intention to have the offset in place prior to commencement of construction. As part of that process, an Offset Management Plan will be developed in late 2021 which will present

Principle	Offset Strategy Compliance
	the outcomes of the habitat quality assessments and the proposed offset management approach.
Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced	The proposed governance arrangements for the offset property will be described in detail in the Offset Management Plan.
In assessing the suitability of an offset, government decision-making will be informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific uncertainty	Noted.
In assessing the suitability of an offset, government decision-making will be conducted in a consistent and transparent manner	Noted.

11.0 References

Andrews, S. P., Gration, G., Quin, D., & Smith, A. P. (1994). Description and assessment of forestry impacts on fauna of the Urbenville Forestry Management Area. Report for State Forests of New South Wales Austeco Environmental Consultants, Armidale.

Agnew, L. R. (2007). A Review of the Vulnerable Squatter Pigeon (southern subspecies) Records with Central Queensland and a Plan to Model Potential Habitat Usage. Prepared for the Commonwealth Department of Environment and Heritage on behalf of BHP Mitsui Coal.

Barker, R. D., & Vestjens, W. J. M. (1984), The Food of Australian Birds, vol. 2 Passerines, CSIRO Australia, Melbourne University Press.

Beadle, N. C. W. (1981). The Vegetation of Australia. Cambridge University Press, Cambridge.

Bennett, A. F., Lumsden, L. F., & Nicholls, A. O. (1994). Tree hollows as a resource for wildlife in remnant woodlands: spatial and temporal patterns across the northern plains of Victoria, Australia. Pacific Conservation Biology 1: 222-235.

Bilney, R., Cooke, R., & White, J. (2006). Change in the diet of sooty owls (Tyto tenebricosa) since European settlement: from terrestrial to arboreal prey and increased overlap with powerful owls. Wildlife research, 33: 17-24.

BirdLife International. (2018). Anthochaera phrygia. The IUCN Red List of Threatened Species 2018.

Birt, P., Markus, N., Collins, L., & Hall, L. S. (1998). Urban Flying-foxes. *Nature Australia*, 26: 54-59.

Bishop, T., & Lyons, R. (2018). Flying-fox Heat Event Response Guidelines SEQ. Local Government Association of Queensland.

Brookes, D., Hereward J., Terry, L., & Walter, J. (2015). *Evolutionary dynamics of a cycad obligate pollination mutualism Pattern and process in extant Macrozamia cycads and their specialist thrips pollinators,* Molecular Phylogenetics and Evolution, 93: 83–93.

Cohen, M. (2019). Nocturnal Survey for Greater Gliders (Petauroides volans) Meadowbank Road Reserve, Minnammoolka, Far North Queensland. Report to Australian Conservation Foundation.

Comport, S. S., Ward, S. J., & Foley, W. J. (1996). Home ranges, time budget and food-tree use in a high-density tropical population of greater gliders, Petauroides volans minor (Pseudocheiridae: Marsupialia). Wildlife Research, 23: 401–419.

Crates, R. A. (2019). Ecology and conservation of the regent honeyeater. PhD Thesis submission, Doctor of Philosophy, Australian National University, Australia.

Crates, R., Rayner, L., Stojanovic, D., Webb, M., & Heinsohn, R. (2017). Undetected Allee effects in Australia's threatened birds: implications for conservation. Emu - Austral Ornithology, 117(3): 207-221.

Crome, F. H. J. (1976). Breeding, moult, and food of the Squatter Pigeon in north-eastern Queensland. *Australian Wildlife Research*, 3: 45-59.

Department of Agriculture, Water and Environment (DAWE). (2021). National Recovery Plan for the Grey-headed Flying-fox *Pteropus poliocephalus*.

Department of Environment (DoE). (2016). National Recovery Plan for the Regent Honeyeater (*Anthochaera phrygia*).

Department of Environment, Climate Change and Water NSW (DoECCW). (2011). National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland. Department of Environment, Climate Change and Water NSW, Sydney.

Department of the Environment and Energy (DoEE). (2014). *EPBC Act referral guidelines for the vulnerable koala*

Department of the Environment and Energy (DoEE). (2019). Geophaps scripta scripta — Squatter Pigeon (southern). Species Profile and Threats Database. Australian Government, Canberra.

Department of Environment and Energy (DoEE). (2019b). *Pteropus poliocephalus* in Species Profile and Threats Database, retrieved 17 July 2019 from http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=186

Department of Environment and Heritage (DEH). (2006). White Box-Yellow Box-Blakely's Red Gum grassy woodlands and derived grasslands. EPBC Act Policy Statement. Department of the Environment and Heritage.

Department of Environment and Heritage Protection (EHP). (2015). Southern Brigalow Belt and New England Tableland - Strategic Offset Investment Corridors

Department of Environment and Heritage Protection (EHP). (2017). *Guide to Determining Terrestrial Habitat Quality – Methods for Assessing Habitat Quality under the Queensland Environmental Offsets Policy Version 1.2*.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC). (2012). *Approved Conservation Advice for Phascolarctos cinereus* (combined populations in Queensland, New South Wales and the Australian Capital Territory).

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC). (2012). *Environment Protection and Biodiversity Conservation Act 1999* EPBC Act Environmental Offsets Policy.

Department of Sustainability, Environment, Water, Population and Communities (DSEWPC). (2011). *Survey Guidelines for Australia's Threatened Mammals*. Commonwealth of Australia.

Department of the Environment, Water, Heritage and the Arts (DWEHA). (2010). *Survey Guidelines for Australia's Threatened Birds*. Commonwealth of Australia.

Department of the Environment, Water, Heritage and the Arts (DEWHA). (2008). *Approved Conservation Advice for Macrozamia conferta*. Canberra, Australia.

Duncan, A., Baker, G. B., & Montgomery, G. B. (1999). *The Action Plan for Australian Bats*. Canberra: Environment Australia.

Eby, P. (1996). Interactions between the Grey-headed Flying-fox *Pteropus poliocephalus* (Chiroptera: Pteropodidae) and its diet plants-seasonal movements and seed dispersal. Ph.D. Thesis. Armidale, NSW: University of New England.

Eby, P. (1998). An analysis of diet specialization in frugivore *Pteropus poliocephalus* in Australian subtropical rainforest. *Australian Journal of Ecology*, 23: 443-45.

Eby, P., & Law, B. (2008). *Ranking the feeding habitats of Grey-headed flying foxes for conservation management* The Department of Environment and Climate Change (NSW) & The Department of Environment, Water, Heritage and the Arts.

Environmental Protection Agency (EPA). (2006). *EPA 2006 Database*. Environmental Protection Agency, Queensland Government.

Environmental Protection Agency (EPA). (2006b). Nature Conservation (Koala) Conservation Plan 2006 and Management Program 2006-2016 Queensland Government.

Environmental Protection Agency (EPA). (2008). Copy of the certified regional ecosystem map for the purpose of Fire and Biodiversity Consortium (2002) Fire & Biodiversity Monitoring Manual V1, Natural Heritage Trust, Australia.

Eyre, T. J. (2002). Habitat preferences and management of large gliding possums in Southern Queensland. PhD thesis, Southern Cross University, Lismore, New South Wales.

Eyre, T. J. (2006). Regional habitat selection of large gliding possums at forest stand and landscape scales in southern Queensland, Australia: I. Greater glider (*Petauroides volans*). *Forest Ecology and Management*, *235*(1-3): 270-282.

Eyre, T. J., Ferguson, D., & Laidlaw, M. J. (2018). Greater Glider Habitat Resource Assessment in the Burnett Mary. Queensland Herbarium, Science Delivery, Department of Environment and Science.

Eyre, T. J., Kelly, A. L, Nelder, V. J., Wilson, B. A., Ferguson, D. J., Laidlaw, M. .J., & Franks, A. J. (2015). BioCondition Assessment Manual Version 2.2 Queensland Department of Science, Information Technology, Innovation and the Arts.

Eyre, T. J., Kelly, A. L., & Neldner, V. J. (2017). *Method for the Establishment and Survey of Reference Sites for BioCondition, Queensland Herbarium Version 3* Queensland Department of Science, Information Technology and Innovation.

Ford, H., Davis, W., Debus, S., Ley, A., Recher, H., & Williams, B. (1993). Foraging and aggressive behaviour of the regent honeyeater Xanthomyza phrygia in Northern New South Wales. Emu, 93: 277-80.

Forster, P. I. (2004). The cycads of Queensland – diversity and conservation. Palms & Cycads, 82: 4–28.

Franklin, D. C., & Robinson, J. L. (1989). Territorial behaviour of a regent honeyeater at feeding sites. Australian Bird Watcher, 13: 129-32.

Franklin, D. C., Menkhorst P. W. & Robinson J. L. (1987). Field surveys of the regent honeyeater Xanthomyza Phrygia in Victoria. Australian Bird Watcher, 12: 91-95.

Franklin, D. C., Menkhorst, P. W., & Robinson, J. L. (1989). Ecology of the Regent Honeyeater *Xanthomyza 63hrygia*. *Emu,* 89: 140-54.

Frith, H. J. (1982). *Pigeons and Doves of Australia*. Melbourne: Rigby.

Fulton, G. R., & Ford, H. A. (2001). The Pied Currawong's role in avian nest predation: a predator removal experiment. Pacific Conservation Biology, 7: 154-160.

Garnett, S. T., & Crowley, G. M. (2000). *The Action Plan for Australian Birds 2000*. Canberra, ACT: Environment Australia and Birds Australia.

Garnett, S. T., & Franklin, D. C. (2014). *Climate Change Adaptation Plan for Australian Birds*. BirdLife Australia, CSIRO Publishing, Collingwood, Australia.

Garnett, S. T., Szabo, J. K., & Dutson, G. (2011). The Action Plan for Australian Birds 2010. Birds Australia, CSIRO Publishing, Melbourne.

Geering D. J., & French, K. (1998). Breeding biology of the Regent Honeyeater, Xanthomyza phrygia in the Capertee Valley, NSW. Emu, 98: 104-116.

GHD. (2020). *MacIntyre Wind Farm MNES Assessment Report* prepared as part of the EPBC Act referral on behalf of ACCIONA Energy Australia Global Pty Ltd.

Gibbons, P., & Lindenmayer, D. B. (2002). Tree hollows and wildlife conservation in Australia CSIRO Publishing, Collingwood.

Goldingay, R. Prof. (2021). A review of the management and monitoring of tree hollow resources for mammals and birds in the forests of New South Wales. Report to Natural Resources Commission. *Southern Cross University, Lismore, NSW*.

Higgins, P. J., Peter, J. M., & Steele, W. K. (Eds) (2001). *Handbook of Australian, New Zealand and Antarctic Birds*. Volume Five - Tyrant-flycatchers to Chats. Melbourne: Oxford University Press.

Higgins, P. J., & Davies, S. J. J. F. (1996). Handbook of Australian, New Zealand, and Antarctic Birds. Vol. 3. Snipe to Pigeons. Oxford University Press, Melbourne.

Hines, H. B. (2008). *Some observations on the vertebrate fauna of Durikai State Forest, southeast Queensland, 2000-2008*. The Queensland Naturalist, 46: 6-8.

Jones, D.L.; Forster, P.I. (1994). *Seven new species of Macrozamia section Parazamia (Miq.) Miq. (Zamiaceae) from Queensland.* Austrobaileya, 4: 269-288.

Kavanagh, R. P. (1984). Seasonal changes in habitat use by gliders and possums in southeastern New South Wales. In Possums and Gliders (eds A. P. Smith & I. D. Hume): 527-543. Surrey Beatty and Sons, Chipping Norton.

Kavanagh, R. P. (2000). Effects of variable-intensity logging and the influence of habitat variables on the distribution of the Greater Glider Petauroides volans in montane forest, southeastern New South Wales. Pacific Conservation Biology, 6: 18-30.

Kavanagh, R. P. (2004). *Distribution and conservation status of possums and gliders in New South Wales*. In The Biology of Australian Possums and Gliders (eds R. L. Goldingay & S. M. Jackson): 130-148. Surrey Beatty and Sons, Chipping Norton.

Kavanagh, R. P., & Webb, G. A. (1989). Silvicultural Options for the Management of Wildlife Habitats in Southeast New South Wales. Unpublished report.

Kavanagh, R. P., & Wheeler, R. J. (2004). Home-range of the greater glider Petauroides volans in tall montane forest of south-eastern New South Wales, and changes following logging. *The Biology of Australian Possums and Gliders*. (Eds R. L. Goldingay and S. M. Jackson.): 413–425. (Surrey Beatty: Sydney.)

Kearney, M. R., Wintle, B. A., & Porter, W. P. (2010*). Correlative and mechanistic models of species distribution provide congruent forecasts under climate change*. *Conservation Letters, 3*: 203-213.

Kehl, J., & Borsboom, A. (1984). Home range, den tree use and activity patterns in the greater glider, Petauroides volans. *Possums and Gliders*. (Eds A. P. Smith and I. D. Hume.): 229–236. (Australian Mammal Society: Sydney.)

Killey, P. (2008). *Modelling the volume of fallen branch debris in Yellow Box – Red Gum Woodlands.* Notes from the Mulligans Flat and Goorooyarroo Woodland Experiment Workshop. August 7-8, 2008.

Laidlaw, M., & Forster, P. (2012). *Climate Predictions Accelerate Decline for Threatened Macrozamia Cycads from Queensland, Australia*, Biology, 1: 880-894; doi:10.3390/biology1030880 *March 2008, <http://www.epa.qld.gov.au/REMAP>*.

Ley, A., & Williams, B. (1992). The Conservation status of the Regent Honeyeater near Armidale, New South Wales. Australian Bird Watcher, 14: 277-281.

Lindenmayer, D. B., Cunningham, R. B., Nix, H. A., Tanton, M. T., & Smith, A. P. (1991a). *Predicting the abundance of hollow-bearing trees in montane forests of south-eastern Australia*. Australian Journal of Ecology, 16: 91-98.

Lindenmayer, D. B., Cunningham, R. B., Tanton, M. T., Smith, A. P., & Nix, H. A. (1991b). Characteristics of hollow-bearing trees occupied by arboreal marsupials in the montane ash forests of the Central Highlands of Victoria, south-east Australia. Forest Ecology and Management, 40: 289-308.

Lindenmayer, D. B., Pope, M. L., & Cunningham, R. B. (2004). Patch use by the greater glider (*Petauroides volans*) in a fragmented forest ecosystem. II. Characteristics of den trees and preliminary data on den-use patterns. *Wildlife Research*, *31*: 569-577.

Lindenmayer, D. B., Lacy, R. C. & Pope, M. L. (2000). Testing a simulation model for population viability analysis. Ecological Applications, 10: 580–597.

Lindenmayer, D. B., Wood, J. T., McBurney, L., MacGregor, C., Youngentob, K. & Banks, S. C. (2011). *How to make a common species rare: a case against conservation complacency*. *Biological Conservation*, *144*: 1663-1672.

Lindenmayer, D. B., Blanchard, W., McBurney, L., Blair, D., Driscoll, D., Smith, A. L., & Gill, A. M. (2013). *Fire severity and landscape context effects on arboreal marsupials*. Biological Conservation, 167: 137-148.

Lumsden, L. F., Nelson, J. L., Todd, C. R., Scroggie, M. P., McNabb, E. G., Raadik, T. A., Smith, S. J., Acevedo, S., Cheers, G., Jemison, M. L., & Nicol, M. D. (2013). A New Strategic Approach to Biodiversity Management – Research Component. Arthur Rylah Institute for Environmental Research. Unpublished Client Report for the Department of Environment and Primary Industries, Heidelberg, Victoria.

Lunney, D., & Moon, C. (1997). Flying-foxes and their camps in the rainforest remnants of north-east NSW. In: Dargavel, J., ed. *Australia's Ever-Changing Forests III*. Canberra: Centre for Resource and Environmental Studies, Australian National University.

Maloney, K. S. (2007). The status of the Greater Glider Petauroides volans in the Illawarra region. M.Sc.-Res. thesis, School of Biological Sciences, University of Wollongong, Wollongong.

McCarthy, M. A., & Lindenmayer, D. B. (2006). Conservation of the greater glider (*Petauroides volans*) in remnant native vegetation within exotic plantation forest. *Animal Conservation*, *2*(3): 203-209.

Manning, A. D., Lindenmayer, D. B., & Cunningham, R. B. (2007). A study of coarse woody debris volumes in two box-gum grassy woodland reserves in the Australian Capital Territory. *Ecological Management & Restoration*, *8*(3): 221-224.

Martin, R., & Handasyde, K. A. (1999). *The Koala: Natural History, Conservation and Management*. UNSW Press.

Matusick, G., Ruthrof, K. K., Brouwers, N. C., Dell, B., & Hardy, G. E. St J. (2013). Sudden forest canopy collapse corresponding with extreme drought and heat in a mediterranean-type eucalypt forest in southwestern Australia. European Journal of Forest Research, 132(3): 497-510.

McGarigal, K. (2017). Landscape metrics for categorical map patterns. *Lecture Notes. Available online: http://www. umass. edu/landeco/teaching/landscape_ecology/schedule/chapter9_metrics. pdf (accessed on 3 July 2018)*.

McIntyre, S., McIvor, J. G., & Heard, K. M. (eds.) (2002). Managing and Conserving Grassy Woodlands. CSIRO Collingwood, Victoria.

McLean, C. M., Bradstock, R., Price, O., & Kavanagh, R. P. (2015). Tree hollows and forest stand structure in Australian warm temperature Eucalyptus forests are adversely affected by logging more than wildfire. *Forest Ecology & Management*, *341*: 37–44.

McLean, C. M., Kavanagh, R. P., Penman, T., Bradstock, R. (2018). The threatened status of the hollow dependent arboreal marsupial, the Greater Glider (Petauroides volans), can be explained by impacts from wildfire and selective logging. *Forest Ecology and Management*, *415*: 19–25.

Menkhorst,. P. (1993). Regent Honeyeater Xanthomyza phrygia. Flora and Fauna Guarantee Action Statement No. 41. Department of Conservation and Natural Resources, Victoria.

Menkhorst, P. (1997). Regent Honeyeater Recovery Plan 1994-1998. Department of Conservation and Natural Resources in conjunction with the Regent Honeyeater Recovery Team.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P., & Franklin, K. (2017). The Australian Bird Guide (1st ed.). Clayton South VIC 3169: CSIRO Publishing.

Menkhorst, P., Schedvin, N., & Geering, D. (1999). Regent Honeyeater Recovery Plan 1999-2003. Department of Natural Resources and Environment, Melbourne.

Menkhorst, P., Rogers, D., Clarke, R., Davies, J., Marsack, P., & Franklin, K. (2017). The Australian Bird Guide (1st ed.). Clayton South VIC 3169: CSIRO Publishing.

Munks, S. A., Corkrey, R., & Foley, W. J. (1996). *Characteristics of Arboreal Marsupial Habitat in the Semi-Arid Woodlands of Northern Queensland*. Wildlife Research, 23(2): 185-195.

Mound, L., & Terry, I. (2001). Thrips pollination of the central Australian cycad, *Macrozamia macdonnellii* (Cycadales). International Journal of Plant Sciences, 162: 147–154. doi: 10.1086/317899

Nature Advisory. (2020). Threatened bird habitat assessment – interim summary of results.

Nelder, V. J., Wilson, B. A., Dillewaard, H. A., Ryan, T. S., Butler, D. W., McDonald, W. J. F., Addicott, E. P., & Appelman, C. N. (2019). *Methodology for Surveying and Mapping Regional Ecosystems and Vegetation Communities in Queensland Version 5.0* Queensland Department of Environment and Science (DES).

Nelson, J. E. (1965). Movements of Australian flying foxes (Pteropodidae: Megachiroptera). *Australian Journal of Zoology*, 13: 53-73.

NSW Scientific Committee. (2002). White Box-Yellow Box Blakely's Red Gum Woodland. Endangered Ecological Community Final Determination. NSW Dept of Environment and Climate Change

Oliver, D. L. (1998). Ecology and Conservation of the Endangered Regent Honeyeater, Xanthomyza phrygia, in northern NSW. Ph.D. thesis University of New England, Armidale, NSW.

Oliver, D. L., Ford, H., & Recher, H. (1999). Ecology and conservation of the endangered Regent Honeyeater,'Xanthomyza phrygia', in northern New South Wales.

Oliver, D. L., Ley, A. J., & Williams, M. B. (1998). Breeding Success and nest site selection of the Regent Honeyeater, Xanthomyza phrygia near Armidale, Emu, 98: 97-103.

Oliver, D. L., Ley, A. J., & Williams, M. B. (1999). Habitat of the Regent Honeyeater Xanthomyza phrygia and the value of the Bundarra-Barraba region for the conservation of avifauna. Pacific Conservation Biology, 5: 224-239.

Oliver, D. L. (2000). Foraging behaviour and resource selection of the Regent Honeyeater *Xanthomyza phrygia* in northern New South Wales. *Emu*, 100: 12-30.

Oliver, D. L., & Lollback, G. W. (2010). Breeding habitat selection by the endangered Regent Honeyeater Anthochaera phrygia (Meliphagidae) at the local and landscape scale. *Pacific Conservation Biology*, *16*(1): 27-35.

Parry-Jones, K., & Augee, M. (1992). Movements of Grey-headed Flying-foxes *(Pteropus poliocephalus)* to and from a Colony Site on the Central Coat of New South Wales. *Wildlife Research*, 19: 331-340.

Pizzey, G. (1981). A field guide to the birds of Australia. Collins, Sydney.

Pizzey, G., & Knight, F. (2012). Graham Pizzey & Frank Knight The field guide to the birds of Australia (9th ed.). Pymble, N.S.W: HarperCollins Publishers Australia.

Primack, R. B., & Miao, S. L. (1992). Dispersal can limit local plant distribution. Conservation Biology, 6: 513–519.

Queensland Herbarium. (2007). National Multi-species Recovery Plan for the cycads, Cycas megacarpa, Cycas ophiolitica, Macrozamia cranei, Macrozamia lomandroides, Macrozamia pauli-guilielmi and Macrozamia platyrhachis

Report to Department of the Environment and Water Resources, Canberra. Queensland Parks and Wildlife Service, Brisbane.

Queensland Herbarium. (2008). Specimen label information as cited in DEWHA 2008. Prober, S.M. and Thiele, K.R. 1993. The ecology and genetics of remnant Grassy White Box Woodlands in relation to their conservation in Victorian Naturalist, 110: 30-36.

Ratcliffe, F. N. (1931). The flying fox (Pteropus) in Australia. *CSIRO Bulletin*, 52: 1-133.

Rawlings, K., Freudenberger, D., & Carr, D. (2010). A guide to managing box gum grassy woodlands: Department of the Environment, Water, Heritage and Arts.

Reis, T. (2012). Squatter Pigeon (southern subspecies) in Curtis L. K., Dennis A. J., McDonald K. R., Kyne P. M., & Debus S. J. S. (eds), Queensland's Threatened Animals. *CSIRO Publishing*.

Rhodes, J. R., Beyer, H. L., Preece, H., & McAlpine, C. (2015). South East Queensland Koala Population Modelling Study. *Technical Report, UniQuest, Brisbane, Australia*.

Schneider, D., Wink, M., Sporer, F., & Lounibos, P. (2002). Cycads: their evolution, toxins, herbivores and insect pollinators. *Naturwissenschaften, 89*: 281–294.

Shelly, D. (2005). *Hollow occurrence in selected trees of the central west catchment of New South Wales*. Department of Infrastructure, Planning and Natural Resources, Dubbo, NSW.

Smith G. C., Lewis T., & Hogan L. (2015). Fauna community trends during early restoration of alluvial open forest/woodland ecosystems on former agricultural land. *Restoration Ecology, 23*: 787-799.

Smith, G. C., Mathieson, M., and Hogan, L. (2007). Home range and habitat use of a low-density population of greater gliders, Petauroides volans (Pseudocheiridae: Marsupialia), in a hollow-limiting environment. *Wildlife Research, 34*(6): 472–483.

Smith, P., & Smith, J. (2018). Decline of the greater glider (*Petauroides volans*) in the lower Blue Mountains, New South Wales. *Australian Journal of Zoology*, *66*(2): 103–114.

Spencer, H. J., Palmer, C., & Parry-Jones, K. (1991). *Movements of fruit-bats in eastern Australia, determined by using radio-tracking.* Wildlife Research,18: 463-468.

Squatter Pigeon Workshop. (2011). Proceedings from the workshop for the Squatter Pigeon (southern). 14-15 December 2011. Toowoomba Office of the Queensland Parks and Wildlife Service.

Stol, J., & Prober, S. M. (2015). *Jewels in the landscape: Managing very high conservation value ground layers in Box-Gum Grassy Woodlands.* Canberra: CSIRO Land and Water Flagship.

Szabo, M. (2016). *Regent Honeyeater news*. Birds New Zealand 9: 11.

Taylor, B. D., & Goldingay, R. L. (2009). Can road-crossing structures improve population viability of an urban gliding mammal? Ecology and Society, 14(2): 13.

Terry, I., Moore, C. J., Forster, P. I., Walter, G. H., Machin, P. J., Donaldson, J. S. (2004). *Pollination ecology of the genus Macrozamia: cone volatiles and pollinator specificity*. In 'Proceedings of the 6th international cycad conference on cycad biology'. (Ed. A Lindstrom): 155–169. (Nong Nooch Tropical Botanical Garden: Chonburi Province, Thailand)

Terry, L., Walter, G., Hull, C. R., Moore, C., & Roemer, R. (2007). *Odour mediated push-pull pollination in cycads*. Science, 318: 70.

Terry, I. Forster, P., Moore, C., Roemer, R., & Machin, P. (2008). Demographics, *Pollination Syndrome And Conservation Status Of Macrozamia Platyrhachis (Zamiaceae), A Geographically Restricted Queensland Cycad*, Australian Journal of Botany, 56: 321–332.

Threatened Species Scientific Committee (TSSC). (2006). *Commonwealth Listing Advice on White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland*.

Threatened Species Scientific Committee (TSSC). (2015). *Commonwealth Listing Conservation Advice on Geophaps scripta scripta (Squatter Pigeon (southern))*.

Threatened Species Scientific Committee (TSSC). (2016). *Commonwealth Listing Conservation Advice on Petauroides volans (Greater glider)*.

Tidemann, C. R., & Vardon, M. (1997). *Pests, pestilence, pollen and pot-roasts: the need for community-based management of flying foxes in Australia*. *Australian Biologist*, 10(1): 77-83.

Tidemann, C. R. (1998). *Grey-headed Flying-fox, Pteropus poliocephalus, Temminck*. 1824. In: Strahan, R., ed. The Mammals of Australia. Frenchs Forest: New Holland Publishers Pty Ltd.

Vanderduys, E. P., Kutt, A. S., & Kemp, J. E. (2012). Upland savannas: the vertebrate fauna of largely unknown but significant habitat in north-eastern Queensland. Australian Zoologist, 36: 59-74.

van der Ree, R., McDonnell, J., Temby, I., Nelson, J., & Whittingham, E. (2005). *The establishment and dynamics of a recently established urban camp of flying foxes (Pteropus poliocephalus) outside their geographic range*. *Journal of Zoology*, 268: 177-185. The Zoological Society of London.

van der Ree, R., Ward, S. J., & Handasyde, K., A. (2004). Distribution and conservation status of possums and gliders in Victoria. In: *The Biology of Australian Possums and Gliders* (eds Goldingay, R. L., & Jackson, S. M.): 91–110. Surrey Beatty, Sydney.

Van Dyck, S., & Strahan, R. (eds) (2008). The Mammals of Australia. Third edition. Reed New Holland, Sydney.

Walker, J., & Hopkins, M. S. (1990). *Vegetation In Australian Soil and Land Survey Field Handbook*. McDonald, R. C., Isbell, R. F., Speight, J. G., Walker, J. & Hopkins, M. S. (2nd Edn). Inkata Press.

Webster, R., & Menkhorst, P. (1992). *The Regent Honeyeater (Xanthomyza 68hrygia): population status and ecology in Victoria and New South Wales*. Arthur Rylah Institute for Environmental Research Technical Report Series No. 126. Department of Conservation and Environment, Victoria.

Woinarski, J. C. Z., Burbidge, A. A., & Harrison, P. L. (2014). *The Action Plan for Australian Mammals 2012*. CSIRO Publishing, Collingwood.

Woinarski, J. C. Z., & Cullen, J. M. (1984). *Distribution of invertebrates on foliage in forests of south-eastern Australia*. Australian Journal of Ecology, 9: 207-232.

Yates, C. J., & Hobbs, R. J. (1997). *Temperate Eucalypt Woodlands: a review of their status, processes threatening their persistence and techniques for restoration*. Australian Journal of Botany, 45: 949-973.

Appendix A

Habitat Scoring Indicators

Koala scoring

The koala is endemic to Australia. The species' range extends from north-eastern Queensland to the south-east corner of South Australia. The distribution of the koala and its habitat are influenced by altitude (generally limited to <800 m above sea level), temperature and, at the western and northern ends of the range, leaf moisture (Munks et al. 1996). In the semi-arid regions in the western and northern parts of the species' range, koala distribution and abundance are strongly influenced by the availability of water in soils from which food trees draw water. Given that average annual rainfall is considerably higher towards the coast, the density of the koala population is generally greater there than inland.

Koalas naturally inhabit a range of temperate, sub-tropical and tropical forest, woodland and semi-arid communities dominated by eucalyptus species (Martin & Handasyde 1999). Along the Great Dividing Range and the coastal belt throughout the species' range, koalas inhabit moist forests and woodlands mostly dominated by eucalyptus species. Koalas are habitat specialists and feed almost exclusively on eucalypt leaves which have low nutritional value and are high in indigestible or toxic materials. Therefore, they are selective about which tree species and leaves they consume. In general, soils with higher fertility and moisture holding capacity produce better quality, more palatable browse, which support koalas (Rhodes et al. 2015).

The species-specific habitat indicators for koala are presented below.

Koala Habitat Scoring Indicators

Habitat Indicator		Scoring
Quality and availability of food and foraging habitat		
Number of non-juvenile Koala habitat trees per ha	% of non-juvenile Koala habitat trees based on BioCondition benchmarks for the relevant RE into 3 classes.	1: < 25% of benchmark 5: 25-75% of benchmark 10: > 75% of benchmark
Richness of non-juvenile Koala habitat trees	The richness of non-juvenile Koala habitat tree species that can occur within a particular regional ecosystem as a % of those found in regional ecosystem technical descriptions.	1: < 25% of benchmark 5: 25-75% of benchmark 10: > 75% of benchmark
Moisture and nutrient content of leaves	Riparian areas, areas with alluvial or colluvial soils, or areas on lower slopes with moisture expression	1: Low 5: Medium 10: High
Number of juvenile koala habitat trees per ha	% of juvenile koala habitat trees based on the BioCondition benchmarks for the relevant REs (S1 & S2 layers) into 3 classes.	1: < 25% of benchmark 5: 25-75% of benchmark 10: > 75% of benchmark
Quality and availability of shelter		
Non-juvenile Koala habitat tree benchmark	% of non-juvenile Koala habitat trees based on BioCondition benchmarks for the relevant RE into 3 classes.	1: < 25% of benchmark 5: 25-75% of benchmark 10: > 75% of benchmark
Non-juvenile tree species with dense foliage per ha	Tree species with closed or dense canopies may provide shelter during extremes of weather (heat, heavy rain periods) based on BioCondition benchmarks for the relevant RE into 3 classes.	1: < 25% of benchmark 5: 25-75% of benchmark 10: > 75% of benchmark

Habitat Indicator		Scoring
Species mobility capacity		
Coarse woody debris	High abundance of coarse woody debris limiting site scale species mobility based on BioCondition benchmarks for the relevant RE into 4 classes.	1: >200% of benchmark 4: 150-200% of benchmark 7: 100-150% of benchmark 10: 100% of benchmark
Number of refuge trees	Presence / abundance of trees to provide refuge from predators (dogs) within the site based on BioCondition benchmarks for the relevant RE into 4 classes.	1: no large trees present 4: 1-25% of benchmark large trees 7: 25-50% of benchmark large trees 10: 51-100% of benchmark large trees
Non-native plant cover	Presence of high threat weeds that have potential to affect species mobility at the site scale include dense swards of large exotic pasture grasses, thicket forming woody weeds or presence of dominant weedy vines.	1: >50% cover of high threat exotic species 4: 25-50% cover of high threat exotic species 7: 5-25% cover of high threat exotic species 10: < 5% cover high threat exotic species
Role of site location to species overall population in the State		
		1: not or unlikely to be critical to species' survival 4: likely to be critical to species' survival 5: critical to species' survival
Threats to species		
		1: high threat level (i.e. likely to result in death, irreversible damage) 7: moderate threat level 15: low threat level (i.e. likely to survive)

Grey-headed Flying-fox scoring

The grey-headed flying-fox is Australia's only endemic flying-fox and occurs in the coastal belt from Rockhampton in central Queensland to Melbourne in Victoria (Tidemann 1998). However, only a small proportion of this range is used at any one time, as the species selectively forages where food is available. As a result, patterns of occurrence and relative abundance within its distribution vary widely between seasons and between years (DoEE 2019).

Grey-headed flying-fox form two different roosting camps, summer camps and winter camps (Nelson 1965). Summer camps are used from September to April or June. In these camps, they establish territories, mate and reproduce (Nelson 1965). Winter camps are used from April to September. The sexes are separated in winter camps and most behaviour is characterised by mutual grooming (Nelson 1965). Summer camps are considered "main camps", while winter camps are referred to as "transit camps".

The grey-headed flying-fox requires foraging resources and roosting sites. It is a canopy-feeding frugivore and nectarivore, which utilises vegetation communities including rainforests, open forests, closed and open woodlands, Melaleuca swamps and Banksia woodlands. The primary food source is blossom from eucalyptus and related genera but in some areas, it also utilises a wide range of rainforest fruits (Eby 1998). None of the vegetation communities used by the grey-headed flying-fox produce continuous foraging resources throughout the year. As a result, the species has adopted complex migration traits in response to ephemeral and patchy food resources (Duncan et al. 1999; Eby 1996; Eby 1998; Nelson 1965; Parry-Jones & Augee 1992; Spencer et al. 1991 as referenced in DoEE 2019).

The Grey-headed Flying-fox roosts in aggregations of various sizes on exposed branches. Roost sites are typically located near water, such as lakes, rivers or the coast (van der Ree et al. 2005). Roost vegetation includes rainforest patches, stands of melaleuca, mangroves and riparian vegetation (Nelson 1965; Ratcliffe 1931), but colonies also use highly modified vegetation in urban and suburban areas (Birt et al. 1998; Tidemann & Vardon 1997; van der Ree et al. 2005). The species can maintain fidelity to roost sites for extended periods (Lunney & Moon 1997), although new sites have been colonised (DoEE 2019).

Based on the National Flying-fox Monitoring Program (NFMP) the total population of grey-headed flying-fox was estimated to be 700,000 in 2018.

The species-specific habitat indicators for GHFF are presented below.

Grey-headed Flying-fox Habitat Quality Attributes Scoring

Habitat Indicator		Scoring
Quality and availability of food and foraging habitat		
Availability of Food Trees Presence of food species within the site, as defined in Eby and Law (2008) Benchmarked against the technical description for the relevant RE (species and cover %).	Density per hectare Blossom diet species: forage species from *Eucalyptus*, *Corymbia* or *Angophora* genus. Fruit diet species.	1: < 25% of potential density 5: 25-75% of potential density 10: > 75% of potential density
Availability of High Yield of Food Trees Habitat wt p*r score indicates the yield of food tree species based on a measure of productivity and reliability (Eby & Law 2008). Benchmarked against the technical description for the relevant RE (species and cover %).	Density per hectare Density of species with a high (>0.65) wt p*r score	1: < 25% of potential density 5: 25-75% of potential density 10: > 75% of potential density

Habitat Indicator		Scoring
Richness of Feed Species Blossom or fruit diet tree species reflecting potential richness for the relevant RE based on the technical description for that RE.	Blossom diet species: forage species from *Eucalyptus*, *Corymbia* or *Angophora* genus. Fruit diet species.	1: < 25% of potential density 5: 25-75% of potential density 10: > 75% of potential density
Quality and availability of shelter		
NA	Not scored	This attribute was not scored because there are no known camps within the project area (the nearest recorded camp is approximately 35km to the northeast) and because the capacity of a site to provide resources during important breeding and food shortage periods is dealt with by meeting richness benchmarks outlined above in quality and availability of food and habitat required for foraging.
Species mobility capacity		
Proximity to nationally important camps Reducing the distance the species has to travel to forage	Distance in km Distance from nationally important flying-fox camps to mid-point of assessment unit.	1: > 50km 4: 30-50km 7: 20-30km 10: < 20km
Presence of large-scale objects preventing dispersal Physical structures that prevent dispersal or access to the assessment unit or site	Presence or absence of structures Scored on the basis of presence or absence of structures that prevent access	1: structures present 10: structures not present
Role of site location to species overall population in the State		
		1: not or unlikely to be critical to species' survival 4: likely to be critical to species' survival 5: critical to species' survival
Threats to species		
		1: high threat level (i.e. likely to result in death, irreversible damage) 7: moderate threat level 15: low threat level (i.e. likely to survive)

Regent Honeyeater Scoring

The regent honeyeater is listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Nature Conservation Act 1992*, having undergone more than 80% population decline within three generations (Garnett et al. 2011).

The regent honeyeater is identified by its black head, neck and upper breast, with its yellow back and lower breast scaled black, and underparts grading into a white rump. The wings have conspicuous yellow patches, and a black tail, edged yellow. The male of the species has yellowish warty bare skin around the eye and the female is generally smaller, with a bare yellowish patch under the eye and less black on the throat (Pizzey 1981; Menkhorst 1993).

The regent honeyeater is endemic to south-eastern Australia. It has a patchy distribution which extends from 100 km north of Brisbane, through NSW and the ACT, to central Victoria. Records are widely distributed across its range, but it is only found regularly at a few localities in NSW and Victoria where most recent sightings are now recorded (Menkhorst et al. 2017).

The species is considered partially migratory or dispersive post the breeding season with evidence of movement into southern Queensland and northern NSW in early autumn (Franklin et al. 1989). It is thought these birds are moving out of cooler climates in search of nectar supplies (Franklin et al. 1989, Pizzey & Knight 2012).

Regent honeyeater populations have undergone significant declines in recent decades with a decline of 80% over a period of approximately 24 years prior to 2011. As of 2011, the entire population of mature individuals was estimated to be a maximum of 400 birds. Subsequent surveys suggest the species population is continuing to decline (Garnett et al. 2011). The decline of the regent honeyeater population appears to be primarily due to habitat loss, fragmentation and general degradation (Garnett et al. 2011). The species relies on several different foraging resources and is particularly susceptible to the removal of large mature trees which offer reliable sources of nectar required for successful reproduction (Franklin et al. 1989; Oliver 2000).

Regent honeyeaters occur mainly in dry box-ironbark eucalypt woodland and sclerophyll forest, but also inhabit riparian vegetation and lowland coastal forest areas (DoE 2016) inland of the Great Dividing Range, particularly favouring those on the wettest, most fertile soils, such as along creek flats and broad river valleys. Other forest types regularly utilised by regent honeyeaters include wet lowland coastal forest dominated by swamp mahogany (*Eucalyptus robusta*), spotted gum-ironbark associations and riverine woodlands (Menkhorst 1997; Geering & French 1998; Oliver et al., 1998; Oliver et al., 1999). Habitat adjacent to box-ironbark woodland (Geering & French 1989; Oliver et al. 1998; Oliver et al., 1999) and within 150m of a water source are also preferred (Crates 2019). Remnant stands of timber, roadside reserves, travelling stock routes and street trees also provide important habitat at certain times (Franklin et al. 1987; Franklin et al. 1989; Ley & Williams 1992; Webster & Menkhorst 1992; Oliver 1998).

The regent honeyeater requires high volumes of nectar, particularly during the breeding season. It is primarily nectivorous but will feed on other resources such as fruit, lerps (psyllids) and arthropods (Franklin & Robinson 1989). Notably important tree species across its geographical range consists of *Eucalyptus sideroxylon*, *E. melliodora*, *E. albens*, and *E. robusta*, with a lesser reliance on *E. eugenioides* and *E. fibrosa*. The species is also known to exploit the fruit and nectar from multiple species of mistletoe – particularly those within the genus of *Amyema*, and search stands of *Allocasuarina* for arthropods (Franklin & Robinson 1989).

Studies undertaken across 92 sites found the percentage of canopy cover, the density of mistletoe, the density of riparian tree species and a lower density of shrubs over 2m were also positively correlated with the presence of regent honeyeater (Oliver et al. 1999).

The regent honeyeater is a generalist forager, although it feeds mainly on the nectar from a relatively small number of eucalypts, preferably taller and larger diameter trees as these typically produce more nectar (Franklin & Robinson 1989; Webster & Menkhorst 1992; Menkhorst et al. 1999; Oliver 2000). Key eucalypt species include mugga ironbark, yellow box, white box and swamp mahogany. Other tree species may be regionally important.

Key tree and mistletoe species associations for the regent honeyeater include:

- Mugga (or red) ironbark, *Eucalyptus sideroxylon;*
- Thin-leaved stringybark, *Eucalyptus eugenioides;*
- Yellow box, *E. melliodora;*
- Blakely's red gum, *E. blakeyi;*
- Grey box, *E. microcarpa;*
- Broad-leaved ironbark, *E. fibrosa;*
- White box, *E. albens;*
- Yellow gum, *E. leucoxylon;*
- Spotted gum, *Corymbia maculate;*
- Swamp mahogany, *E. robusta;*
- Needle-leaf mistletoe, *Amyema cambagei* on river sheoak, *Casuarina cunninghamiana;*
- *Amyema miquelii*;
- *A. pendula;*
- Box mistletoe, *A. miquelii;*
- Long-flower mistletoe, *Dendropthoe vitellina*.

When nectar is scarce lerp and honeydew can comprise a large proportion of the diet. Insects make up about 15% of the total diet and are important components of the diet of nestlings (Geering & French 1998). Particularly when breeding, this includes gum exudate from stems of Eucalyptus and Banksia species, bees, ants and spiders, insects including Hemiptera, Psyllidae, Coleoptera, Carabidae, Scarabaeidae, Elateridae, Bostrychidae, Coccinellidae Chrysomelidae, Apionidae, Diptera, Lepidoptera, Hymenoptera, Tenthredinidae, Chalcididae, Formicidae, Arachnida and Araneae (Barker & Vestjens 1984; BirdLife International 2018).

In Queensland, the regent honeyeater has been primarily recorded from the south-east corner, south of a line between Chinchilla and the Sunshine Coast. There are records from several State Forests, including breeding activity in suitable habitat, particularly in the Warwick-Stanthorpe districts (Hines 2008).

The species breeds between July and January in box-ironbark and other temperate woodlands and riparian gallery forest dominated by river sheoak. Regent honeyeaters usually nest in horizontal branches or forks in tall (>8m) mature eucalypts and sheoaks but also nest in mistletoe haustoria. Within its current distribution there are four known key breeding areas where the species is regularly recorded. These are the Bundarra-Barraba, Capertee Valley and Hunter Valley districts in New South Wales, and the Chiltern area in north-east Victoria. Breeding has also been regularly recorded in the Cement Mills-Durakai area west of Warwick, Queensland and in the Australian Capital Territory (DoE 2016).

Breeding territories contain a nest-tree and surrounding feeding areas can extend 5-40m or more from the nest-tree (Higgins et al. 2001). Nests are usually established in the canopy of mature trees with rough bark including ironbark, sheoaks (*Casuarina*) and rough-barked apple (*Angophora*). Nests can be up to 700m from a resource tree (Geering & French 1998) and distances between nests can range from 40-110m depending on location and habitat (Higgins et al. 2001). Nests position in upright forks between 4-25m above ground at extremity of branches (Oliver et al. 1998).

The major cause for the decline in the regent honeyeater population has been the clearing and fragmentation of woodland and forest containing the bird's preferred eucalypt species. Whilst clearing directly reduces the amount of available habitat, it can also make remaining remnants unsuitable as they become too small, isolated, or degraded and increase competition with large, aggressive nectivorous species including noisy miners *Manorina melanocephala,* noisy friarbird *Philemon corniculatus,* and red wattlebird *Anthochaera carunculata*. Nest predation by multiple arboreal marsupial and bird species is a significant threat to the species' ability to recruit (DoE 2016). The primary threats to the regent honeyeater are highly interactive and relate to the species' small population size, habitat loss and fragmentation, competition, and degradation of remnant habitat.

The species habitat assessment indicators (see table below) for the regent honeyeater have been determined through the use of information contained within the Species National Recovery Plan (DoE 2016) and scientific investigations into the species habitat and behaviours (as referenced throughout).

Regent Honeyeater Habitat Quality Attributes Scoring

Habitat Indicator		Scoring
Quality and availability of food and foraging habitat		
Availability of Food Trees	Density High Quality Habitat consists of old growth >50-70% (Nature Advisory 2020) with abundance of key food trees: • Mugga (or red) ironbark (*E. sideroxylon),* • Thin-leaved stringybark (*E. eugenioides*), • Yellow box (*E. melliodora*), • Blakely's red gum *E. blakeyi,* • Grey box (*E. microcarpa*), • Broad-leaved ironbark (*E. fibrosa*), • White box (*E. albens*), • Yellow gum (*E. leucoxylon*), • Swamp mahogany (*E. robusta*), • Spotted gum (*Corymbia maculata*), • River sheoak (*Casuarina cunninghamiana*),	1: < 10% old growth 5: 10-50% old growth 10: > 50% old growth
Quality and availability of shelter		
Availability of nesting trees	Density per hectare Nests are established in the canopy of mature rough-barked trees: • Ironbark (*Eucalyptus sideroxylon*) • Broad-leaved ironbark (*E. fibrosa*) • Swamp mahogany (*E. robusta*) • River sheoak (*Casuarina cunninhamiana*) • Rough-barked apple (*Angophora*) And where mistletoe species may be present: • Needle-leaf mistletoe, *Amyema cambagei* • *Amyema miquelii,* • *Amyema pendula* • Box mistletoe, *Amyema miquelii* • Long-flower mistletoe, *Dendropthoe vitellina*	1: 0 mature rough-barked trees 5: 10-50 mature rough-barked trees 10: > 50 mature rough-barked trees
Species mobility capacity		

Habitat Indicator		Scoring
Availability of linear habitat patches	Perimeter-Area ratio Oliver and Lollback (2010) found higher presence of RHE closer to the edge of linear high quality, well connected remnants, with low proportion of woodland habitat within a 1-2km radius. Ratio follows that of McGarigal (2017) landscape metric 'Shape Index' whereby linearity of a patch is quantified by perimeter-area ratio compared to a standardised shape to account for size dependency: $$Shape\ Index = \frac{p}{\sqrt{a^2}}$$ When *Shape Index* = 1, patch is circular and increasing values represent increasing linearity	1: = 1 Shape Index 5: 1-2.67 Shape Index 10: >2.67 Shape Index Value – based on the min. perimeter and area in Oliver and Lollback (2010) where species presences were highest
Role of site location to species overall population in the State		
		1: not or unlikely to be critical to species' survival 4: likely to be critical to species' survival 5: critical to species' survival
Threats to species		
		1: high threat level (i.e. likely to result in death, irreversible damage) 7: moderate threat level 15: low threat level (i.e. likely to survive)

Central Greater Glider Scoring

The greater glider is listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Nature Conservation Act 1992*.

The greater glider is an arboreal nocturnal marsupial, largely restricted to old-growth, contiguous open eucalypt forests and woodlands along the Great Dividing Range with patchy distribution from north-eastern Queensland to south-eastern and central Victoria, across an elevational range from sea level to 1200m above sea level (Kavanagh 2000; Smith & Smith 2018). The species is primarily folivorous, with a diet mostly comprising eucalypt leaves, and occasionally flowers (van der Ree et al. 2004). It is typically found in highest abundance in taller, mature, moist eucalypt forests and woodlands with relatively large trees, excluding non-remnant (regrowth) and rainforest habitats (Kavanagh 2000; Eyre et al. 2018; van der Ree et al. 2004; Vanderduys et al. 2012; Van Dyck & Strahan 2008).

The greater glider favours forests with a diversity of eucalypt species, due to seasonal variation in its preferred tree species, and large hollow-bearing trees are a key habitat feature required within its home range of 1-4 ha to maintain high density populations (Kavanagh 1984, 2000; Eyre 2006; Lindenmayer et al. 2004; McLean et al. 2015). In Queensland, greater gliders preference of habitat is dry, mixed eucalypt forest and woodlands dominated by a variety of hollow-bearing ironbark and smooth bark tree species (Cohen 2019). They feed on the young leaves of eucalypts, and shelter in large hollow branches (TSSC 2016).

Notwithstanding relatively small home ranges, but in part because of low dispersal ability, greater gilders may be sensitive to fragmentation (Eyre 2006; McCarthy & Lindenmayer 2006; Lindenmayer et al. 2000; Taylor & Goldingay 2009), have relatively low persistence in small forest fragments, and disperse poorly across vegetation that is not native forest. Modelling suggests that they require native forest patches of at least 160 km^2 to maintain viable greater glider populations (Eyre 2002). Kavanagh and Webb (1989) found no significant movement of greater gliders into unlogged reserves from surrounding logged areas.

The species habitat assessment indicators (see table below) for the greater glider have been determined using information contained within the Approved Conservation Advice for Greater Glider (*Petauroides volans*) via The Action Plan for Australian Mammals 2012 (TSSC 2016; Woinarski et al. 2014), and scientific investigations into the species habitat and behaviours (as referenced throughout).

Central Greater Glider Habitat Quality Attributes Scoring

Habitat Indicator		Scoring
Quality and availability of food and foraging habitat		
<u>Availability of Food Trees</u> Presence of food species within the site, as defined by Eyre (2002), benchmarked against the technical description for the relevant RE (species and cover %).	<u>Density per hectare</u> Species has a specified folivorous diet and prefers foraging from larger *Myrtaceous* tree species. Habitat tree species identified based on local distribution/ locality literature (Smith et al. 2007); • *A. floribunda* • *A. leiocarpa* • *C. citriodora* • *C. citriodora subsp. variegata* • *C. clarksoniana* • *C. intermedia* • *C. tessellaris* • *E. albens* • *E. albens x E. melanophloia* • *E. albens x E. melliodora* • *E. andrewsii* • *E. camaldulensis* • *E. camaldulensis subsp. camaldulensis*	1: <10% of potential tree canopy cover 5: 10-50% of potential tree canopy cover 10: >50% of potential tree canopy cover

Habitat Indicator		Scoring
	• *E. crebra* • *E. fibrosa* • *E. fibrosa subsp. fibrosa* • *E. fibrosa subsp. nubilis* • *E. melanophloia* • *E. melanophloia subsp. melanophloia* • *E. melliodora* • *E. moluccana* • *E. punctata* • *E. sideroxylon subsp. sideroxlon* • *E. tereticornis* • *E. tereticornis subsp. basaltica* • *E. tereticornis subsp. tereticornis*	
Richness of greater glider habitat trees	The richness of greater glider habitat tree species that can occur within a particular regional ecosystem as a % of those found in regional ecosystem technical descriptions.	1: < 25% of benchmark 5: 25-75% of benchmark 10: >75% of benchmark
Site Fertility/ Productivity Increased site productivity leads to an increase in resource availability and vigour of eucalypts, providing greater and extended foraging opportunities for the species (Eyre 2006).	Vegetation community indicative of high site fertility / moisture	1: Low 5: Medium 10: High
Quality and availability of shelter		
Number of large eucalypt trees Include reference to describe frequency of hollows in mature trees**	Number of mature trees within suitable regional ecosystems (i.e., RE 13.11.6, 13.11.5, 13.11.8) as a % of benchmark	1: <25% of benchmark large trees 5: 25-75% of benchmark large trees 10: >75% of benchmark large trees
Availability of food trees Greater gliders shelter within close proximity to preferred food trees	Density per hectare Species has a specified folivorous diet and prefers foraging from larger *Myrtaceous* tree species. Habitat tree species identified based on local distribution/ locality literature (Smith et al. 2007 etc.); • *A. floribunda* • *A. leiocarpa* • *C. citriodora* • *C. citriodora subsp. variegata* • *C. clarksoniana* • *C. intermedia* • *C. tessellaris* • *E. albens* • *E. albens x E. melanophloia* • *E. albens x E. melliodora* • *E. andrewsii* • *E. camaldulensis* • *E. camaldulensis subsp. camaldulensis* • *E. crebra*	1: <10% of potential tree canopy cover 5: 10-50% of potential tree canopy cover 10: >50% of potential tree canopy cover

Habitat Indicator		Scoring
	• *E. fibrosa* • *E. fibrosa subsp. fibrosa* • *E. fibrosa subsp. nubilis* • *E. melanophloia* • *E. melanophloia subsp. melanophloia* • *E. melliodora* • *E. moluccana* • *E. punctata* • *E. sideroxylon subsp. sideroxlon* • *E. tereticornis* • *E. tereticornis subsp. basaltica* • *E. tereticornis subsp. tereticornis*	
Species mobility capacity		
Number of mature trees	Large mature trees (30-70cm DBH) are preferred and required for arboreal species for mobility, movement, and gliding (Smith et al. 2007)	1: <25% of benchmark large trees 4: 25-50% of benchmark large trees 7: 51-75% of benchmark large trees 10: >75% of benchmark large trees
Role of site location to species overall population in the State		
		1: Not or unlikely to be critical to species' survival 4: Likely to be critical to species' survival 5: Critical to species' survival
Threats to species		
		1: High threat level (results in loss of large hollow-bearing trees, irreversible damage) 7: Moderate threat level (Evidence of infrequent, low intensity fire) 15: Low threat level (No evidence of fire)

Squatter Pigeon (southern)

The squatter pigeon (southern) (*Geophaps scripta scripta*) is listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act). The subspecies occurs throughout remnant and regrowth open-forest to sparse open-woodlands and scrub dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* species with patchy, tussock-grassy understorey (Higgins & Davies 1996; TSSC 2015). Its current distribution extends from central Queensland, west to Longreach and Charleville, east to the coast between Port Curtis and Proserpine, and south to New South Wales north of 29° S (Cooper et al. 2014). The squatter pigeon (southern) was once common and widespread nationally, however, at present is pervasive in the north-east and north of the QLD state border with rare occurrences in NSW (Higgins & Davies 1996). Populations known to occur in the Warwick-Inglewood-Texas region (including the local population) are important populations for the species under the EPBC Act, given they occur near the southern extent of the species range in an area within which the species has experienced substantial declines (Squatter Pigeon Workshop 2011).

Squatter pigeons are not dependent on remnant vegetation communities and often favour thinned habitats where grazing cattle create favourable open patches of ground for foraging, and some introduced pastures (*Urochloa mosambicensis* and *Stylosanthes spp.*) also provide a valuable food source for the species (Crome 1976). Although less common where Buffel Grass (*Cenchrus ciliaris*) dominates the grass cover (Reis 2012). Disturbed areas where the sub-species has been recorded foraging include cattle yards, road and railway easements, and sown pastures with scattered trees (Squatter Pigeon Workshop 2011). Soil type is often a useful indication of their foraging and breeding habitat of which is generally restricted to well-draining, gravelly, sandy, or loamy soils (land zones 5 and 7, and Land Zone 3 when imbedded in Land Zone 5 and/or 7) (Squatter Pigeon Workshop 2011). These typically support a patchy ground layer composed of native perennial tussock grasses or a mix of native perennial tussock grasses and low shrubs or forbs (DoEE 2019b; Squatter Pigeon Workshop 2011). The ground-dwelling subspecies forages on a wide range of seeds from grasses, legumes, herbs, and shrubs, as well as insects with diet varying seasonally depending on food availability (Higgins & Davies 1996). Breeding habitats are typically on stony rises within 1 km of a suitable, permanent waterbody (dams and/or standing water), and nests are usually shallow depressions in the ground, sometimes among, or sheltered by vegetation, including short, dry grass, grass tussocks or bushes (Frith 1982; Squatter Pigeon Workshop 2011).

The subspecies is unlikely to move far from woodland trees which provide protection from predatory birds (Squatter Pigeon Workshop 2011). Where scattered trees still occur, and the distance of cleared land between remnant trees or patches of habitat does not exceed 100 m, individuals may be found foraging in, or moving across modified or degraded environments (Squatter Pigeon Workshop 2011).

The habitat assessment indicators (see table below) for the squatter pigeon (southern) have been determined through the use of information contained within the Conservation Advice (TSSC 2015) and scientific literature of the species behavioural ecology (as referenced throughout).

Squatter Pigeon (southern) Habitat Quality Attributes Scoring

Habitat Indicator		Scoring
Quality and availability of food and foraging habitat		
Availability of suitable habitat	Density Preferred habitat: regrowth and remnant dry open forests, woodlands and scrub dominated by *Eucalyptus*, *Corymbia*, *Acacia* or *Callitris* species	1: <10% or >75% tree canopy cover 5: 10-30% or >50-75% tree canopy cover 10: 30-50% tree canopy cover
Availability of suitable foraging habitat	Projected ground-level cover A patchy, ground-level vegetation cover including native tussock grasses not exceeding 33% total ground area is important for suitable	1: >50% ground cover 5: 33-50% ground cover 10: No more than 33% ground cover

Habitat Indicator		Scoring
	foraging habitat (Squatter Pigeon Workshop 2011)	
Non-native plant cover	Non-native plant cover Invasive plant species outcompete the species' preferred native food plants (TSSC 2015)	1: >5% non-native plant cover 5: 1-5% non-native plant cover 10: <1% non-native plant cover
Quality and availability of shelter		
Tree canopy height	Nocturnal roost tree height Squatter pigeon roost overnight in low trees (TSSC 2015).	1: Ecologically Dominant Layer (EDL) < 50% of benchmark 5: EDL 50-80% of benchmark 10: EDL > 80% of benchmark
Availability of suitable foraging habitat	Projected ground-level cover A patchy, ground-level vegetation cover including native tussock grasses not exceeding 33% total ground area is important for suitable breeding habitat (Squatter Pigeon Workshop 2011)	1: >50% ground cover 5: 33-50% ground cover 10: No more than 33% ground cover
Species mobility capacity		
Availability of suitable movement for foraging and nesting	Extent of understorey vegetation thickening Thick and high density of understorey and ground-level vegetation cover represents unpreferred habitat	1: Severely restricted (>75% shrub, T2, T3 and low T1 cover) 4: Highly restricted (>50-75% shrub, T2, T3 and low T1 cover) 7: Moderately restricted (25-50% shrub, T2, T3 and low T1 cover) 10: Minor restriction (<25% shrub, T2, T3 and low T1 cover)
Role of site location to species overall population in the State		
		1: Not or unlikely to be critical to species' survival 4: Likely to be critical to species' survival 5: Critical to species' survival
Threats to species		
		1: High threat level (results in loss of large hollow-bearing trees, irreversible damage) 7: Moderate threat level (Evidence of infrequent, low intensity fire) 15: Low threat level (No evidence of fire)

Appendix B

Macrozamia conferta Translocation and Propagation Plan

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Macrozamia conferta Translocation and Propagation Plan

Prepared for:
ACCIONA Energy Australia Global Pty Ltd

2 September 2021

Document Information

DOCUMENT	Macrozamia conferta Translocation and Propagation Plan
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REVIEWED BY	Jeromy Claridge

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1.0 Introduction

ACCIONA Energy Australia Global Pty Ltd (ACCIONA) proposes to develop and operate the MacIntyre Wind Farm (the Project). Development of the Project will involve potential significant residual impacts to *Macrozamia conferta*, which is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act). Impacts are proposed to be mitigated and offset through the translocation and propagation of *M. conferta* as outlined in this Plan.

1.1 Purpose and Scope

This Plan sets out proposed approach to offset potential impacts on *M. conferta* and has been prepared to support assessment and approval of the Project under the EPBC Act (ref. EPBC 2020/8756). The Preliminary Documentation outlines the significant impact assessment for the species and provides information on the scale of the potential impacts on the species relative to the overall population. This Plan sets out relevant information on *M. conferta* ecology, conservation advice (including listed threats), proposed offsets, approach to translocation and propagation, management and monitoring, assessment of risks and corrective actions, and overall objectives and performance principles.

The structure of the Plan has been developed to address information set out in the *Land-based Offsets Management Plan EPBC* template provided by the Department of Agriculture, Water and the Environment (DAWE), with additional information supporting and justifying the proposed approach to translocation and mitigation. This Plan presents information on the availability of potential offset sites currently being investigated and will be updated with site-specific information on proposed offsets following the completion of commercial discissions with existing landholders. In addition, this Plan addresses requirements set out in the *National Multi-Species Recovery Plan for Cycads* (Queensland Herbarium 2007) and *Guidelines for the Translocation of Threatened Plants in Australia* (Commander et al. 2018).

1.2 Project Description

The Project is anticipated to consist of up to 169 wind turbines that will generate approximately 963 MW of renewable energy to contribute to the national electrical grid, together with associated ancillary infrastructure including:

- Wind turbine foundations and hard stand areas;
- Main site access from Carbean Road;
- Access tracks;
- Overhead 33 kV electrical reticulation;
- Underground 33 kV electrical reticulation;
- Up to two (2) substations;
- A potential battery energy storage facility;
- Up to six (6) permanent meteorological masts;
- Up to two (2) construction compounds;
- Up to three (3) laydown areas;

- A workers' accommodation facility;
- Up to two (2) operation and maintenance facilities.

The Project is located approximately 40 km south-west of the township of Warwick and 70 km south-west of Toowoomba and is located within the Southern Downs Regional Council and Goondiwindi Regional Council Local Government Areas. The Project area is a total of 31,846 ha of which 2,789 ha is the Project infrastructure footprint (i.e. the maximum disturbance area). The Project area and infrastructure components are shown in **Figure 4.1**.

The regional wind resource has informed the selection of the Project area. The local wind resource has been measured and confirmed that the Project area is suitable for the establishment of a wind farm. Considerations to the wind resource, environment, physical environment, constructability, grid proximity, procurement and the detailed design of the Project, will inform the Project's final layout.

The Project is anticipated to be constructed over a period of three years depending on weather conditions, speed of construction and availability of materials. Works are anticipated to occur for six days a week, for 12 hours a day, with exceptions which may occur to these timings due to requirements of the Project schedule. The Project has an operational design life of 30 years, with potential impacts to *M. conferta* assumed to be permanent.

1.3 Impact and Offset Summary

Field surveys by GHD (2021) identified 2,578 *M. conferta* occur within the Project construction footprint. Prior to the commencement of construction pre-clearance surveys will be undertaken to further avoid *M. conferta* within the construction footprint.

The *Offsets Assessment Guide For use in determining offsets under the Environment Protection and Biodiversity Conservation Act 1999* (2 October 2012) outlines the offset calculator. **Table 1.1** shows the results of the offset calculator using the *Threatened Species* field and impacts to *Number of individuals*. Assumptions and justifications of inputs are described in relevant sections of the Plan.

Table 1.1 *Macrozamia conferta* offset calculator – Offsets Assessment Guide 2021

Protected Matter Attributes	Total Quantum of Impact	Proposed Offset	Time Horizon (years)	Start Value	Future Value without Offset	Future Value with Offset	Confidence in Result (%)	Adjusted Gain	Net Present Value	% of Impact Offset
Number of *M. conferta* individual plants	2,578	2,578 plants translocated	20	0	0	3,094	90%	2,785	2,676	103.78%

1.4 Relevant Conservation Advice

This Plan has been prepared to address a number of relevant recovery plans and documents as set in **Table 1.2**.

Table 1.2 Conservation Advices, Recovery Plans, and Threat Abatement Plans

Document Name	Where and how the strategy addresses the condition
National Recovery Plan for Cycads	The National Recovery Plan for Cycads outlines recovery objectives to: a) prevent further loss of individuals, populations, pollinator species and habitat critical to the species' survival b) recover existing populations to normal reproductive capacity to ensure viability in the long-term, prevent extinction, maintain genetic viability, and improve conservation status. This Plan addresses the first objective: site preparation and maintenance pre and post translocation will eliminate any threats and provide ongoing protection to the translocated and recipient *M. conferta* populations. This Plan addresses the second objective: translocation of *M. conferta* into recipient populations increases genetic diversity for both *M. conferta* and pollinator species.
Approved Conservation Advice for *Macrozamia conferta*	Key threats and threat abatements are identified in the Conservation Advice and incorporated into recipient site preparation and maintenance actions in this Plan.
Guidelines for the Translocation of Threatened Plants in Australia (Third Edition)	The Guidelines documents best-practice methods of translocation for threatened plants which has been incorporated into site preparation and maintenance actions in this Plan.
Listed threatened ecological communities, species and migratory species (GHD 2021).	Appendix C to the MacIntyre Wind Farm EPBC 2020/8756 Additional Information Response Report. Field surveys documented in this report provided the number of individual *M. conferta* in the Project footprint.
Guidance for deriving 'Risk of Loss' estimates when evaluating biodiversity offset proposals under the EPBC Act	Evaluation of risk of loss to *M. conferta* if translocation did not occur.

2.0 *Macrozamia conferta* Ecology

2.1 Ecology

M. conferta is a small cycad (**Plate 2-1**) that occurs in undulating to hilly terrain at altitudes between 600-750 m above sea level. The species is mostly found in open eucalypt forest communities that occur in flat areas or low ridges in ash-grey to white, silty loam or on skeletal, grey-white soils on steep slopes (Jones and Forster 1994; Halford 1997; DEWHA 2008). The species is closely associated with remnant Regional Ecosystem (RE) 13.11.6 described as open forest dominated by Lemon-scented gum (*Corymbia citriodora subsp. variegata*), Broad-leaved red ironbark (*Eucalyptus fibrosa*), Yellow Box (*E. melliodora*), Narrow-leaved ironbark (*E. crebra*) and Grey Box (*E. moluccana*) with an understorey comprised of *Acacia lineata*, *A. fimbriata*, *Jacksonia scoparia* and *Melichrus urceolatus* on metamorphics, but also corresponds to REs 13.11.3, 13.11.5 and 13.11.8. Known populations are largely found within a 25 km^2 area that includes Durikai, Bringalily and Devine State Forests, west of Warwick, Queensland (Queensland Herbarium 2008).

M. conferta has an obligate pollination mutualism with a species of *Tranes* weevil (Forster et al. 1994) to achieve cross-pollination of male and female cones that develop on separate plants (Terry 2001). Mature cones have been recorded in October and November whilst ripe seeds have been observed in February and March. However, seed germination does not occur for another 12 months due to the delayed fertilisation process of Macrozamia (Norstog and Nicholls 1997).

Population-level mast-seeding events can vary with access to water, nutrients and sunlight (Halliday and Pate 1976; Ornduff 1990; 1991). Male cones are cylindrical and 7-18 cm long with 2.5-4 cm in diameter whilst female cones are ovoid and 6-12 cm long with 3.5-6 cm in diameter (DES 2019). Seeds are ovoid and are 2-2.5 cm long with 1.6-2cm in diameter and become red when ripe (DES 2019) (**Plate 2-1**). Cone and seed development may be hindered if the plant is exposed to unfavourable conditions (Halford 1997).

The species is restricted to areas of unique geology and topology in Queensland and are not likely to colonize outside of these areas due to poor dispersal of large and heavy seeds from the existing populations (Terry et al. 2008). Laidlaw and Forster (2012) found the species is already restricted to refugial areas and that the species' limited dispersal (short distance <100 m or no dispersal), slow generational turnover (20-25 years, 60-80 years for three generations) and obligate pollination mutualisms are the biggest threats impeding expansion into nearby suitable areas. Hall and Walter (2013) studying *Cycas ophiolitica* found of 840 seeds only 24 were dispersed >1 m and recruitment was an average of 2.2 seedling and 0.7 juveniles, suggesting seedlings within this dispersal range perish. Multiple faunal classes have been observed to disperse *Macrozamia* spp. seeds (White 1912; Loaring 1952; Eckenwalder 1980; Jones 2002; Banack and Cox 2003; Chemnick 2007; J. A. Hall pers. obsv.) but is likely to reflect infrequent chance events rather than the typical pattern.

Plate 2-1 Typical *Macrozamia conferta* present in the Project area (Attexo 2021)

2.2 Threats to the Species

Key threats to *M. conferta* were derived from the Approved Conservation Advice for *Macrozamia conferta* (DEWHA 2008) and the *National Multi-species Recovery Plan for the cycads* (Queensland Herbarium 2007) and are provided in **Table 2.1**.

Table 2.1 Key threats to *Macrozamia conferta*

Threat	Description
Predation of foliage	Threat of predation by grazing animals is unlikely as all species belonging to *Macrozamia* contain cyasin which can cause debilitating symptoms or death if ingested in sufficient quantities by many mammals (Halford 1997). Grazing by livestock or native fauna on *M. conferta* foliage can result in plant death or serious injury (Seawright et al. 1993). The foliage is predated by native insects that are dependent on the cycads for their lifestyle (Forster & Machin 1994).
Poisoning	To reduce the likelihood of livestock being poisoned by cycads, chemicals including power kerosene, arsenic or herbicides were applied to the growing points of plants to remove them from grazing areas (Kelly 1967; Vitelli 1993).
Illegal harvesting of adult plants	Removal of adult *M. conferta* from the population is thought to have an immediate and long-term deleterious effect on population viability (Raimondo and Donaldson 2003) given the species slow growth and reproduction turnover.
Loss of genetic variation and insect pollinators	*M. conferta* depends on a species of *Tranes* weevil to complete pollination hence reproduction whilst the weevil depends on *M. conferta* to complete its life cycle. Disruption of this obligate mutualistic relationship in combination with *M. conferta* growth period (see **Section 2.0**) will ultimately result in extinction of both species via inbreeding depression and lack of genetic variation and recruitment (Bond 1994). Loss of genetic variation and insect pollinators are caused by all other threats listed in this table.
Frequent high-intensity fire	Adult *M. conferta* are fire-tolerant, generally resprouting after fires where the above ground foliage is entirely burnt. High intensity fires that occur during masting events result in high losses of potential seed and destroy seed banks on surface soil. Seedlings do survive low intensity burns; however, too frequent or too hot fire will result in cumulative seedling loss. Fire kills seeds and any germinating seedlings. Intense fires sterilise the topsoil and only larger subadults and mature cycads are able to survive (P. Forster pers. comm. 2021). Fire impacts on insect-plant pollination interactions is unknown but should be avoided when plants are coning and receptive to pollinators.
Timber harvesting	Heavy machinery used for timber harvesting damage individuals and may result in soil compaction caused by vehicle tracks. Damage to adult *M. conferta* is minimal as the species has a subterranean trunk; however, soil compaction may impact root development and the positioning of log dumps may impact individuals.

3.0 Proposed Translocation and Propagation Approach

The overarching approach to offset potential impacts to the species is to:

- Translocate all individual plants potentially impacted by construction to a translocation recipient site closely linked to an existing *M. conferta* population;
- Collect seed and propagate in a nursery setting until plants are suitable to plant out at the translocation recipient site;
- Establish a self-sustaining population of 3,094 plants (equal to 120% of the number of plants impacted by the Project);
- Tissue culture and propagation is proposed as a back-up measure to be implemented if there is failure of the standard translocation and propagation method proposed.

Information on methodologies are presented in the following sections.

4.0 Impact and Recipient Translocation Site Description

4.1 Impact Area Habitat Description

The presence of *M. conferta* within the Project footprint was confirmed during seasonal ecological surveys undertaken in 2021 (Attexo 2021; GHD 2021). Stratified meander grids and random meanders were performed to detect plants in four broad areas within the Project area and relative densities in each broad area were estimated. Using the density estimates, an approximate density of *M. conferta* in the Project footprint, and total count of individuals impacted was achieved.

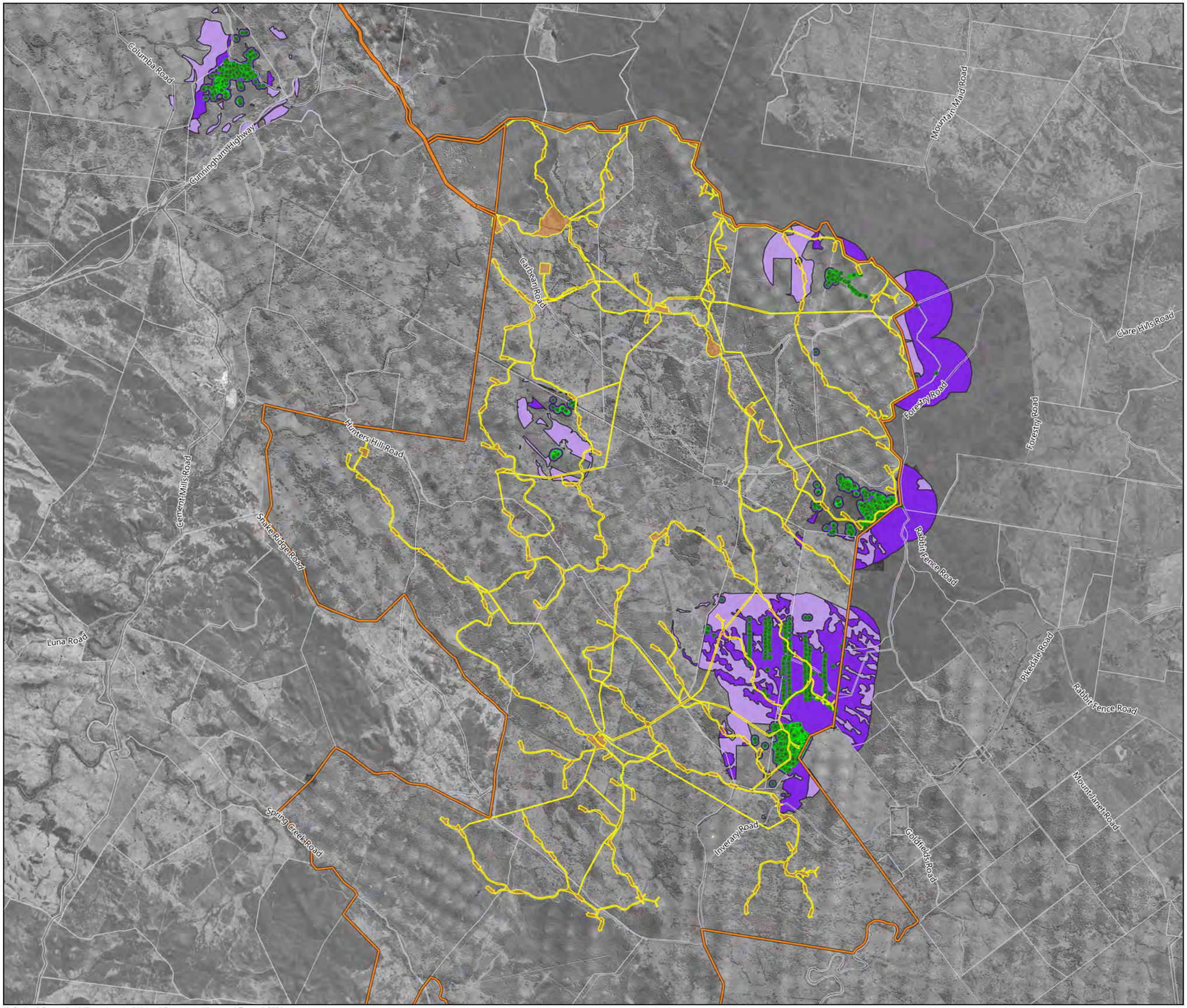
To assess the condition of vegetation and habitat within the Project footprint, 37 BioCondition surveys were undertaken in accordance with Eyre et al. (2015) of which 8 surveys confirmed the presence of *M. conferta*. Nine reference sites were established in the adjacent Durikai State Forest to assess the degree to which the attributes of the vegetation within the BioCondition survey sites differed from the attributes of the same vegetation in its reference state (Eyre et al. 2015). Of the 8 surveys where *M. conferta* was confirmed present, the vegetation structure and composition ranged from grassy woodlands to open eucalypt forests with sparse understorey. High density populations of *M. conferta* were found in open forest communities of RE 13.11.5 and 13.11.6 whilst lower densities were associated with RE 13.11.3 and 13.11.8, with some individuals in non-remnant areas. REs with *M. conferta* present are described as follows:

- RE 13.11.3 - *Eucalyptus crebra, E. dealbata, E. albens* grassy woodland on metamorphics (Of Concern VM Act);
- RE 13.11.5 - *Eucalyptus sideroxylon, E. fibrosa subsp. nubilis* open forest on metamorphics (Least Concern VM Act);
- RE 13.11.6 - *Corymbia citriodora subsp. variegata, Eucalyptus crebra, E. dealbata* open forest on metamorphics (Least Concern VM Act);
- RE 13.11.8 - *Eucalyptus melliodora* and/or *E. microcarpa/E. moluccana* woodland +/- *E. albens, E. dealbata, E. crebra, E. melanophloia* on metamorphics.

The population density of *M. conferta* within the Project area is variable with densities ranging from 1 to 592 plants per hectare. Population structure observed was 1:8 female to male with 96% of the population adult plants. The location of *M. conferta* and associated habitat are shown in **Figure 4.1**.

Habitat mapping for *M. conferta* was based on critical and potential habitat as defined by GHD (2021). The two categories of habitat are described as follows:

- Critical habitat;
  - All records of *M. conferta* collected within the Project area buffered by 100 m;
  - All areas of the REs known to contain high densities of *M. conferta* (RE 13.11.5 and RE 13.11.6, and mixed polygons of these REs that could not be surveyed and that are located within one kilometres of any *M. conferta* record – these REs were observed to have a higher likelihood of hosting populations of this species in higher densities;
- Potential habitat;
  - All areas of remnant vegetation not mapped as critical habitat that meet the conservation advice description (DEWHA 2008) (that is REs 13.11.3, 13.11.5, 13.11.6 or 13.11.8) within 1 km of any *M. conferta* record, except for areas in which absence of the species has been confirmed.



Attexo

MacIntyre Wind Farm

Macrozamia conferta records and habitat in Project area

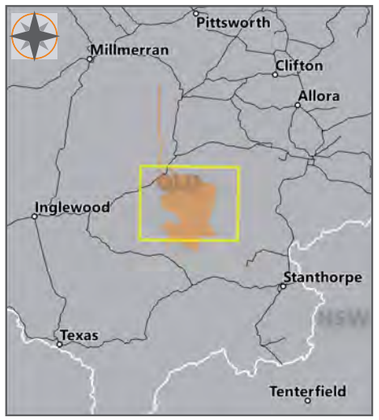
Figure 4.1

- Project Boundary
- Project Footprint
- Macrozamia conferta observation

Macrozamia conferta Habitat

- Critical habitat
- Potential habitat
- Road
- Lot Boundary

Date: 2021-08-06
Author: TOD
Reviewed: NOD
Project: ACC-005



0 1 2 3 4 5 km

1:100000 @ A3

Data Source(s):
DCDB - Department of Natural Resources, Mines and Energy (2021)
Queensland Imagery Whole Of State Satellite Public Basemap Service

4.2 Recipient Translocation Site Description

M. conferta salvaged from the Project footprint and any specimens propagated from seed will be translocated into suitable sites within areas of critical or potential habitat for *M. conferta* as defined in the Preliminary Documentation. Discussions with landholders about potential sites are ongoing, but it is expected that the recipient translocation site will occur within the broader offset for fauna habitat. The following sections describe the overarching requirements of the recipient translocation sites.

Translocation sites will be established in proximity to existing specimens as per the requirements outlined in the *Guidelines for the Translocation of Threatened Plant in Australia* (Commander et al. 2018). Having existing specimens within or adjacent the translocation sites will maximise the likelihood that relevant habitat factors are present (e.g. obligate pollination mutualism with insect pollinator *Tranes sp.*).

Translocation sites will be established within the same REs known to provide habitat in the Project area (open forest communities of REs 13.11.3, 13.11.5, 13.11.6 and 13.11.8). As highest density populations within impact areas were recorded within REs 13.11.5 and 13.11.6, these REs will be prioritised for translocation areas. Key vegetation habitat structure features required at translocation sites are described in in **Table 4.1**.

Table 4.1 Vegetation structure and community of recipient translocation sites

Vegetation Structure	Translocation Sites within 13.11.5	Translocation Sites within 13.11.6
Canopy species	*Eucalyptus sideroxylon* subsp. *sideroxylon, E. fibrosa* subsp. *nubilis, Callitris endlicheri, C. glaucophylla*	*Corymbia citriodora* subsp. *variegata, Eucalyptus crebra, E. fibrosa* subsp. *fibrosa, E. fibrosa* subsp. *nubilis*
Sub-canopy species	*E. fibrosa* subsp. *nubilis, E. woollsiana, E. crebra, Callitris glaucophylla, C. endlicheri*	*Allocasuarina littoralis, Corymbia citriodora, Eucalyptus tereticornis, E. dealbata, E. crebra*
Shrub layer species	*Daviesia mimosoides* subsp. *mimosoides, Eucalyptus infera, Cassinia laevis, Acacia semilunata, A. ixiophylla, A, conferta, Olearia elliptica, Melaleuca decora, Dodonaea triangularis*	*Acacia glaucocarpa, A. penninervis* var. *penninervis, A. falcata, A. conferta, A. fimbriata, a. neriifolia, Exocarps cupressiformis, Leucopogon muticus, Corymbia citriodora*
Ground layer species	*Acacia lineata, Entolasia stricta, Schoenus subaphyllus, Paspalidium caespitosum, Gahnia aspera*	*Melichrus urceolatus, Lissanthe strigose* subsp. *subulata, Desmodium brachypodum, Entolasia stricta, Acacia falciformis*

All proposed translocation sites occur within state and regional biodiversity corridors and adjoin existing specimens, therefore maintaining genetic connectivity.

In addition to vegetation structure and composition habitat requirements, soils at translocation sites will be ash-grey/white silty loam and stony/skeletal grey-white soils in line with soils present at existing high density populations. *M. conferta* populations in the Project footprint occur on flat to low undulating terrain at altitudes ranging from 600-750 m above sea level. The translocation sites are located within the same elevation ranges.

With consideration of the above habitat requirements, and proximity to exiting populations, translocation sites are most likely to have similar climate and rainfall conditions as *M. conferta* populations in the Project footprint.

The proposed density of *M. conferta* at translocation sites is proposed to be 300 to 500 plants per hectare. High density populations of *M. conferta* containing plants brought from different locations, and adjacent existing plants, are likely to provide benefits relating to; improved probability of pollination, increased genetic diversity, and connectivity to existing populations.

4.3 Recipient Translocation Site Suitability

Commander et al. (2018) developed criteria to assess the long-term suitability of translocation recipient sites. These criteria are used to determine the suitability of the *M. conferta* translocation site and are described in **Table 4.2**.

Table 4.2 Criteria for suitable recipient translocation site

Criterion	Description	Compliance
a)	Habitat is matched as close as possible to source location (i.e. same or similar regional ecosystem, topography, altitude),	The translocation sites are in the same geographic range of *M. conferta* natural range. The sites are within the same Bioregion (New England Tableland) and subregion. Proposed sites occur within the same regional ecosystems, topography, attitude, soil type and climatic conditions.
b)	Habitat area is large enough to support a self-sustaining population and whether ecological requirements are met	Translocation sites are located in large patches of remnant and/or regrowth vegetation and are a part of or close to large contiguous areas of remnant vegetation.
c)	Connectivity to other patches of supporting habitat and other *M. conferta* populations is maintained	The translocation sites are in close proximity to existing populations (see **Section 2.0**). Connectivity for gene flow and pollinator dispersal will be maintained between existing populations and translocated populations by large contiguous patches of remnant critical and potential habitat adjacent to the translocation sites.
d)	Microclimate is appropriate	The translocation site is remnant vegetation o the same vegetation structure and community as the source location. There is no known existing literature or approved advice regarding *M. conferta* microclimate requirements.
e)	Future climate projections and the sustainability of the species and population at the site	The translocation sites are in close proximity to impacted plants. The climatic requirements of *M. conferta* are currently unknown, but having translocation sites in close proximity to existing populations will increase the probability of success.
f)	Known ecological functions are present in the site (i.e. pollinators, mycorrhizal fungi)	Ecological functions of *M. conferta* is its obligate pollinator species. High-densities of *M. conferta* mimicking natural populations are proposed in translocation sites, which should maximise the potential success of obligate pollinators.
g)	Land use history and degree of disturbance on the site (i.e. grazing and weed infestation)	The translocation sites are currently grazed, with areas of selective timber harvesting throughout. BioCondition surveys across the Project area have identified limited existing weed populations. Livestock will be excluded from translocation sites prior to translocation activities being undertaken. Fire breaks will be created and controlled burns undertaken prior to translocation where relevant.

Criterion	Description	Compliance
h)	Ecosystem functional status/the ability of the ecosystem to regenerate without continual support once pressure is removed	Translocation sites are proposed in remnant vegetation areas with limited existing weed populations. Ecosystem function should continue post the translocation maintenance period, with the site protected for future clearing by the proposed protection mechanism.
i)	Processes impacting soil health and stability	Activities during site preparation and translocation will impact soil health and stability (i.e. mechanical/chemical weeding, digging transplant holes, pedestrian and excavation machinery). Care will be taken to minimise potential impacts during translocation. Soils at translocation sites have not been assessed as having high erosive or dispersive potentials and are unlikely to be significantly impacted by translocation activities.
j)	Existing threats and management in place to eliminate or control (i.e. current weed, feral animal or fire control)	Existing threats at the translocation site are primarily livestock grazing and trampling and will be controlled and eliminated prior (see **Section 8.0**) and post translocation (see **Section 8.4**). Site maintenance post-translocation will include annual inspection and repair of exclusion fencing and weed, feral animal and fire management.
k)	Long-term security of the site to ensure ongoing protection of translocated population (i.e. private land signed covenants with conservation agreement)	Long-term security of the site will be achieved under Section 19F of the *Vegetation Management Act 1999* where it is secured for the purposes of an environmental offset.
l)	Compatibility of current and future management of the site with managing a translocated population (i.e. will proposed fire management be compatible with current site conditions)	Proposed management of identified risks to the species are consistent with current and future land management practices that seek to minimise the risk of high-intensity fires and control livestock access.
m)	Adjacent land use impact on translocation site and if a buffer is required, and proximity to existing and future infrastructure (i.e. access tracks) which will dictate accessibility for re-location and ongoing management	Adjacent land uses include Durikai and MacIntyre State Forest, and land within the Project area. Translocation sites will be where existing *M. conferta* populations occur therefore apparent that adjacent land use does not and will not have any impact on the translocation site.

Section 6.7 of the *Guidelines for the Translocation of Threatened Plants in Australia* (Commander et al. 2018) outline the importance of removing, ameliorating or controlling threats at the recipient translocation site pre and post translocation. Site preparation prior to translocation will be undertaken (as outlined in **Section 4.1**) and movement between translocation site and areas within Project footprints with be planned to avoid damage to existing *M. conferta* populations.

Table 4.3 describes the net benefits of translocation into an existing *M. conferta* population and how threats and threatening processes are controlled, ameliorated or eliminated.

Table 4.3 Net gain for recipient translocation site *M. conferta* population

Threat	Net Gain
Destruction of habitat and individuals	This threat to existing *M. conferta* populations in the recipient translocation site will be eliminated post-translocation as management actions (i.e. gated fences with lock system, signage and legal protection against clearing activities) will prevent any clearing or access within the recipient translocation sites.
Predation of foliage	This threat to existing *M. conferta* populations in the recipient translocation site will be eliminated post-translocation as management actions (i.e. gated fences with lock system, cattle grids) and monitoring (i.e. annual inspections for damage and repair) will prevent livestock entering the recipient translocation sites.
Poisoning	This threat to existing *M. conferta* populations in the recipient translocation site will be eliminated post-translocation as management actions (i.e. gated fences with lock system, signage and legal protection against clearing activities) will prevent any access within the recipient translocation sites.
Illegal harvesting of adult plants	This threat to existing *M. conferta* populations in the recipient translocation site will be eliminated post-translocation as management actions (i.e. gated fences with lock system, signage and legal protection against clearing activities) will prevent any access within the recipient translocation sites.
Loss of genetic variation and insect pollinators	Implementation of this translocation plan will improve genetic diversity by bringing specimens from different impact areas together into one translocation site. This will also improve the likelihood of success of obligate pollinators.
Frequent high-intensity fire	This threat to existing *M. conferta* populations in the recipient translocation site will be eliminated post-translocation as management actions (i.e. site preparation including reducing fire fuel hazards, implementing fire breaks, annual inspection) will reduce the risk of extreme fire events within the recipient translocation sites.
Timber harvesting	This threat to existing *M. conferta* populations in the recipient translocation site will be eliminated post-translocation as management actions (i.e. gated fences with lock system, signage and legal protection against clearing activities) will prevent any clearing or access within the recipient translocation sites.

5.0 Recipient Translocation Site Legal Security Mechanism

Legal security will be provided for recipient translocation sites following agreement with landholders. The legal security mechanism would be registered on the land title and provide protection for the duration of the action.

Sites are proposed to be declared as areas of high nature conservation value under Section 19F of the *Vegetation Management Act 1999* where it is secured for the purposes of an environmental offset. To accompany this request for declaration, a management plan that outlines the activities required to achieve successful *M. conferta* establishment will be provided (this Plan will be part of the management plan). Once declaration is made it is registered in title and is binding on all current and future owners of the land until the intent and outcomes of the management plan have been achieved.

6.0 Review of Relevant Translocation Programs

Both Macrozamia and Cycad genera belong to the order Cycadales, hence share similar biology, growth process and habitat requirements (Jones 1993). A number of translocation programs for these genera have been undertake in Queensland. Information and learnings from these translocation programs were reviewed. **Table 6.1** lists previous Cycas and Macrozamia translocation programs relevant to this Plan.

Table 6.1 Relevant *Cycas* and *Macrozamia* translocation programs

Document Number/Reference	Title
60162199	AECOM (2011) – Translocation Program for *Macrozamia pauli-guilielmi*
WBYD-1355	Department of Transport and Main Roads (DTMR) (2015) – Bruce Highway Cooroy to Curra (Section D: Woondum to Curra)
EPBC Approval 2017/7892	GHD (2017) – *Macrozamia pauli-guilielmi* Impact Management Plan
EPBC Approval 2012/6279	Vegetation Matters (2013) – Translocation Performance Report for *Macrozamia pauli-guilielmi* and *Acacia attenuata*
3380-GLNG-4-1.3-0013	GLNG Gas Transmission Pipeline (2013) – *Cycas megacarpa* Translocation and Management Plan
Q-LNG01-15-MP-0118	Australia Pacific LNG Upstream (2014) – *Cycas megacarpa* Management and Translocation Plan
2018.8141 CCWF CTP.V4.3	Clarke Creek Wind Farm (2020) – Cycad Translocation and Management Plan
QCLNG-BX00-ENV-PLN-000025	QCLNG Pipeline Project (2016) – *Cycas Megacarpa* Translocation and Management Plan

The methods and management actions proposed in this Plan were developed with consideration of the above-listed translocation plans. The *Macrozamia pauli-guilielmi* (*M. pauli-guilielmi*) translocation program and performance reviews undertaken by Vegetation Matters (2013), GHD (2017) and DTMR (2015) are particularly relevant to *M. conferta*.

The translocation programs undertaken to date identified that *Macrozamia* species are resilient to translocation and generally recover well, particularly if minimal damage to the underground stem occurs. The stem of adult plants provides a substantial store of water and nutrients and acts as a buffer for plants to withstand the temporary loss of leaves and photosynthetic potential and regrow the fine root system following uprooting during translocation (DTMR 2015). Vegetation Matters (2013) achieved high survivorship (88%) of *M. pauli-guilielmi,* highlighting the use of experienced successful operators is a major strength of translocation projects and is critical to translocation success. These *M. pauli-guilielmi* translocation programs identified the following challenges for successful translocation:

- The sandy nature of the soil: which can lead to difficulty in retaining soil around the rootball during excavation; and
- The size of the underground stem: which must be carefully accessed before excavation to avoid damage; and
- The optimal time for translocation is in the cooler months prior to new leaf flushes and masting in spring

M. pauli guilielmi translocation is highly applicable to *M. conferta* translocation as they belong to the same genus and share similar features as outlined in **Table 6.2**. Challenges for *M. pauli-guilielmi* are relevant to *M. conferta* and are

addressed throughout this Plan. Specifically, through appropriate excavation methods that will be used to retain soil around the larger rootball (see **Section 8.2.1**) and translocation to take place in the cooler months (see **Section 8.2**).

Table 6.2 Morphology of *M. conferta* and *M. pauli-guilielmi*

Feature	*Macrozamia pauli-guilielmi*	*Macrozamia conferta*
Morphology		
Underground Stem	20 cm diameter 25 cm long Subterranean	15-30 cm diameter Up to 1 m long Subterranean
Leaves	1-6 leaves 30-50 cm long	1-5 leaves 35-60 cm long
Rachis	Spirally twisted (>2 times)	Spirally twisted (2-3 times)
Leaflets	140-200 leaflets 15-30 cm long by 2-4 mm wide	50-90 leaflets 6-30cm long by 2-6 mm wide

7.0 Review of Macrozamia Propagation

Numerous Macrozamia species are propagated commercially throughout Australia. As a result there is a wealth of information on techniques for germination and propagation of Macrozamia, and a large number of nurseries that grow and sell the genus.

Macrozamia propagation is generally from seed which germinates easily without the need for any pre-treatment. Optimum germination occurs at 30°C and as low as 20°C, although the time taken for seeds to germinate will be correspondingly longer. Temperatures lower than 10°C or in excess of 38°C can cause damage (Elliot and Jones 1993).

8.0 Translocation and Propagation Methods

Translocation will be managed by a suitably qualified ecologist with ecological restoration, translocation and plant establishment experience. A Translocation Database (TD) with information and records of all *M. conferta* proposed for relocation and seed collection will be developed for use in monitoring and maintenance of plants post-translocation and will include the following data:

- Site ID, specimen ID, GPS location, time of excavation;
- Age class: seed, seedling, juvenile, sub-adult, adult at reproductive maturity;
- Sex (distinguishable when cones produced, see **Section 2.1**);
- Female to male ratio, to replicate translocated population dynamics (see **Section 4.1**);
- Presence of cones and maturity: undeveloped, ripe, old;
- Proximity of seedlings to the maternal parent and identification number of maternal parent;
- Foliage characteristics: number of fronds, new growth, dead fronds;
- Evidence of disturbance: presence of fire, insect damage, defoliation;
- Severity of disturbance: low, medium, high;
- Evidence of damage incurred to the plant through the translocation process, especially caudex damage and loss of the coralloid root clusters that are critical for nitrogen uptake.

8.1 Recipient Translocation Site Preparation

8.1.1 Fencing and Access Restriction

Prior to translocation commencing the translocation site will have domestic stock exclusion fencing erected to reduce potential trampling of *M. conferta* by livestock and to prevent access by unauthorised personnel or vehicles. This will minimise any disturbance to native vegetation and limit ongoing anthropogenic edge effects within the translocation zone. Fence design will be plain fencing and devoid of barbed wire to reduce threat of potential entanglement of native species (e.g. Grey-headed Flying-fox, *Pteropsus poliocephalus*). Fencing will be maintained for the duration of the management and monitoring program.

8.1.2 Weed Management

Woody weeds have had significant adverse impacts to both flora and fauna in eucalypt forests in south-east Queensland as they dominate the understorey and effectively outcompete and suppress recruitment of native groundcover (Batianoff and Butler 2002). Two species listed as restricted invasive weeds under the *Biosecurity Act 2014* that occur within the Project area include:

- *Opuntia tomentosa;*
- *Opuntia stricta.*

Field surveys confirmed the absence of key potential high-risk weed species including Buffel grass (*Cenchrus ciliaris*) and Lantana (*Lantana camara*) within the Project area. Both Lantana and Buffel grass are competitive against native species that suppresses native flora recruitment and growth, and as a result increases fire fuel loads and alter fire regimes that increase the risk of extreme fire events.

Prior to translocation both the impact and translocation area will be assessed for existing weeds and if found, will be removed to prevent transfer between sites. Specific control measures to reduce the impacts of weeds within both impact and translocation site include the following:

- Mechanical removal – topsoil scalping to remove weed seed bed and removal of established weeds by hand, or brush cutter;
- Chemical removal – application of herbicides to individual weeds;
- Fire – controlled burns to remove weeds and accumulated organic fuel load, and prevent the germination of new weeds;
- A combination of two or more of the above methods.

8.1.3 Fire Management

Adult *Macrozamia* have an underground stem and are able to resprout after loss of above-ground foliage from fire, however, seedlings and unburied seeds are immediately destroyed (Queensland Herbarium 2007). Mast-seeding events often follows fire, with a small percentage of individuals coning in the first year following the fire, and a high percentage of individuals coning in the second year. Based on this response to fire, the following measures will be implemented to both stimulate growth post-translocation and reduce the severity of fire hazard within the translocation site:

- Establish and maintain fire breaks (maintenance annually at beginning of dry season);
- Reduce standing and accumulated fuel load (either with initial low-intensity controlled burn or brush cutting, slashing, herbicide application).
- Controlled burns based on present fuel load and regional ecosystems, as outlined in the Regional Ecosystem Description Database (Peeters and Butler 2014)

8.2 Translocation Method

Translocation methods follow established guidelines, legislation and codes listed below:

- *Nature Conservation (Plants) Regulation 2020*;
- Code of Practice – For the harvest and use of protected plants (NC Act);
- National Multi-species Recovery Plan for the cycads (Queensland Herbarium 2007);
- Guidelines for the Translocation of Threatened Plants in Australia (Commander et al. 2018).

The optimal time for translocation is immediately before the emergence of new growth in Spring before the onset of the wet season. However, translocation at any time of year is likely to be appropriate, particularly when soil moisture is high. Damage to plants incurred by excavation is reduced when there is soil moisture as opposed to very dry conditions (P. Forster pers. comm.). Seedlings and mature plants of most *Macrozamia* can be readily transplanted and

can tolerate minor root damage; however, care is required for maintaining the taproot as this can be up to 1 m long in *M. conferta* and coralloid root masses as these a critical for nitrogen uptake (P. Forster pers. comms. 2021).

Excavation of individual plants will be undertaken through a combination of both machine-driven extraction and careful in-close treatment of each individual plant using a sharp spade. The excavation method will be selected based on the size of the plant to be translocated, with smaller plants excavated by hand, and larger plants using machinery.

Relocation and replanting of individual plants will occur as soon as possible from the time the plant is excavated to minimise the amount of time that the plant is out of the ground.

To achieve successful translocation the following conditions of individual plants will be assessed prior to excavation to avoid damage:

- The size of taproot and coralloid root mass;
- The extent of the micro-habitat established around the base of the plant;
- Presence of pollinator species (*Tranes* spp. of weevil, thrips, beetles).

In review of several published *Cycas* and *Macrozamia* translocation programs that have been successfully undertaken (see **Section 6.0**) and discussed with Dr Paul Forster (pers. comm. 2021) from the Queensland Herbarium, a methodology was developed to specifically address these matters and is described in the following sections.

8.2.1 Plant and Soil Removal

At the area of impact, the following actions will be undertaken for the removal of *M. conferta* prior to translocation and replanting:

1. Use marker paint or fluorescent dye to denote the north side of every plant to ensure relocated plants retain similar north-south orientation
2. Trim all fronds back to where the rachis is attached to the stems.
3. Apply an anti-transpirant (e.g., Envy®) to the foliage of each plant to prevent drying out.
4. Assess the topography and soil conditions (moist or dry) for each plant and overall safety of the area. If soil is too dry, water to wet root ball prior to excavation.
5. Depending on soil conditions, hand-digging may be required for small individuals, however, excavation of mature plants will ideally be with an excavator (nominally 13t) mounted tree spade with basket attachment.

   Note: care will be taken during excavation as the subterranean caudex can be up to 1 m long and in retaining as much of the soil around the rootball as possible as the weight of the soil falling off the rootball can damage the roots of the plant.
6. Movement of larger and heavier individuals will ideally be done using a tree spade. Where soil conditions make this impractical a soft sling on an excavator bucket and packed using hessian sacking (or similar material) will be employed to avoid bruising and damage of stems and roots.
7. Wrap the rootball and roots in rolls of hessian sacking (or similar) and spray with water to retain moisture of the root ball while the plant is awaiting replanting.
8. If roots become damaged, they will be trimmed with sterilised secateurs and a fungicide applied by spraying the roots with Banrot® to prevent infection. Damaged root ends will either be allowed to form a callus (by leaving

plants in the shade within the holding area for two weeks) or be painted with a standard arboricultural stem sealant. A rooting hormone (such as Formula20®, Vitamin B or Seaweed) will also be applied to promote root growth.

9. Translocation will be managed to limit the time period that *M. conferta* specimens are out of the ground and to minimise bruising of plant stems.

8.2.2 Replanting of Translocated Plants

At the recipient translocation site, the following actions will be undertaken for the replanting of *M. conferta*:

1. Holes to receive translocated plants will be dug by hand or with the Excavator mounted tree spade depending on the size of individual plants. The soil within the hole will be loosened, and the hole not much deeper than the rootball of the plants being transplanted.
2. Plants will be positioned in new holes. Just prior to planting, the hessian will be removed, and any further damaged roots will be trimmed and Banrot® and rooting formula reapplied.
3. The rootball of each plant will be re-packed with sandy loam from the site to provide a suitable substrate for new roots to grow and original topsoil removed from the hole will be used to fill the remainder. Plants will be placed in a vertical alignment.
4. The foliage will be sprayed a second time with an anti-transpirant (Envy®) to prevent drying out.
5. Each plant will be watered thoroughly with potable water.
6. A systemic fungicide will be applied around each rootball.
7. Each plant will be watered about once a month (10-20 litres) depending on rainfall for 6 months after replanting or as appropriate.
8. Where insect damage to translocated specimens is observed during monitoring a control program will be employed that does not impact on pollinator populations.

Tree guards will be placed around juvenile *M. conferta* to limit impacts from native herbivores until individuals have achieved leaf lengths of 35-60 cm, at which time the specimens have reached maturity and defence mechanisms (cyasin) against browsing have developed.

8.3 Propagation and Cultivation

The translocation will be supplemented with propagation of *M. conferta* seed in a nursery. Seeds will be collected by a suitably qualified person and propagation will be undertaken by a nursery with experience growing Macrozamia species.

8.3.1 Seed Collection and Storage

Macrozamia have seeds with a delayed germination mechanism (dormancy). Harvested straight out of the disintegrating fruiting cone and where the seeds still have fleshy sarcotesta, they are not ready to germinate and require storage for 8-12 months for full development of the embryo. Older seeds where the sarcotesta has been removed, may be picked up from the ground and should be ready to germinate (P. Forster pers. comm. 2021).

They will be stored in paper bags in a dry, well ventilated space away from extremes of temperature. Viable seeds can be determined by the float test (i.e. put in a bucket of water, those that sink should be viable, those that float should be thrown away).

Collection will be undertaken in accordance with the *Code of Practice for the harvest and use of Protected Plants* (DES 2017) and will include the following:

- Seed collection from individuals that are and are not being impacted by the Project to ensure genetic variation is maintained for overall population viability;
- Upon collection, maternal plant and seed will be labelled with unique ID, date, GPS location and collector's details;
- Only fully ripe fruit to be collected – seed must have been shed or to the point of being shed;
- Cuts to be made to fruit will be made with sterilised equipment as close to the base as possible;
- No more than 20% of the total number of fruits will be collected from any one plant in any 12 month period.

Information related to each seed collected will be stored and managed in the translocation database for monitoring the progress and survival rate of propagated individuals and allow the assessment of seed viability and fitness of maternal plants.

Seeds will be collected from any plants being translocated, with additional seed collected from adjacent populations in accordance with the parameters outlined above. Based on previous successful translocation programs (see **Section 6.0**) that had >70 % survivorship, it is expected that at least 1,805 *M. conferta* will survive translocation. To achieve the goal of establishing a self-sustaining population of at least 3,094 plants (a 20% increase in the number of plants impacted by the Project) a total of 1,289 plants will be propagated at a nursery. With a germination rate of >90%, a total of 1,432 seeds will need to be collected.

Some seeds collected will be suitable for germination straight away, with other seeds requiring storage for 8-12 months before germination. Where storage is required, these seeds will be stored in paper bags in dry, well ventilated space away from extremes of temperature (P. Forster pers. comm. 2021).

8.3.2 Propagation

Propagation will take place off-site at a suitably experience nursery and will follow a tailored method to meet the germination requirements of *M. conferta*. The nursery will be responsible for the establishment and management for seed propagation, will have relevant experience in *Cycas* and *Macrozamia* nursery propagation methods and will operate under the *Australian Standards for maintenance of plant health* and the *Nursery Industry and Garden Australia Standard*.

Seeds are known to germinate best in the warmer months of the year. Germination will occur in communal pots/trays with the seed lightly pressed into the substrate surface and not totally buried (P. Forster pers. comm. 2021). The following methodology outlines the general horticultural techniques of propagation:

- Remove flesh from seed;
- Initial planting of seed in suitable seed raising mix and irrigated regularly throughout growth;
- First leaf appears and seed taken root, seed will be planted into 140 mm pots and transferred into nursery;
- Once rootball formed and filling 140 mm pot (9-12 months), transfer into 300 mm pot with same potting mix;

- Final transfer into translocation site will occur when the plant is large enough – approximately three years after germination.

8.3.3 Tissue Cultivation

Tissue culture is proposed as a back-up measure to seed collection and propagation. Tissue culture will only be applied if there are significant failings in the methods outlined above.

Tissue culture of cycads has been successful as outlined in numerous studies:

- Nadaranjan et. al. (2018) reported that cycad conservation could benefit from application of in-vitro micro-propagation. The study cited the production and medium to long term storage of explants initiated from seed tissue and reported that progress has been made in vitro growth of cycad tissues.
- The International Union for Conservation of Nature – Species Survival Commission (IUCN-SSC) Cycad Action Plan (Donaldson 2003) highlights the potential for using in vitro propagation and tissue culture to improve germination, increase growth rates of seedlings, and develop plants from tissue culture for species with low seed set, all of which contribute to having more plants in cultivation. Litz et al. (2004) reported that biotechnology – specifically tissue culture – is a viable way to conserve the germplasm of this ancient plant group (Cycads).
- The University of Florida – Institute of Food and Agriculture has been successfully undertaking ex situ conservation of Cycads through tissue culture. Studies have been focussed on the use of mature specimen leaf tissue with the work aimed at commercialising in-vitro cycad production for conservation purposes (UF/IFAS, 1996). Forsyth and Giddy (1990) reported that despite Cycads being protected by the Convention in International Trade in Endangered Species of Flora and Fauna (CITES 2014), and legal protection in various countries, there has not been a substantial increase in cycad numbers in the wild mainly due to reproductive failure, as a very few seeds germinate in nature.
- Da Silva et. al. (2015) undertook a study into the various methods in use for in-vitro propagation of Cycadales. The study found that seedling tissue, new leaf tissue from mature specimens, megagametophytes and zygotic embryos have been used successfully. Ex-plants from these methods produced callus, coralloid roots and somatic embryos in-vitro. The study found that the most productive method for mass production and preservation of cycads was organogenesis where plantlets were acclimatized in less than 200 days.
- Charvez and Litz (1999) trialled a range of tissue culture substrates in a randomized block trial and found that in Zamiaceae callus initiation occurred on a wide range of medium, whereas shoot initiation required a specific medium supplemented with 2.26uM 2,4-D. The trial successfully produced explants from a range of tissue sources.
- Chaplot and Jasril (2000) developed protocols for root shoot differentiation in *Cycas revoluta* and produced shoot primordia within 20 – 25 days of cultivation.
- Da Silva et. al. (2015) in their review of previous studies into tissue culture of Cycadales found that Cycads were successfully produced by tissue culture as early as 1954 (*Zamia floridana*) and published the growing media protocols from a range of studies for numerous species.

There are a number of commercial tissue culture laboratories in Queensland, four were contacted regarding the potential to produce Macrozamia conferta plantlets from tissue culture. They considered that provided they were able to link up with laboratories who have previously successfully produced Cycadales in-vitro (i.e. UF-IFA)(to short cut experimentation on production protocols) that is highly likely that M. conferta could be propagated via tissue culture.

An in-vitro propagation program for M. conferta is proposed to support the translocation and traditional propagation by seed programs described in this plan. A commercial tissue culture laboratory would be commissioned to liaise

with international laboratories on previously successful mediums and methods for Cycadales, the collection of propagation material and subsequent tissue culture production of M. conferta plantlets.

8.3.4 Planting from Nursery Stock

Nursery stock of *M. conferta* will be planted out within the translocation sites following similar methods to the establishment of translocated plants:

1. Holes at the translocation locality will be dug by and the soil within the hole will be loosened, and the hole not much deeper than the rootball of the plants being transplanted.
2. Each plant will be watered thoroughly with pottable water.
3. A systemic fungicide will be applied around each rootball.
4. Each plant will be watered about once a month (10-20 litres) depending on rainfall for 6 months after replanting or as appropriate.
5. Where insect damage to translocated specimens is observed during monitoring a control program will be employed that does not impact on pollinator populations.

8.3.5 Time to Ecological Benefit

The time to ecological benefit of *M. conferta* translocation, propagation and seedling planting is summarised below:

- **Commencement:** Assess and identify *M. conferta* for removal from Project footprint – site access will be concurrent with pre-clearance/additional targeted surveys;
- **Within 6 months:** Secure translocation sites and nursery propagation facility and prepare collection program and begin translocation site preparation;
- **Within 6 months:** Seed collection: assessment as for *M. conferta* inspections (collect from individuals inside and outside of Project footprint);
  - Old seed can be propagated straight away (P. Forster pers. comm. 2021);
  - Propagation of young seed (with fresh fleshy/coloured sarcotesta) takes 8-12 months until ready to germinate/propagate;
- **Within 12 months:** Site preparation complete, salvage and translocate *M. conferta* in cooler months – commence care and management;
- **Years 3 and 4:** Planting of seedlings as available and climatic conditions are suitable (i.e. adequate rainfall and average daily temperature does not exceed 35^0C).

The time to ecological benefit is expected to be less than five years, but 20 years has been used in the offsets calculator to ensure that a conservative approach has been undertaken.

Over the course of this Plan, planting additional seedlings into the translocation sites will ensure 20% more plants are established than the number impacted.

Table 8.1 outlines the ecological benefits gained through translocation of *M. conferta* and how key threats (see **Table 2.1**) have been addressed.

Table 8.1 Ecological benefits of this Plan

Ecological benefit	Description and key threats addressed
Improved genetic diversity	The introduction of individuals with different geographic and genetic origin into the recipient population will increase genetic diversity as the gene pool of the recipient population is widened and genetic variability maintained. High genetic diversity at the population level reduces the risk of *M. conferta* inbreeding depression, see **Table 4.3**.
Self-sustaining population	The addition of individuals into the recipient population introduces more pollinator individuals therefore increases the density and access of pollinator recipient population and increases the capacity of pollination for *M. conferta*. A self-sustaining population as a result of a net gain in population reduces the risk of loss of genetic variation and facilitates an increase in pollination therefore increases *M. conferta* reproduction, see **Table 3.3**.
Net gain in population	The addition of individuals achieves a net gain in the recipient population numbers and population structure. A net gain in mature individuals increases reproduction and pollination whilst a net gain in juveniles and sub-adults will increase the number of mature individuals once established. A net gain in population reduces the risk of genetic inbreeding depression and facilitates pollination, see **Table 3.3**.
Increased protection	The translocation process will increase the overall protection for *M. conferta* as the recipient population will be legally secured for conservation purposes (see **Section 5.0**) and threats of illegal harvesting and poisoning reduced (see **Table 3.3**).

8.4 Recipient Translocation Site Maintenance

Maintenance will occur at translocation sites for the duration of the Plan and will involve the following actions:

- Each individual translocated plant will be tracked through the planting process and information stored in the TD (i.e. total population number, number of deaths and damage, growth stage, presence of cone/seed etc.);
- Plants will be watered once a month post translocation, the amount depending on the regions' rainfall levels, for the first six months;
- Ongoing weed management will take place post translocation annually to reduce competition of nutrients and water by aggressive weeds (if present) and lower fire hazard;
- Ongoing application of insecticide if insect herbivory is detected post translocation;
- If root damage or plant rot is evident, ongoing preventative treatment (i.e. sealant, fungicide, removing damaged parts) will be implemented to minimise further damage;
- Fencing maintenance (see **Section 8.1.1**)
- Fire breaks and controlled burns (see **Section 8.1.3**)

Table 8.2 identifies auditable performance and completion criteria for recipient translocation site maintenance post-translocation of *M. conferta*. Site maintenance is necessary to ensure potential threats to *M. conferta* (see **Section 2.1**) do not become established in recipient sites. Maintenance and management of specimens will continue until the end of the period of effect of the approval or achievement of all commitments within this Plan. Maintenance actions

undertaken throughout the translocation and monitoring period will be recorded in the annual report (see **Section 6.5**) and will aid in the assessment of the overall success of *M. conferta* translocation.

Table 8.2 Post-translocation performance measures for recipient translocation site

Criteria	Frequency	Action if non-compliant
Translocation Site Maintenance and Condition		
Fence established Fence maintained	Start Once/year	Prior to translocation of *M. conferta* Repair and inspection
Damage by pest insects	Once a year	Pest control plan and action if required
Weeds	Once a year	Weed removal and management if required
Fire breaks established Fire breaks maintained	Start Once a year	Prior to translocation of *M. conferta* Repair and inspect (start of dry season)
Fuel load	Once a year	Weed removal and management if required (i.e. grass < 0.5 m high; cover < 50% extending at least 0.5 m from plants)
Erosion control established Erosion control maintained	Start Once a year	Erosion control plan and action if required Apply appropriate measures if required
Translocation Success Criteria		
A population of 120% of the initial number impacted is established and self-sustaining	Once a year	Additional propagation and planting *M. conferta* up to target population numbers
Maintenance Criteria		
Records of watering, weed and insect control, fire management, fence maintenance, erosion control measures, etc.	As conducted	Ensure TD is continually updated and data management implemented, reporting procedures established and followed

9.0 Monitoring and Evaluation

Monitoring will evaluate the success of the translocation, propagation and maintenance programs implemented. Monitoring results will be used to determine which corrective actions should be implemented and when (ie if there is a decline in the health and/or survival of translocated plants relative to reference populations, additional plants will be established from propagated stock).

9.1 Reference Site Establishment

Reference plots within existing populations will be established to allow to an assessment of overall population changes in response to climatic conditions. The reference plots will occur where there is a representative sample of the existing population of similar density, population structure (i.e. adults, sub-adults, seedlings), vegetation community, soil and altitude to the translocated population.

Field surveys have identified suitable reference plots that occur within Durikai State Forest and within the Project area. Three reference plots will be established within each reference site to ensure the survival of translocated individuals is assessed statistically in comparison to sound baseline data. Unique reference IDs will be given to reference plots corresponding to their translocation sites and information collected in monitoring events will be stored in the TD.

Reference sites will follow a plot design of 100 m by 20 m that will have each corner marked by star-pickets.

9.2 Monitoring of translocated *M. conferta*

Three translocation plots will be established per recipient site. The parameters described in **Table 9.1** will be monitored post-translocation to measure and assess individual and population growth, identify potential threats or environmental factors within the translocation that may impact M. conferta, and provide recommendations to improve methods of translocation. At each monitoring event the following information will be recorded to assess the overall success of the translocation at the completion of the monitoring period:

- Ecologist on site, date, time, translocation site ID (for corresponding reference plot);
- Identify individual with unique ID, GPS location and record:
  - Photo log;
  - New frond growth;
  - Cone development and sex;
  - Seed development;
  - Recruitment;
  - Presence of pollinators[1].

[1] Only likely to be present in October / November

Table 9.1 Monitoring of *M. conferta* at recipient translocation sites

Parameter	Description	Frequency
Growth of *M. conferta* individuals and population		
Survival/mortality	Total number of individuals present and population structure (i.e. % dead, mature and coning, mature, juvenile or seedling)	• 1-3 months: once a month. • 4-24 months: once every quarter • Annually for the remainder
Gender and reproduction	Presence of reproductive organs (i.e. cones and seed) and M:F ratio in population	
New growth	Presence or absence of new growth	
Predation	Presence or absence of insect damage (i.e. leaves or cones)	
Identification of potential and existing threats		
Fire	Reduce fuel loads in the wider area and around base of individuals if necessary (i.e. removal of weeds, litter bed and standing fuel) Inspect firebreaks and monitor density of high-risk weed species (i.e. Lantana camara)	• Once a year
Weeds	Monitor existing density of known weeds and during ongoing weed management practices, including areas in the immediate vicinity	
Fencing and access	Inspect damage, signs of access and repair	
Pests	Inspect signs of access and damage	

9.3 Monitoring of Propagated *M. conferta* Seedlings

9.3.1 Seedlings in Nursery

The nursery will be responsible for the establishment and management for seed propagation, and monitoring of seedling health and success. At minimum, the following monitoring actions and information will be recorded in the TD:

- Seeds and propagated individuals will be watered following a schedule that will be inspected weekly to ensure over or underwatering doesn't occur. Rescheduling of watering times may take place depending on climatic conditions but changes to schedule must be recorded and all personnel notified.

- Seeds and propagated individuals will be inspected weekly for signs of desiccation or high soil moisture, damage from fungal disease or insects, or established weeds.
- Pests and disease will be treated as necessary using appropriate control methods approved by senior nursery staffer.
- Weed control will be undertaken if necessary using appropriate removal methods.
- Slow release fertilizer will be applied to all plants on a bi-annual basis.
- The nursery will undergo hygiene inspections and management methods in accordance with the *Biosecurity Manual for the Nursery Production Industry v.1* (Plant Health Australia 2010).

9.3.2 Seedlings in Recipient Translocation Sites

Seedlings that have been planted into the recipient translocation sites will be monitored in the same way as the translocated plants outlined in **Section 6.2**.

9.4 Corrective Actions

Successful translocation programs for *Cycas* species have been undertaken for a range of projects (Santos GLNG Project, Australia Pacific LNG, QCLNG). These propagation programs identified survival rates of >95% for specimens planted from nursery stock and ~70-90% for directly translocated specimens. Similarly, successful seed collection and propagation programs for *Cycas* species have been undertaken for a range of projects (Santos GLNG Project, Australia Pacific LNG, QCLNG). These propagation programs identified >70% germination and survival rates of cycad seedlings in nursery.

Corrective triggers and corrective actions will be undertaken in the event of any of the following occurring:

- There is a 10% decline in the translocated population compared with reference plots – additional planting will be undertaken within four weeks from nursery stock and a review of management actions will be undertaken;
- Any weeds are observed within the groundcover layer of the translocation site – weeds present will be controlled;
- The germination rates of seeds in the nursery is <70% – additional seeds will be collected and germinated.

9.5 Reporting Requirements

An annual report that includes assessment of translocation actions and results will be prepared. Information to be reported and submitted (on request) will include a summary of the results of the previous 12 months, Translocation Database information, and evaluation of translocation success and monitoring methods implemented.

The report will include details of all actions taken during translocation process and how outcomes demonstrate compliance and achieved a sustainable population of *M. conferta*. These include:

- The final number of *M. conferta* collected from the Project footprint;
- The final number of seed collected from individuals inside and outside of the Project footprint;
- Propagation success in nursery of seeds collected;
- The success and health status of translocated *M. conferta*;

- The success and health status of propagated seedlings transferred into recipient sites;
- Any problems that impeded propagation and translocation methods and overall success;
- All individuals and facilities involved in the translocation process;
- Demonstrated compliance with management actions outlined in this Plan.

9.6 Confidence of Translocation, Propagation and Monitoring Methods

At 20 years from the completion of translocation activities, the total number of plants within the translocation sites will be at least 20% more than the total number of plants impacted by the Project.

The health of translocated and propagated individuals will be equal to or greater than those within the disturbed site prior to disturbance occurring from the Project (according to age class) based on the following:

- Crown health;
- Reproductive capacity (i.e. recruitment).

There is a high degree of confidence (>90%) in the methods and outcomes outlined in this Plan as it has been developed and reviewed in correspondence with suitably qualified ecologists, cycad experts and approved *Cycas* and *Macrozamia* translocation plans.

- Competent and experienced operators on site doing the translocation;
- Improved methods of excavation (tree spades);
- Translocation of *M. conferta* is logistically easier to move (P. Forster pers. comm. 2021) (smaller plant and no emergent trunk will be easier to move with machinery and less damage to plant);
- Methods, management and monitoring based on approved methods of cycad translocation;
- Translocation sites selected to meet all habitat and ecological requirements of *M. conferta*.

Further, this plan has applied a risk-based approach, where the results of monitoring activities inform corrective actions to be applied. In addition, this plan has been reviewed by Dr Paul Forster from the Queensland Herbarium.

10.0 Risk Assessment and Corrective Actions

Salvage and translocation are a proven methods for mitigating the impacts of land clearing and has been undertaken successfully in previous *Cycas* and *Macrozamia* translocation programs (Queensland Herbarium 2007). *Macrozamia* translocation has been undertaken successfully with experienced personnel and careful excavation techniques as the key drivers of success (P. Forster pers. comm. 2021). In addition, *Macrozamia* translocation is logistically much simpler to do than *Cycas* translocation and may have higher success rates (P. Forster pers. comm. 2021) given:

- *M. conferta* is a much smaller plant that *Cycas*: plants can fit easily in a digger bucket;
- *M. conferta* do not have trunks like *Cycas*: increased damage of snapped trunks during translocation;
- *M. conferta* has a much more compact growth form with minimal area for damage (i.e. a ball) whereas *Cycas* have the caudex plus aerial trunk(s);
- To ensure the survival of translocated *M. conferta* and propagated seedlings in recipient translocation sites is successful, careful management and mitigation actions will be undertaken throughout the translocation process. To mitigate threats that impact the survival of *M. conferta* (see **Section 2.1**) and minimise the risk of loss and damage to individuals during and post translocation, the following actions in **Table 10.1** will be performed.

Table 10.1 Risks / Threats and Management Actions

Risk/Threat	Description	Management Action	Timeframe
Desiccation	Planting during poor climatic conditions in addition to insufficient watering can cause wilting, no nutrient uptake and eventually death	• Controlled watering in the case of dry events • Local water supply and water cartage tanks will be available on site so watering can be done where/when necessary	• Watering will begin when seedlings and individuals are first introduced into recipient sites and monthly post-introduction
Waterlogging	Too much watering can cause root rot and eventually death	• Controlled and monitor watering events and schedule with monthly rainfall received • Inspect 10 cm of surrounding surface soil to check if too wet, rescheduling of future watering (i.e. no watering necessary during wet season)	• Watering of seedlings and individuals be monitored and scheduled in accordance with rainfall patterns from first introduction into recipient sites and monthly post-introduction
Weed infestation	Limited weeds occur in the Project area and are unlikely to pose a threat to *M. conferta*. Nevertheless, there is a risk of woody weeds suppressing *M. conferta* growth and increasing fire fuel if they become established.	• Targeted manual and chemical weed control in accordance with the manufacturing label or an off-label permit issued by the Australian Pesticides and Veterinary Medicines Authority will be	• Until complete establishment of translocated and propagated seedlings

Risk/Threat	Description	Management Action	Timeframe
		conducted by trained personnel pre-translocation (see **Section 8.1.2**) and following translocation of *M. conferta* and seedlings. This will remove the risk of establishment of introduced weeds and accumulation of fire fuel. • Strict weed control hygiene will be followed during movement between Project footprint and recipient sites (see S**ection 8.1.2**) to reduce spreading of weeds	
Habitat destruction and loss of individuals	Due to livestock and native animal grazing and trampling, illegal harvesting, timber harvesting, fire, poisoning	• Fencing with access restriction (see **Section 8.1.1**) will be erected at recipient translocation sites and maintained post-translocation to prevent access of livestock and native animals, unauthorised personnel and vehicles • Weed control will reduce accumulation of standing fuel and accumulation of debris that may increase extreme fire events. • Current fire regimes will be monitored (i.e. conducting cool burns to reduce fuel loads) following RE-specific burns and fire breaks implemented and maintained	• Until complete establishment of translocated and propagated seedlings

This Plan has considered the risks that may inhibit achieving the completion criteria for the offset site, including risks that may be wholly outside the approval holder's control. The risks have been assessed using the Risk Matrix (see **Table 10.2**) supplied by the Department of Agriculture, Water, and the Environment.

Table 10.2 Risk Matrix (DAWE 2021)

RISK MATRIX	
Likelihood (L): A qualitative measure of likelihood how likely is it that this event/circumstances will occur both before and after management activities are implemented	
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the project
Possible	Might occur during the life of the project
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances
Consequence (C): Qualitative measure of what will be the consequence/result if the issue does occur	
Minor	Minor incident of environmental damage that can be reversed (*e.g. short-term delays to achieving strategy objectives, implementing low-cost, well-characterised corrective actions*)
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts (*e.g. short-term delays to achieving strategy objectives, implementing well-characterised, high cost/effort corrective actions*)
High	Substantial instances of environmental damage that could be reversed with intensive efforts (*e.g. medium-long term delays to achieving objectives, implementing uncertain, high-cost/effort corrective actions*)
Major	Major loss of environmental amenity and real danger of continuing (*e.g. strategy objectives are unlikely to be achieved, with significant legislative, technical, ecological and/or administrative barriers to attainment that have no evidenced mitigation strategies*)
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage (*e.g. strategy objectives are unable to be achieved, with no evidenced mitigation strategies*)

Final Risk Rating (R): A function of multiplying Likelihood (L) and Consequence (C)

		Consequence				
		Minor	Moderate	High	Major	Critical
Likelihood	Highly Likely	Medium	High	High	Severe	Severe
	Likely	Low	Medium	High	High	Severe
	Possible	Low	Medium	Medium	High	Severe
	Unlikely	Low	Low	Medium	High	High
	Rare	Low	Low	Low	Medium	High

The risks were assessed in the Risk Analysis Table to consider their severity, as defined by the Risk Matrix, before and after management actions.

Table 10.3 Risks associated with translocation and mitigation actions (DAWE 2021)

Risk Event	Risk Description	Initial Risk Rating*			Management Measures / Actions	Residual Risk Rating*			Performance Criteria	Management Triggers	Corrective Actions	Monitoring Mechanism
		L	C	R		L	C	R				
***Force Majeure* Events**												
Drought	Extreme weather event	Likely	Moderate	Medium	Local supply of water on site	Likely	Moderate	Medium	Monitoring post-translocation: ensure watering completed against schedule	There is a 10% decline in the translocated population compared with reference plots	Monitor watering schedule and plant and site conditions in accordance with climatic conditions	Monitor monthly rainfall and inspection of wilting
Cyclones/ Severe tropical lows / flooding	Extreme weather event	Likely	Moderate	Medium	Salvage and rehabilitation of damaged survivors and supplementary planting	Likely	Minor	Low		There is a 10% decline in the translocated population compared with reference plots		
Catastrophic Bushfire	Extreme weather event or uncontrolled burn causing habitat degradation and loss of biodiversity	Possible	Critical	Severe	Salvage and rehabilitation of damaged survivors and supplementary planting	Possible	Critical	Severe	Site maintenance: inspection of fire breaks and fuel load	There is a 10% decline in the translocated population compared with reference plots	Ensure fire breaks are maintained and fuel load reduced	Annual fire monitoring

Risk Event	Risk Description	Initial Risk Rating*			Management Measures / Actions	Residual Risk Rating*			Performance Criteria	Management Triggers	Corrective Actions	Monitoring Mechanism
		L	C	R		L	C	R				
Standard Risks												
The Offset failing (regardless of cause)	Target number of plants not achieved	Possible	Critical	Severe	Supplementary planting and propagation	Rare	Critical	High	Monitoring of *M. conferta* life stages post-translocation and site maintenance	There is a 10% decline in the translocated population compared with reference plots	In the event of total failure of the offset, the Department will require, and the approval holder commits to providing, a replacement offset. That replacement offset must be agreed with the Department within twenty-four months of the failure of the offset becoming apparent.	See monitoring schedule in **Table 9.1**.

Risk Event	Risk Description	Initial Risk Rating*			Management Measures / Actions	Residual Risk Rating*			Performance Criteria	Management Triggers	Corrective Actions	Monitoring Mechanism
		L	C	R		L	C	R				
Timber harvesting/collection	Loss of habitat and individuals	Unlikely	Moderate	Low	Fencing to prohibit entry from unauthorised personnel	Rare	Moderate	Low	No evidence of timber harvesting, fence maintenance	Evidence of trespassing	Increase restrictive measures	Annual maintenance
Unplanned or not controlled fire in offset area.	Loss of habitat and individuals	Unlikely	Moderate	Low	Fire breaks and fuel reduction methods	Rare	Moderate	Low	Low fuel loads and fire breaks	Scorch marks	Inspect and repair fire breaks and perform fuel load reduction	Annual maintenance
New infestations of invasive weed species in the offset area.	Degradation of habitat and suppression of individuals	Possible	High	Medium	Monitor existing density of known high threat weeds and during ongoing weed management practices	Unlikely	Low	Low	No high threat weeds	Weeds high threat present	Inspect and perform appropriate weed control methods where necessary	Annual maintenance

Risk Event	Risk Description	Initial Risk Rating*			Management Measures / Actions	Residual Risk Rating*			Performance Criteria	Management Triggers	Corrective Actions	Monitoring Mechanism
		L	C	R		L	C	R				
Expansion of existing infestations of declared weed species in the offset area	Degradation of habitat and suppression of individuals	Highly likely	High	High	Monitor existing density of known high threat weeds and during ongoing weed management practices	Unlikely	Low	Low	No high threat weeds	Weeds high threat present	Inspect and perform appropriate weed control methods where necessary	Annual maintenance
Unauthorised or inappropriate grazing in offset area	Loss of habitat and individuals	Possible	High	Medium	Monitoring for evidence of grazing disturbance	Unlikely	Minor	Low	No evidence of grazing or trampling, fence maintenance	Evidence of grazing disturbance	Increase restrictive measures	Annual maintenance

An overall confidence result of 90% has been given to the averted loss of *M. conferta*. This confidence in result relates to the level of certainty of the proposed methods in this Plan will be successful in improving the number of *M. conferta* individual plants being translocated. This confidence result takes into account not only the confidence in being able to achieve net gain in *M. conferta* but also takes into account the risk that the offset may not be delivered.

11.0 Outcomes

The long-term success of translocation programs can depend on a number of factors including, propagation techniques and personnel, suitability of the recipient site, genetic variation of the translocated individuals and the survival rate of the translocated plants. Given the translocated plants will be sourced from the immediate area and propagated seedlings will be replanted into an existing population of *M. conferta*, the majority of the aforementioned factors inhibiting success are minimised.

The implementation of this Plan will be considered a success where the translocation sites maintain a stable population of *M. conferta* at least 20% more than the number of plants impacted by the development of the Project.

11.1 Translocation Results

Table 11.1 provides a summary of the outcomes that will be achieved through this Plan and how translocation of *M. conferta* into recipient translocation sites (quantum of ecological benefit) is greater than the quantum of impact at the impact site (Project footprint).

Table 11.1 Outcomes of translocation of *M. conferta*

Proposed Outcome	Outcome Achieved
Evidence for all projected decline in site quality under the 'without offset' scenario	If *M. conferta* that occur in the Project footprint were otherwise not translocated into preferred habitat with existing populations, a total of 2,578 individuals would be cleared
Proposed sources of quality gain in the 'with offset' scenario, and a demonstration that those sources of gain are distinct from the 'business as usual' situation (that is, proving additionality) including all local council and state government obligations that currently exist	By the end of the translocation and monitoring period, translocation of 2,578 *M. conferta* and additional plantings of propagated individuals into recipient translocation sites will result in a net increase of 20% of individuals for recipient populations, including increased genetic diversity and protection from key threats,
Evidence that the proposed environmental improvements are achievable in the timeframe specified	The timeline for implementation of the Plan was prepared based on previous successful *Cycas* and *Macrozamia* translocation plans and the growth cycle of *M. conferta*.
If a risk of loss is being proposed for the site is higher than the risk of loss for the region, evidence of unique threats/risks at that specific site must be provided to justify the heightened risk of loss.	The risk of loss is not higher than the risk of loss for the region.
The legally-binding mechanism that will be used to secure the offset site in accordance with the Department's EPBC Act Offsets Policy and the Approval Conditions for the project	Recipient translocation sites are located in secured offset properties

11.2 Compliance with the Offsets Policy Principles

Offset requirements under the *EPBC Act Environmental Offsets Policy* (2012) have been met through the translocation design and recipient site selection and is described in **Table 11.2.**

Table 11.2 Offset Policy Principles addressed in the Plan

Principles of the Offset Policy	Offsets and Offset Proposals must:	Compliance:
1. Deliver an overall conservation outcome that improves or maintains the viability of the protected matter	• Improve or maintain the viability of the protected matter compared to what would have occurred under the status quo (i.e. no action and no offset), resulting in No Net Loss or a Net Gain for the protected matter (refer to **Section 3.1**) • Be like-for like; achieve a positive conservation outcome for the same protected matter as being impacted, and the same attribute (e.g. habitat type) or one of better conservation value. If this is not able to be achieved then the proposed impact may be deemed unacceptable. • Evidence that the protected matter is either on the offset site, or adjacent to (with connecting habitat/vegetation) and likely to inhabit the offset site once management makes it suitable for the matter • Be implemented for the duration of the impact (not just the action itself) • Not support or recreate non-endemic vegetation or ecosystems • Commit to a future quality that is equal to, or greater than, the quality of the impact site to be attained by the nominated time until ecological benefit and then maintained at for the duration of the impact (direct offsets only)	• The translocation plan will result in Net Gain for both translocated *M. conferta* and *M. conferta* in recipient population directly through increase in individuals in population, genetic diversity, legal protection and control and elimination of key threats to the species • The proposed offset will involve translocation of individuals to locations where suitable habitat occurs. As such this is a like-for-like solution. There will be a net increase in the total number of *M. conferta* as a result of the offset, along with other benefits such as improved genetic etc. • Field studies have recorded *M. conferta* at and adjacent to recipient translocation areas in preferred habitat that is remnant vegetation that is a part of/in proximity to state and regional corridors. • Translocation sites will be protected through the proposed protection mechanism registered on the land title. • *M. conferta* is endemic to the region and translocation will not involve the use of any non-endemic vegetation. • Recipient translocation sites provide preferred habitat requirements to *M. conferta* and will be managed to achieve a self-sustaining population.
2. Be built around direct offsets but can include other compensatory measures	• Be at least 90% direct offset • Direct offsets provide a measurable conservation gain for the impacted protected matter • Other compensatory measures must lead to benefits for the same aspect of the impacted protected matter • Address key threats and priority actions in relevant Recovery Plans, Threat Abatement Plans, Conservation/Listing Advice • Be legally secured for conservation purposes (i.e. protection mechanism that changes land tenure) for at least the duration of the impact if there is a risk of loss or degradation of the site without offset • The most secure and permanent protection mechanisms available should be used, and they	• The translocation is 100% direct offset with 103.78% of impact offset by end of 20 year plan. • Key threats have been reviewed from the Multi-species National Recovery Plan for Cycads and Approved Conservation Advice and have been incorporated into the objectives and methods of translocation and management actions with the goal of controlling or eliminating these. • Recipient translocation areas will be legally secured under a Voluntary Declaration under the *Vegetation Management Act 1999* which is the most secure and permanent protection mechanism available. Declaration ensures legal binding of current and

Principles of the Offset Policy	Offsets and Offset Proposals must:	Compliance:
	should restrict activities not conducive to conservation of the protected matter	
3. Be in proportion to the level of statutory protection that applies to the protected matter	• Consider the accurate level of statutory protection (vulnerable, endangered or critically endangered) for the listed threatened species or ecological community • This is achieved by selecting the correct category in the 'EPBC Act status' box of the Offsets Assessment Guide (Offsets Calculator). Note where a matter has been uplisted in the time since approval, the uplisted status is generally required to be used.	• *M. conferta* is listed as Vulnerable under EPBC Act and NC Act and has been incorporated into the Offset Assessment Guide Calculator.
4. Be of a size and scale proportionate to the residual impacts on the protected matter	• Detail the attributes of the protected matter being impacted, the quality and importance of those attributes, the nature of the impact (e.g. permanent or temporary), the level of threat applicable to the offset site, the time it will take to achieve a conservation gain for the protected matter, and risk of the conservation gain not being realised. • Ensure that offsets calculations for threatened species and ecological communities are as accurate as possible and implement the Precautionary Principle where there is scientific uncertainty	• Individual *M. conferta* plants likely to be impacted by the Project will be translocated to suitable recipient sites. In addition, plants will be propagated in a nursery for supplementary planting at the recipient site so that there is a net increase in the number of plants. The net increase, and therefore net gain, will be achieved within 5 years of commencement of the Plan. • The offset calculations are based on achieving a net increase of 20% additional plants at recipient sites in addition to the plants translocated. The number of plants likely to be impacted has been conservatively calculated, but is likely to be fewer than current calculations as construction methodologies are employed to avoid impacts where possible.
5. Effectively account for and manage the risks of the offset not succeeding	• Consider the reduced risk of using direct offsets compared to other compensatory measures • Advanced offsets reduce this risk further • Include a risk analysis of factors that could affect the success of the offset (i.e. attain the completion criteria by the nominated time until ecological benefit and maintain this for the duration of the impact), with input from multiple environmental specialists • Assess the potential effectiveness of each management and corrective action (including for stochastic events), financial and business limitations, possible perverse outcomes from the offset, and any other potential limiting factors • Propose compensatory measures for if the offset fails, such as additional offsets to compensate for both the impact and failed offset	• A risk analysis against the risk matrix was used to assess the risk of translocation not succeeding. In addition to key threats that directly impact *M. conferta* survival, appropriate contingency measures are planned to ensure that the offset provides a net benefit. The first level of contingency involves seed collection and propagation in a nursery before planting out at recipient sites. The second level of contingency involves propagation using tissue culture and planting out at recipient sites.

Principles of the Offset Policy	Offsets and Offset Proposals must:	Compliance:
	• Details of how and when the Precautionary Principle has been applied	
6. Be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs	• Detail the duty of care requirements applicable to the offset site, such as the landowner's responsibility to control certain weeds and feral animals • Specify environmental planning laws that apply to the offset site (e.g. statutory protection of riparian areas) • Conservation gains paid for, or achieved, while participating in other schemes (e.g. carbon offset scheme) • Provide conservation gains that are in addition to duty of care, environmental planning laws or other schemes	• Voluntary declaration under Queensland *Vegetation Management Act 1999* will ensure that the offset site is protected. This method links the protection of the site with the implementation of this Plan. • Conservation gains are achieved through declaration as landholders are participating in conservation incentive programs, provision of legal security for offset areas required under the *Environmental Offsets Act 2014*
7. Be efficient, effective, timely, transparent, scientifically robust and reasonable	• Maintain or improve the viability of the protected matter through sound allocation of resources, including for any required management and monitoring of the offset • Be implemented before, or at the same time as, the impact occurring • Be based on scientifically robust and verifiable information, including best-practice surveys undertaken by suitably qualified experts • All supporting evidence must be provided to the Department, and any assumptions or limitations must be specified • The Precautionary Principle must be implemented if there is not scientific certainty • Use scientifically robust and peer-reviewed methods for collecting and analysing environmental data • Have realistic offset commitments and completion criteria that are likely to be achieved despite any potential threats or risks	• Maintenance and monitoring requirements are explicitly outlined in the Plan to achieve a net benefit to the species a self-sustaining population is established that will persist post the implementation of the Plan. • Translocation sites will be established with key risk controlled (including stock exclusion fencing) prior to receiving translocated plants. • Translocation activities will occur prior to construction at each location. • The results of monitoring programs assessing the success of the Plan against key completion criteria will be provided to the Department as outlined in this Plan. • Proposed translocation and propagation methodologies outlined in this Plan have been peer-reviewed by the Queensland Herbarium. • This Plan incorporates feedback from the peer-review and includes realistic and achievable completion criteria and timeframes.
8. Have transparent governance arrangements including being able to be readily measured, monitored,	• Detail governance of the offset site, including ensuring that offset actions are fully funded for the required timeframe • Commitments to measure and monitor the performance of the offset, and report on this annually to the Department	• Implementation of the Plan will be overseen by ACCIONA during the construction and operation of the Project. Funding of the Plan, including management and monitoring, will occur as part of delivery of the Project. • Auditable performance and completion criteria are stated to assess overall translocation success, monitoring and site maintenance actions and

Principles of the Offset Policy	Offsets and Offset Proposals must:	Compliance:
audited and enforced	• As appropriate, be delivered through contractual arrangements with a third party • Ensure that offset commitments are measurable and specific so that they can be audited and enforced	further actions are provided where these are not complied with. • Corrective actions are explicitly stated to address poor outcomes

12.0 References

AECOM. (2011). Translocation Program for *Macrozamia pauli-guilielmi.* Wide Bay Training Area DEOS MIRF. AECOM Australia Pty Ltd.

Anon, BLOGS.IFA2 1996. University of Florida – Institute of Food and Agriculture. http://blogs.ifas.ufl.edu/news/1996/02/16/ufifas-cycad-research-helps-save-living-fossils/, accessed 2/07/2021.

Australia Pacific LNG. (2014). *Cycas megacarpa* Management and Translocation Plan. Revision 8.

Banack, S. & Cox, P. (2003). Biomagnification of cycad neurotoxins in flying foxes: Implications for ALS-PDC in Guam. Neurology 61:387-389.

Batianoff, G. N., & Butler, D. W. (2002). Assessment of invasive naturalized plants in south-east Queensland. Plant Protection Quarterly, 17(1), 27-34.

Chaplot, B. B. and Jasrai, Y.T. 2000. Differentiation of shoot buds in bulb-scale cultures of Cycas revoluta Thunb. Phytomorphology 50: 37-40.

Charvez, V. M., Litz, R.E. Organogenesis from megagametophyte and zygotic embryo explants of the gymnosperm Dioon edule Lindley (Zamiaceae, Cycadales). Plant Cell, Tissue and Organic Culture58, 219-222.

Chemnick, J. (2007). Seed dispersal agents of two Mexican cycads. In A. P. Vovides, D. Stevenson, and R. Osborne [eds.], Proceedings of Cycad 2005 the 7th International Conference on Cycad Biology. New York Botanical Gardens Press, New York, New York, USA.

Commander, L. E., Coates, D. J., Broadhurst, L., Offord, C. A., Makinson, R. O. & Matthes, M. (2018). Guidelines for the translocation of threatened plants in Australia. Australian Network for Plant Conservation Incorporated.

Department of Environment and Science (DES). (2021). Species Profile – *Macrozamia conferta.* Accessed 24/06/2021.

Department of the Environment, Water, Heritage and the Arts (DEWHA). (2008). *Macrozamia conferta* in Species Profile and Threats Database, Department of the Environment, Water, Heritage and the Arts, Canberra. Accessed 24/06/2021.

Donaldson J. S., Dehgan B., Vovides A. P. & Tang W. (2003) Cycads in trade and sustainable use of Cycad populations. In: Cycads Status Survey and Conservation Action Plan (ed J. S. Donaldson). IUCN, Gland, Switzerland.

Donaldson, J. S. 2003. Cycads: Status Survey and Conservation Action Plan. IUCN/SSC Cycad Specialist Group, IUCN, Gland, Switzerland and Cambridge, UK.

Eckenwalder, J. E. (1980). Dispersal of the West Indian cycad *Zamia pumilia* L. Biotropica 12: 79-80.

Forster, P. I., Machin, P., Mound, L. & Wilson, G. (1994). Insects associated with the reproductive structures of cycads in Queensland and north-east New South Wales, Australia. Biotropica 26: 217-222.

Franklin, I. R. 1980. Evolutionary change in small populations. Pages 135 – 140 in: Soule. M. E. and Wilcox. B. A. (eds.), Conservation Biology: An Evolutionary-Ecological Perspective. Sunderland, Mass.: Sinauer Associates.

GHD. (2021). Listed threatened ecological communities, species and migratory species. Overhead Transmission Line Project – Appendix C. ACCIONA Energy Australia Global Pty. Ltd. 92-94.

Halford, D. (1997). *Macrozamia conferta*, in Species Management Manual. Department of Natural Resources, Brisbane.

Hall J. A. & Walter G. H. (2013) Seed dispersal of the Australian cycad *Macrozamia miquelii* (Zamiaceae): are cycads megafauna-dispersed "grove forming" plants? Am. J. Bot. 100, 1127–36.

Halliday, J. & Pate, J. S. (1976). Symbiotic nitrogen fixation by coralloid roots of the cycad *Macrozamia riedlei*: physiological characteristics and ecological significance. Australian Journal of Plant Physiology 3, 349-358.

Jones, D. L. & Forster, P. I. (1994). Seven new species of *Macrozamia* section *Parazamia* (Miq.) Miq. (Zamiaceae section *Parazamia*) from Queensland. Austrobaileya 4(2): 271.

Jones, D. L. (2002). Cycads of the world, 2 ed. Reed New Holland Books, Sydney, Australia.

Loaring, W. A. (1952). Birds eating the fleshy outer coat of zamia seeds. Western Australian Naturalist. 3, 94.

Nadarajan, J., Benson, E. E., Xaba P., Harding K., Lindstrom A., Donaldson J., Seal C. E., Kamoga D., Agoo E. M. G, Li N., King E. & Pritchard H. W. Comparative Biology of Cycad Pollen, Seed and Tissue - A Plant Conservation Perspective. The Botanical Review 84: 295 – 314.

NGH Environmental. (2020). Cycad Translocation and Management Plan – Clarke Creek Wind Farm. NGH Environmental Pty Ltd.

Norman M. A. & Mullins R. G. (2005) Effect of Seed Age, Sowing Season and Burial Depth on Establishment of Zamia (Macrozamia reidlei). Alcoa World Alumina Australia, Perth.

Norstog, K. J. & Nicholls, T. J. (1997). The Biology of the Cycads. Cornell University Press, Ithaca and London.

Ornduff R. (1990) Geographic variation in reproductive behavior and size structure of the Australian cycad Macrozamia communis (Zamiaceae). Am. J. Bot. 77, 92–99.

Ornduff R. (1991) Coning phenology of the cycad Macrozamia riedlei (Zamiaceae) over a five-year interval. Bull. Torrey Botanical Club 118, 6–11.

QGC. (2016). *Cycas megacarpa* Translocation and Management Plan. QCLNG Pipeline Project.

Queensland Herbarium. (2007). National Multi-species Recovery Plan for the cycads, *Cycas megacarpa, Cycas ophiolitica, Macrozamia cranei, Macrozamia lomandroides, Macrozamia pauli-guilielmi* and *Macrozamia platyrhachis*. Queensland Parks and Wildlife Service, Brisbane.

Queensland Herbarium. HERBRECS. (2008). *Macrozamia conferta*, in BriMapper version 2.12. Queensland Herbarium. Accessed 24/06/2021.

Rodríguez de la O., Lazarous J., Flores V.A., Robledo Monterrubio M.S., Contreras Cruz F. 2019 Evaluation of responses embryogenic Cycas revoluta thumb., from callus culture obtained in vitro, Journal of Applied Biotechnology and Bioengineering, Volume 6 issue 4

Rowe, T. and Rowe, C. (1995). Transplanting *Cycas ophiolitica*. Palms and Cycads 47, 15-17.

Santos GLNG. (2013). *Cycas megacarpa* Management and Translocation Plan. GLNG Gas Transmission Pipeline.

Teixeira da Silva, J.A., W.R. Woodenberg, & SA. Zeng. 2014. Cycads in vitro. Plant Tissue Culture & Biotechnology 24: 287–301.

Terry I., Forster P., Moore C. J., Roemer R. B. & Machin P. J. (2008) Demographics, pollination syndrome and conservation status of *Macrozamia platyrhachis* (Zamiaceae), a geographically restricted Queensland cycad. Austral. J. Bot. 56, 321–32.

Terry, I. (2001). Thrips and weevils as dual, specialist pollinators of the Australian cycad *Macrozamia communis* (Zamiaceae). International Journal of Plant Sciences 162, 1293-1305.

White, L. M. (1912). Notes on the cassowary (*Casuarius australis*, Wall). Emu 12: 172-181.