17. TERRESTRIAL ECOLOGY

This chapter describes the terrestrial ecology values within and surrounding the project area, assesses the potential impacts of the project on these values and describes the measures Arrow Energy will implement through project design, construction, operation and decommissioning to manage impacts on these terrestrial ecology values.

This chapter is based on information in the terrestrial ecology impact assessment (Appendix 9, Terrestrial Ecology Impact Assessment) and the pest management plan (Appendix 10, Pest Management Plan). Both studies were prepared by Ecosure Pty Ltd. A bushfire hazard and risk assessment prepared by Eco Logical Australia Pty Ltd (Appendix 26, Bushfire Hazard and Risk Assessment) is discussed in Chapter 29, Hazard and Risk. Some elements of the bushfire study are reported in this terrestrial ecology chapter where they relate to potential changes in the burning regime associated with the project.

Impacts on freshwater ecology and marine ecology (below highest astronomical tide (HAT)) are discussed in Chapter 18, Freshwater Ecology, and Chapter 19, Marine and Estuarine Ecology. Areas of intertidal mudflat are assessed in this chapter for their importance to shorebird species and mangrove habitat for water mouse.

The objectives for terrestrial ecology have been developed based on the relevant legislative context with the aim of protecting the existing values. The objectives for terrestrial ecology are set out in Box 17.1.

Box 17.1 Objectives: Terrestrial ecology

- To avoid or reduce the adverse effects on terrestrial ecology values during project construction, operation and decommissioning.
- To protect terrestrial ecology and associated biodiversity of state and national significance.
- To prevent the introduction and spread of new or existing weeds or plant and animal pathogens.
- To avoid or reduce the direct loss of terrestrial habitat and achieve a net gain biodiversity offset.

17.1 Legislative Context and Standards

This section outlines the specific legislation and policies that are enforced to protect the values of the terrestrial ecology environment within and surrounding the study area.

17.1.1 Commonwealth and State Legislation

The following legislation and guidelines are relevant to managing impacts to terrestrial ecology through all project phases:

- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act). The act provides for the protection of matters of national environmental significance (MNES), including listed threatened species and ecosystems, listed migratory species and protected areas. The development proposal has been declared a controlled action under the EPBC Act, and the EIS must address potential impacts on MNES identified under the EPBC referrals for the project (EPBC 2009/5007 and EPBC 2009/5008).

  Threatened ecological communities and flora and fauna species of conservation significance (including listed migratory species) are discussed in this chapter.

- *The Environmental Protection Act 1994* (Qld). This act provides for the protection of Queensland's environment while allowing for ecologically sustainable development. The Environmental Protection Regulation 2008, in accordance with the act, lists category A and B environmentally sensitive areas (ESAs) that are protected and may be impacted by the project and regulates environmentally relevant activities. Category C ESAs are not listed under the schedules of the regulations to the act and are provided within the Draft Code of Environmental Compliance for Level 2 Petroleum Activities forming part of the environmental compliance and conditioning framework.

- *Vegetation Management Act 1999* (Qld). The act regulates clearance of native vegetation on freehold and leasehold land and seeks to maintain ecological function in these areas. The Vegetation Management Regulation 2000 classifies regional ecosystems (REs) in accordance with the act, and provides a list of 'endangered', 'of concern' and 'of least concern' regional ecosystems. Regional ecosystems are defined according to their vegetation management status and biodiversity status, and are listed in the regional ecosystem description database maintained by the Department of Environment and Resource Management (DERM, 2011g).

  The Regrowth Vegetation Code sets out the requirements for clearing high value regrowth vegetation under the Vegetation Management Act. Exemptions to the code apply to clearing of regrowth vegetation as the holder of a petroleum authority. Schedule 6 applies to clearing for an extractive industry that is not in a key resource area. Clearing for extractive industry in a key resource area is exempt and this code does not apply, although the permit holder must account for impacts to biodiversity, and demonstrate that no alternative exists and that clearing is limited to the extent necessary for construction and operation of the project.

  Any clearing must maintain bank stability and water quality if carried out in stream protection zones, the Great Barrier Reef protection area or within 100 m of a wetland. The Great Barrier Reef Marine Park is discussed in Chapter 19, Marine and Estuarine Ecology.

- *Nature Conservation Act 1992* (Qld). The act is the principal legislation in Queensland that supports biological diversity, ecologically sustainable use of wildlife and ecologically sustainable development, and the conservation of nature that may be impacted by the project. The act places requirements on any person taking, using or interfering with protected flora or fauna. Subordinate to the act are:

  – Nature Conservation (Protected Areas) Regulation 1994 (Qld) identifies national parks, conservation parks, resource reserves and nature refuges that are of particular importance to terrestrial ecology.

  – Nature Conservation (Wildlife) Regulation 2006 (Qld) defines the conservation status of native wildlife species in Queensland and non-native species with a declared management intent for each class.

- *Land Protection (Pest and Stock Route Management) Act 2002* (Qld). The act regulates the use of the stock route network in Queensland and provides a framework for the management of pest flora and fauna. The act designates exotic species that threaten natural resources, conservation of biodiversity and remnant vegetation, reduce agricultural production and interfere with human health. The declaration of a pest places a legal obligation on landholders to control or eradicate the species.

17.1.2 Plans, Policies and Environmental Management

The following key non-statutory mechanisms apply to terrestrial ecology and the Arrow LNG Plant:

- Code of environmental practice for onshore pipelines (APIA, 2009). The code includes industry standard management measures to alleviate the environmental impact of pipeline projects in construction and operation.
- Draft policy statement for the use of environmental offsets under the EPBC Act (DEWR, 2007). The statement outlines the position of the Commonwealth Government on environmental offsets under the EPBC Act, and ensures the consistent application of offsets to projects under the act.
- Queensland Government environmental offsets policy (EPA, 2008b). The policy aims to address impacts to biodiversity values which may be lost as a result of development or other activities and sets out the Queensland Government's policy on offsets.

  Subordinate to the policy is the Queensland biodiversity offset policy (DERM, 2011h). This policy came into effect in October 2011 and provides a framework for the long-term protection of Queensland's biodiversity. The policy is relevant where residual impacts on state significant biodiversity values are unavoidable.
- Policy for vegetation management offsets (DERM, 2011l). The policy describes vegetation management offsets required for development and infrastructure projects under state government legislative control, to ensure the long-term conservation of remnant regional ecosystems, and sets criteria for acceptable offsets.
- Biodiversity planning assessments (EPA, 2002). Prepared by DERM, the assessments identify areas of state, regional and local biodiversity significance. The assessments for several of Queensland's bioregions determine biodiversity significance on the basis of ecological criteria including ecosystem diversity, condition, connectivity, tract size and habitat value. The assessments are used by statutory bodies to inform the decision making process in conservation planning.

17.2 Assessment Method

The terrestrial ecology impact assessment was carried out through literature review, field survey and assessments (Appendix 9, Terrestrial Ecology Impact Assessment). The study method has adopted the significance (sensitivity and magnitude) approach.

17.2.1 Baseline Assessment

The study area is shown in Figure 1.2 and encompasses all the area that will be disturbed or potentially disturbed as a result of project activities on Curtis Island and the mainland. Terrestrial ecology field surveys undertaken for the project were concentrated in the study area.

The project area is defined as the actual footprint of the project also shown on Figure 1.2.

Desktop Study

A literature review identified flora and fauna species present in the study area.

Database searches and the literature review also included an area extending 30 km from the study area boundary to identify all significant species with the potential to occur within the study area. Environmental databases used in the desktop flora and fauna studies included:

- Commonwealth's online EPBC Protected Matters Search Tool (DSEWPC, 2011c).
- DERM wildlife online database (DERM, 2010a).
- DERM regional ecosystem description database (REDD) (DERM, 2011g).
- DERM biodiversity planning assessment GIS database (BAMM) (EPA, 2002).
- DERM Wetland*info* database (DERM, 2011c).
- Queensland Herbarium HERBRECS database (DERM, 2011i).
- Queensland Museum collection database (Queensland Museum, 2011).
- Birds Australia atlas GIS database (Birds Australia, 2011).

Datasets obtained from these sources and the literature review were used to identify significant flora and fauna species and ESAs potentially occurring within the study area to be targeted in the field surveys.

Other literature reviewed included technical reports, field guides, primary texts and reports from other projects considered in the baseline and cumulative assessment. In particular, the other environmental impact assessments in the public domain relating to LNG proponents on Curtis Island were checked for comparative purposes and to validate the current study.

The literature review for the pest management plan incorporated data from Biosecurity Queensland's annual pest survey distribution (Biosecurity Queensland, 2009) and the Queensland Herbarium naturalised flora database, in the Census of the Queensland Flora (Bostock & Holland, 2010).

Field Survey

Field surveys undertaken for the project consisted of both flora and fauna surveys.

Flora

A survey program over four stages was undertaken between 2009 and 2011. All surveys were undertaken following the process set out by the Queensland Herbarium (Neldner et al., 2005) and data collected within the surveys will be submitted to the Queensland Herbarium.

The field surveys covered a range of seasonal conditions and included a preliminary survey of the study area, detailed surveys within DERM-mapped remnant and regulated regrowth vegetation, surveys of areas with a potentially new species of tuckeroo (*Cupaniopsis* sp. indet) and surveys focused on areas of project infrastructure including the mainland tunnel entry shaft and tunnel spoil disposal area, the headland between North China Bay and Hamilton Point on Curtis Island, and two potential temporary workers' accommodation facility (TWAF) locations on the mainland.

Assessment sites during fieldwork were allocated within REs, regulated regrowth vegetation or non-remnant vegetation. Seventy-three sites were assessed with most RE types having multiple assessment sites. Secondary, tertiary and quaternary assessments were conducted.

A floral inventory was compiled and relative abundance of species assessed. The ecologically dominant layer was given most focus, as the species in this stratum define the community and allows the classification of RE type.

REs mapped by DERM were validated in the field using transect data and geological mapping. Where required, the boundaries of REs were remapped using hand held GPS and the assistance of aerial photography.

A random meander technique (Cropper, 1993) was also employed to obtain representative site coverage and to identify further flora species not identified at one of the assessment sites. Field surveys also established areas of weed infestation and habitat for rare and threatened species.

Fauna

The fieldwork took place over five survey events between 2009 and 2011. The surveys targeted species listed under the EPBC Act or Nature Conservation Act, and all broad habitat types in the study area. Areas of remnant vegetation and regulated regrowth vegetation were targeted as well as determined by aerial photograph interpretation.

The field surveys included a preliminary survey of the study area, wet season conditions on the mainland, opportunistic surveys on Curtis Island and parts of the mainland, detailed surveys within DERM mapped remnant and regulated regrowth vegetation and habitats over the whole of the study area to cover the main habitat types and incidental observations during supplementary surveys for *Cupaniopsis* sp. indet throughout the study area.

A range of survey techniques was employed based upon habitat type, condition, ecological value and likely presence of conservation listed species.

A fauna inventory was compiled for survey sites and the study area as a whole, with the habitat value of the study area assessed in relation to fauna presence and distribution.

Survey Limitations

Full details of the desktop study, field survey methods and survey limitations are presented in the terrestrial ecology assessment (Appendix 9, Terrestrial Ecology Impact Assessment). Of note is the timing of the surveys in the dry season only. Heavy rain prevented detailed surveys being undertaken in the planned wet season in February 2010. Access to launch site 1 and TWAF 7 was not possible during the field surveys. Both sites were included in the literature review and surveyed from public access points on the perimeter.

Overall, the assessment provides a valid representation of the flora and fauna of the study area. Species considered likely to occur in the study area were carried forward to the impact assessment, whether they were recorded by field survey or not.

17.2.2 Impact Assessment

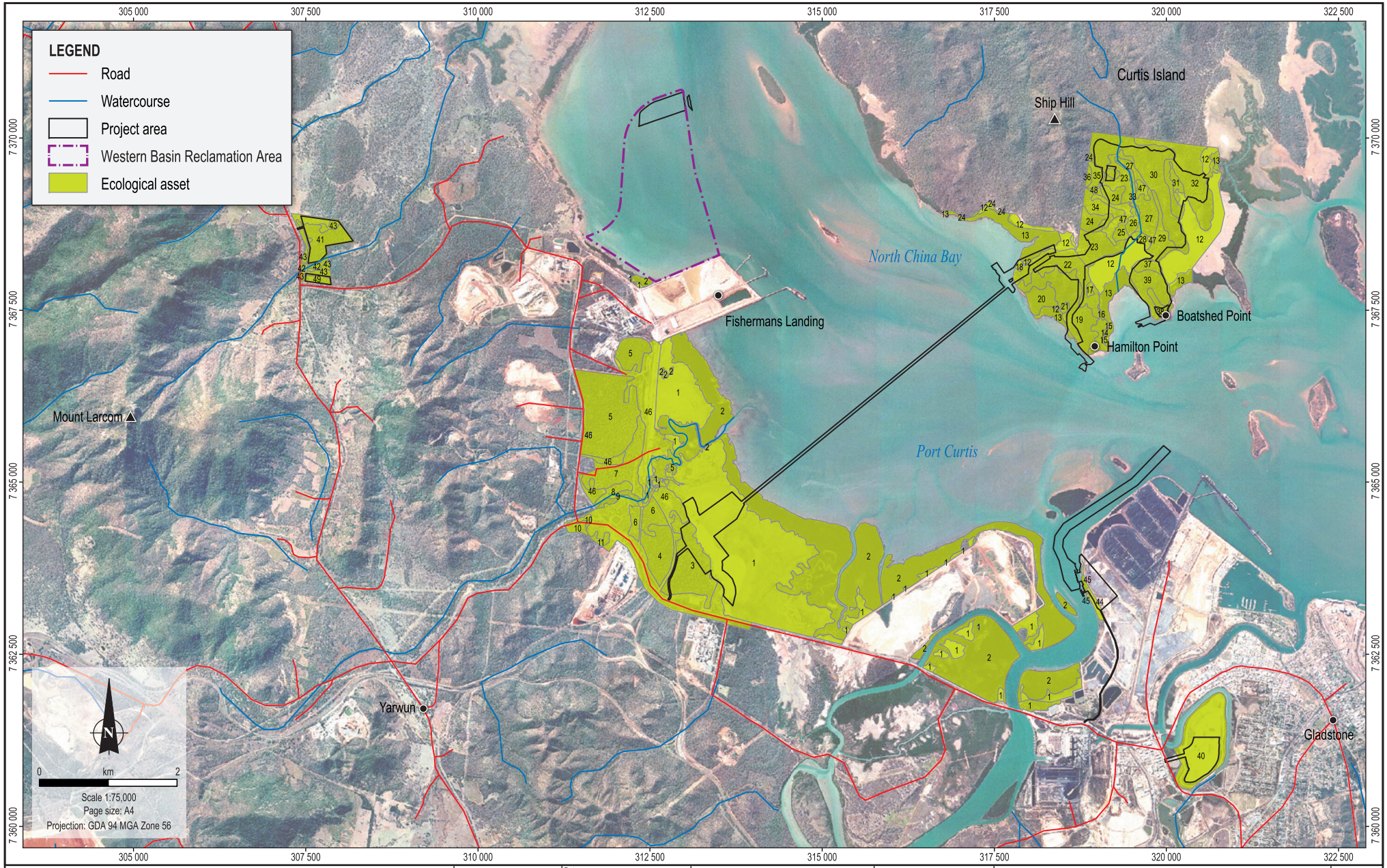
The terrestrial ecology impact assessment assigned ecological attributes to assessment units (ecological assets) based on vegetation community type across the study area. The assessment units are shown in Figure 17.1.

Forty-nine ecological assets were mapped based on ground truthed regional ecosystem data and desktop and field surveys. Areas that were field-validated as non-remnant vegetation within the study area were grouped within the mainland tunnel entry shaft and tunnel spoil disposal area, and TWAF 8 on the mainland, and on Curtis Island were grouped depending on whether or not they were in the construction footprint.

Three key attributes (species, community and function) were considered to form the overall ecological asset. The sensitivity of each ecological asset was assessed as very high, high, medium, low or very low sensitivity using the five criteria set out below:

- Conservation status. Defined through an assessment of statutory designations applicable to the asset, an assessment of biodiversity values through the desktop review and field survey and the likelihood of species of conservation significance being present. Sensitivity categories for the definition of conservation status are shown in Table 17.1.

  Threatened flora and fauna species known to be present within each asset, or assessed as a moderate or above likelihood of being present within each value, are included in the assessment of conservation status of each value.



Source:
Place names, roads and watercourses from DME.
Ecological assets (values based on regional ecosystem ground truth data) from Ecosure.
Project area and digital elevation model from Coffey Environments.
Western Basin Reclamation Area from Gladstone Ports Corporation.

Imagery from SPOT (2004-2007).
Note:
Numbering represents unique identification number allocation to ecological assets mapped by Ecosure

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Arrow Energy

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Ecological assets assessed

Figure No: 17.1

Table 17.1 Definition of conservation status

Conservation Status	Relevant Value
Very high	Great Barrier Reef World Heritage Area. Conservation reserves. Marine protected areas (including Great Barrier Reef Marine Park). National parks. Critically endangered ecological communities (Commonwealth). Endangered ecological communities (Commonwealth). Endangered REs (Queensland). Regulated regrowth, analogous with endangered regional ecosystems, in a restricted area (Queensland). Significant coastal wetlands (Queensland).
High	Core habitat of listed fauna species. Marine plants as defined by the Fisheries Act. Of concern regional ecosystems (Queensland). Regulated regrowth, analogous with endangered regional ecosystems, not in a restricted area (Queensland). Presence of a listed flora species (Commonwealth and state). Essential habitat (Queensland).
Medium	State forest where listed for conservation. Non-core habitat of listed fauna species. Least concern regional ecosystems (Queensland). Regulated regrowth, analogous with of concern or least concern regional ecosystems in a restricted area (Queensland). Habitat for listed flora species (Commonwealth and state). Flora or fauna at or beyond their distributional range.
Low	Regulated regrowth, analogous with of concern or least concern regional ecosystems, not in a restricted area (Queensland).
Very low	Non-remnant vegetation.

- Intactness. Whether the asset is intact in its existing state or heavily fragmented, and how representative it is in possessing characteristics that are features of that particular ecosystem. An asset would score very highly for this criterion where it is equivalent to the benchmark for that regional ecosystem. Its score would be low where it is fragmented and contains very few of the characteristics typical of that regional ecosystem.
- Uniqueness or rarity. The abundance and distribution of the asset within and beyond the study area, and bioregion. An asset would be considered to have a very high uniqueness value where it is the only known example of that asset within the Gladstone region. An asset would have a very low uniqueness value where it is considered common within the Gladstone region.
- Degree of non-resilience to change. How easily the asset is able to adapt to change without affecting its conservation status, intactness or uniqueness, and how quickly the asset is able to return to a state comparable to the status quo. An asset with a very high score for this criterion would be extremely sensitive to change. It may require 25 years or more to naturally return to a state comparable to the original. An asset with a low score may be able to naturally return to original state within less than one year. An asset with a very low score for this criterion would be insensitive to change, and any impact would be minimal.

- Degree of difficulty of replacement. How hard it is to replace any losses of the asset and offset the asset within the region. An asset with a very high score would be one that was almost impossible to offset. An asset with a very low score would have readily available areas that could be used as offsets within the Gladstone region.

The magnitude of a potential impact on each ecological asset was determined as very high, high, medium, low or negligible using the three key attributes below:

- Geographical extent. Whether the impact occurs at a site, local, regional or statewide/national level. The geographical extent would be defined as very high where the project impact has a national or international effect. The magnitude would be negligible where the impact was wholly contained within the project area.
- Duration. The timescale of the impact occurring, ranging from in perpetuity to less than a day. The duration would be very high where it is expected to last in perpetuity. High duration may be considered greater than five years and medium would be from one to five years. It would be low where duration is expected to last less than one year and negligible where duration is expected to last less than a day.
- Severity. An assessment of the degree of change from the existing condition of the asset. The severity would be considered to be very high where there is an extensive impact that could potentially lead to extinction or system collapse. A high severity impact would potentially result in irreversible or long-term loss or damage. A moderate severity impact may result in a permanent reduction in local/regional biodiversity values. A low severity impact would result in limited loss or disturbance and impacts on biodiversity, which would be considered limited and/or temporary. A negligible severity would relate to an impact with undetectable or minor impacts and may have a positive impact on the ecological value. This might include activities such as the control of pest species or habitat rehabilitation.

The sensitivity of ecological assets and the magnitude of each impact were then assessed to determine the significance of an impact on the terrestrial ecology values of the study area using the matrix in Table 17.2.

Table 17.2 Matrix of significance

	Sensitivity of Environmental Asset				
Magnitude of Impact	**Very High**	**High**	**Medium**	**Low**	**Very Low**
Very High	Major	Major	High	Moderate	Moderate
High	Major	High	Moderate	Moderate	Minor
Medium	High	Moderate	Moderate	Minor	Negligible
Low	Moderate	Moderate	Minor	Minor	Negligible
Negligible	Moderate	Minor	Negligible	Negligible	Negligible

Significance levels were defined as follows:

- Major impact significance. An impact on an ecological asset that is irreplaceable due to its uniqueness or rarity, which is long term, irreversible or widespread. The only effective forms of mitigation are avoidance or offsets.
- High impact significance. Where proposed activities are likely to exacerbate existing threatening processes, affecting the intrinsic characteristics and structural elements of the ecological value. While replacement of unavoidable losses is possible, avoidance through

appropriate design responses is preferred in order to preserve intactness or conservation status.

- Moderate impact significance. Occurs where, although reasonably resilient to change, the ecological asset would be degraded/further degraded due to the scale and nature of the works, or its susceptibility to further change. The abundance of the ecological asset ensures it is adequately represented in the region and that replacement, if required, is achievable.
- Minor impact significance. Occurs where an ecological asset is of local importance and temporary and transient changes will not adversely affect its viability, provided standard environmental controls are implemented.
- Negligible impact significance. An impact that will not result in any noticeable change in the intrinsic value of the ecological asset. This typically occurs where the activities take place in industrial or highly disturbed areas.

17.3 Existing Environment and Environmental Values

This section outlines the existing environmental values which occur within the study area in order to establish baseline conditions against which to assess potential impacts of the project. These existing environmental values incorporate both the physical habitat and existing flora and fauna, and are based on findings during field investigations and the desktop study.

17.3.1 Bioregion Context

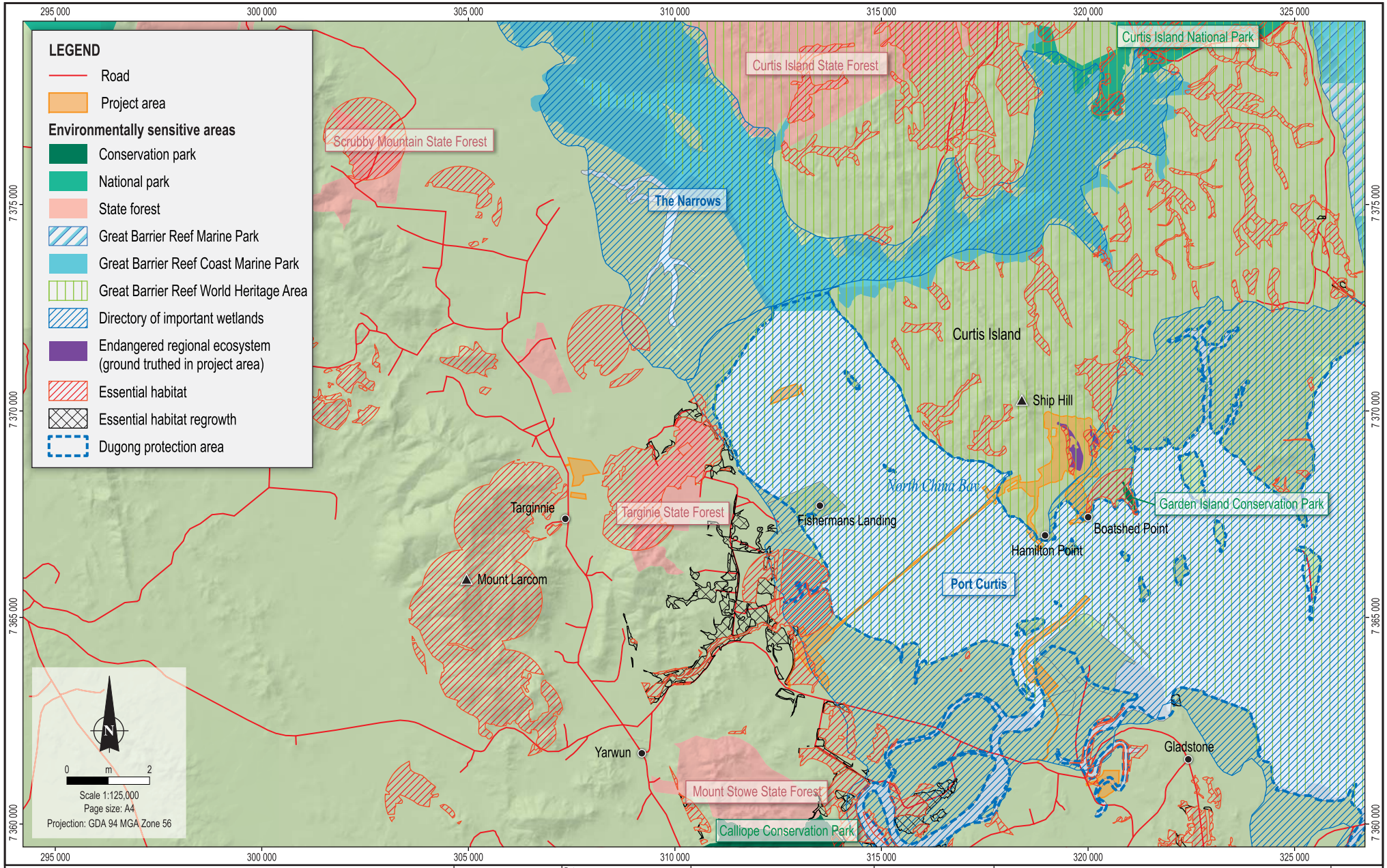
The study area is situated at the junction of three bioregions. The boundaries reflect the major underlying geology, landscape and climate patterns of each area.

The study area is located within the Southeast Queensland bioregion. This bioregion possesses a wide range of habitats and associated flora and fauna species, with high rates of endemism and substantial numbers of conservation listed species. Within the Southeast Queensland bioregion, there are ten subregions, with the study area situated within the Burnett-Curtis Hills and Ranges subregion. The eastern part of the subregion, within which the study area is located, is characterised by granite hills and ranges in the east (GHD, 2009d).

The Brigalow Belt North and South bioregions are located close to the western boundary of the study area. The Brigalow Belt North bioregion comprises by rugged ranges and alluvial plains, with acacia woodlands and eucalypt forests dominating the vegetation cover. The Brigalow Belt South bioregion is characterised by alluvial plains and undulating, hilly areas, with a vegetation cover of eucalypt woodland and brigalow scrub (DSEWPC, 2008).

17.3.2 Environmentally Sensitive Areas

Categories A, B and other ESAs (including areas under the Nature Conservation Act 1992), which may be impacted by project activities, are identified below and shown in Figure 17.2.



Source:
Place names and roads from DME.
Project area and digital elevation model from Coffey Environments.
World heritage areas from DEWHA.
Parks, forests and directory of important wetlands from EPA.
Great Barrier Reef Marine Park from GBRMPA.
Essential habitat from DERM.
Endangered regional ecosystems ground truthed by Ecosure.
Dugong protection area from Fisheries Queensland (DEEDI).

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Arrow Energy

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Environmentally sensitive areas within and adjacent to the study area

Figure No: **17.2**

Category A ESAs

- Garden Island Conservation Park is located adjacent to the eastern Curtis Island study area boundary and, at its closest point, is 1.1 km east of the study area.
- Calliope Conservation Park is located approximately 2 km south of the study area on the mainland.
- Curtis Island National Park is located approximately 8 km northeast of the study area boundary. The park contains a variety of vegetation types (including heathland, grassland and eucalypt forest) (GHD, 2009d).

Category B ESAs

- The Great Barrier Reef World Heritage Area commences at the low water mark of the mainland side of The Narrows, and encompasses Curtis Island. The heritage area is considered to be a MNES and provides habitat for listed threatened species and communities, and migratory birds.
- Conventions to which Australia is signatory including the 'Convention on the Conservation of Migratory Species of Wild Animals', the 'Convention on Wetlands of International Importance' (Ramsar Convention, Iran, 1971), and three Australian Government bilateral migratory bird agreements (Japan-Australia Migratory Bird Agreement (JAMBA), China-Australia Migratory Bird Agreement (CAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)). Port Curtis is not listed as a Ramsar wetland, but is listed under the Directory of Important Wetlands (Environment Australia (DEWHA), 2001).
- The State Significant Wetland of Port Curtis.
- Three REs with a biodiversity status of endangered were mapped within the study area. RE data is dependent on the accuracy of the mapping and conversion between GIS formats and different projections can cause errors in the boundary definition of the RE. However, each has been ground truthed (see Appendix 9: Terrestrial Ecology Impact Assessment).

Other ESAs

Other ESAs considered include three state forests located within or adjacent to the study area (Curtis Island State Forest, Mount Stowe State Forest and Targinie State Forest), coastal wetland vegetation (which fringes large parts of the study area on both the mainland and Curtis Island), of concern REs and areas of essential habitat for endangered, vulnerable or rare taxa under a conservation plan. Essential habitats within the study area include:

- Woodland and scrub adjacent to the mainland tunnel entry shaft and tunnel spoil disposal area, which is listed as essential habitat for the koala (*Phascolarctos cinereus*).
- Sections of Curtis Island on which the LNG plant will be situated listed as essential habitat for the koala.
- Areas adjacent to TWAF 8, which are mapped as essential habitat for the koala.
- Areas adjacent to TWAF 8, which are mapped as essential habitat for one threatened flora species, grease nut (*Hernandia bivalvis*).
- Boatshed Point Asset 38, Hamilton Point Asset 14, which are listed as being habitat for threatened species, such as grey-headed flying-fox (*Pteropus poliocephalus*) and coastal sheathtail bat (*Taphozous australis*).

Targeted searches for koala were undertaken within and in the vicinity of all essential habitat areas. No koala were observed, however they could occur within the study area. Other studies undertaken on Curtis Island and the mainland in the vicinity of the study area did not record koala during field surveys (URS, 2009d; QGC, 2009; APLNG, 2010). The species was noted 15 km to the north of the study area in similar habitat during surveys for the Gladstone–Fitzroy Pipeline project (GAWB, 2008).

Suitable habitat likely to support the threatened grease nut species was identified upslope and outside the boundary of the study area at TWAF 8. However, grease nut was not observed during field surveys.

17.3.3 Vegetation Communities

Conservation listed vegetation communities present within the study area are regulated under Commonwealth or state legislation.

Regulated Vegetation – Commonwealth

A review of the EPBC Protected Matters Search Tool (DSEWPC, 2011c) concluded that two of the four potentially present EPBC Act-listed threatened ecological communities were located within the study area and the area 30 km from the study area boundary. The other two communities were assessed as unlikely to occur within the study area.

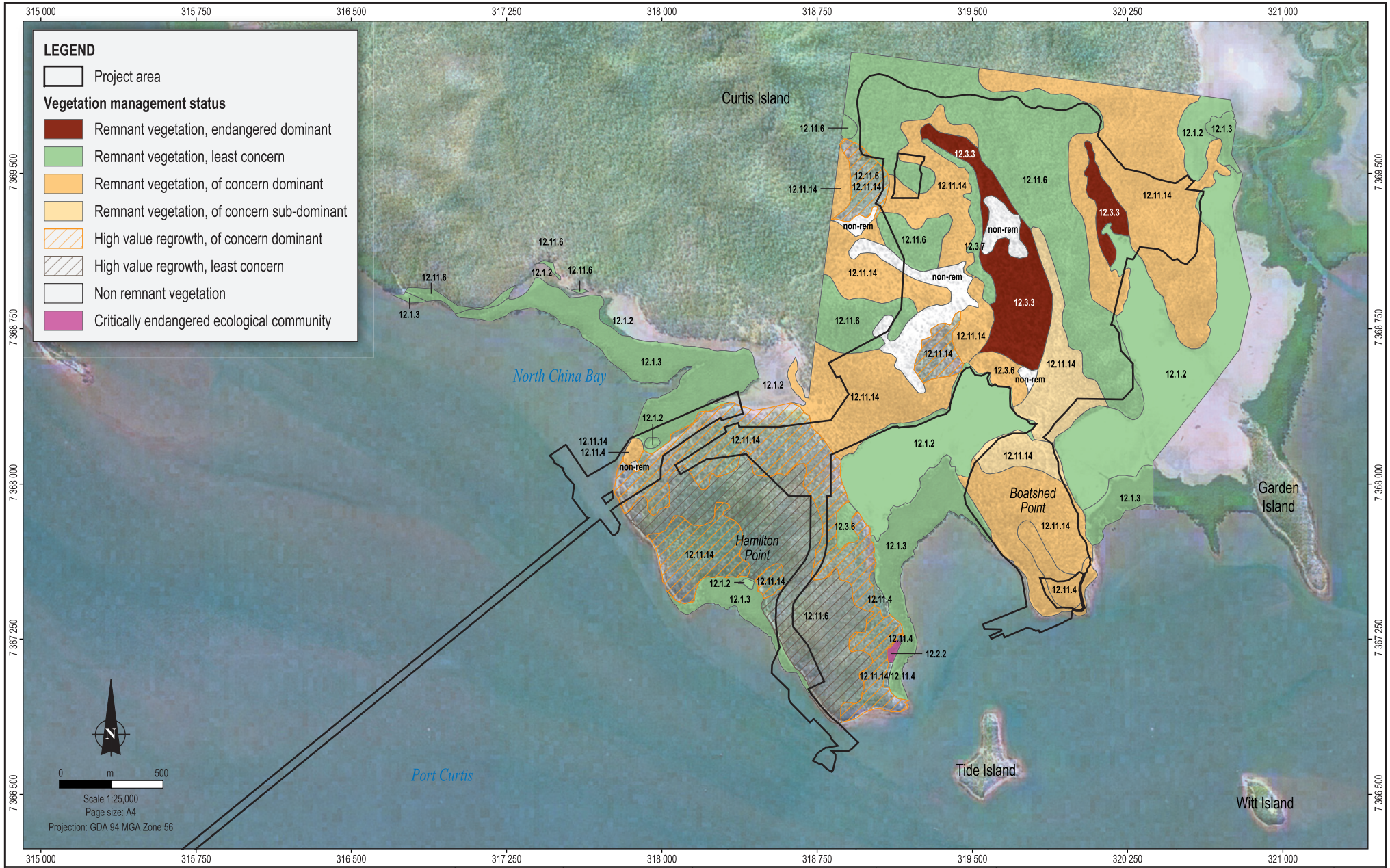
- Littoral rainforest and coastal vine thickets of eastern Australia ('Critically Endangered') – this community is characterised by a number of RE types, with RE 12.2.2 being representative of the community found within the study area. This community typically occurs within 2 km of the coast and is characterised by a closed canopy structure with several vegetation layers present (DEWHA, 2009b). This community supports fauna species such as the grey-headed flying-fox and black-breasted button-quail (*Turnix melanogaster*). Within the study area, this community was represented by small pockets of low microphyll/notophyll vine forest, including a small pocket on the eastern side of Hamilton Point.
- Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar bioregions ('Endangered') – field surveys did not locate this community within the study area although communities of semi-evergreen vine thickets of the Brigalow Belt were observed on the foothills and lower slopes of Mount Larcom, 3 km to the northwest of the study area. REs associated with this community include RE 11.11.18 and RE 11.3.11.

The EPBC Act listed threatened ecological communities within or adjacent to the study area are shown in Figure 17.3 and 17.4.

Regulated Vegetation – State

Regional ecosystems are vegetation communities within a bioregion that are characterised by a combination of soil type, landform and geology, which manifest in a diagnostic vegetation community and flagship flora species. The significance of a RE is defined by its vegetation management status and biodiversity status. The vegetation management status, is a statutory classification, and is based on the preclearing and remnant extent of an RE, and applies to remnant and high value regrowth vegetation. The biodiversity status of a RE is classified by DERM based on the condition of remnant vegetation.

Full details of the assessment of REs are provided in Appendix F of the terrestrial ecology assessment (Appendix 9, Terrestrial Ecology Impact Assessment).



Source:
Place names from DME.
Project area from Coffey Environments.
Vegetation management status (field validated) from Ecosure.
Imagery from SPOT (2004-2007).

Note:
Numbering represents unique identification number allocation to ecological assets mapped by Ecosure

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Arrow Energy

Arrow LNG Plant

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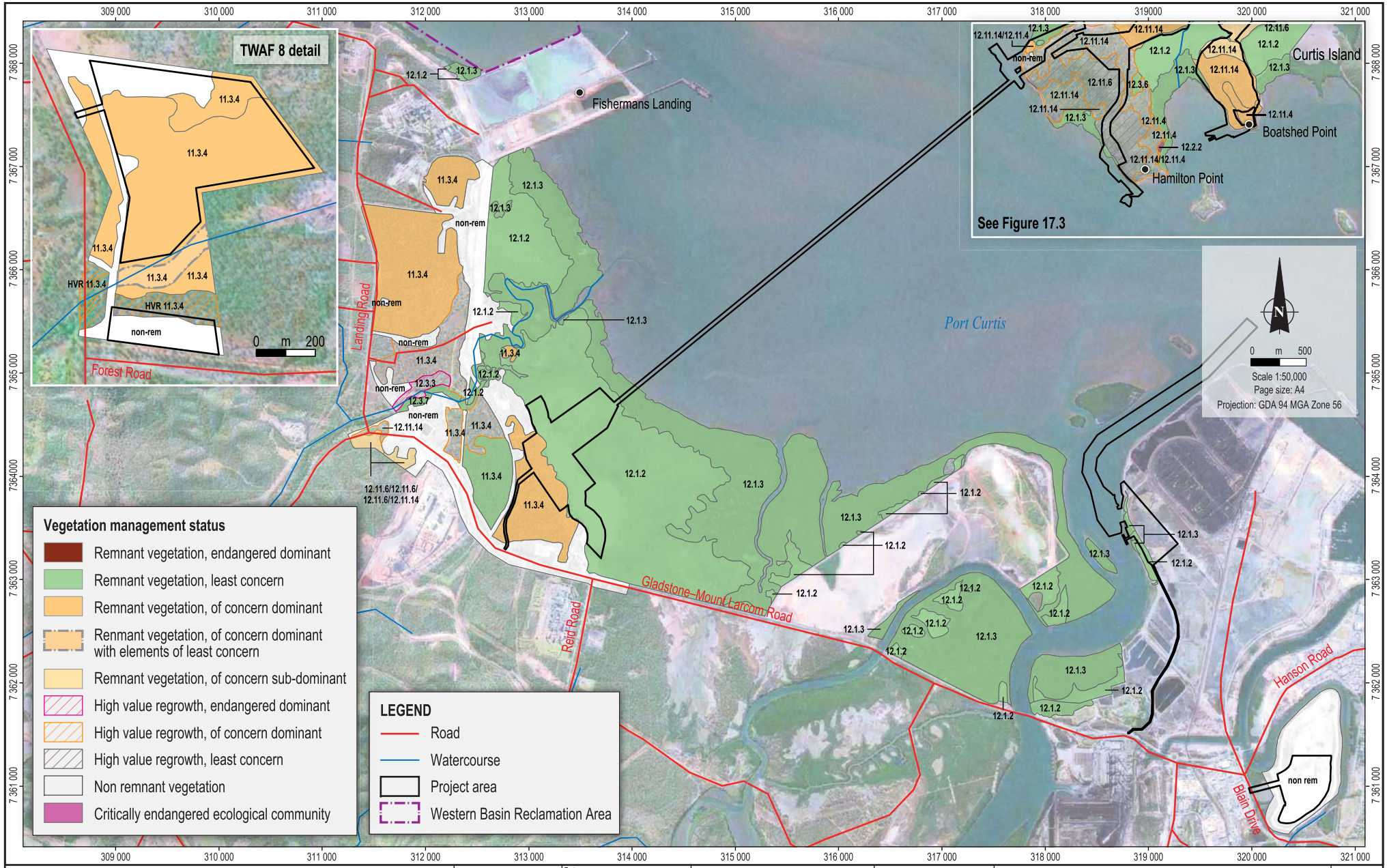
EPBC Act-listed communities and field validated vegetation communities - LNG plant site

Figure No: 17.3



Source:
Place names, roads and watercourses from DME.
Project area from Coffey Environments.
Vegetation management status (field validated) from Ecosure
Western Basin Reclamation Area from Gladstone Ports Corporation.
Imagery from SPOT (2004-2007).

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File Name: 7033_07_F17.04_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

EPBC Act-listed communities and field validated vegetation communities - mainland infrastructure

Figure No: 17.4

Of the 14 DERM-mapped REs within the study area, two are considered 'Endangered', five 'Of Concern' and seven 'Least Concern' for vegetation management status. This is mirrored in the biodiversity status classifications, with the exception of RE 12.2.2 which has a biodiversity status of 'Endangered'.

REs within the study area, and their vegetation management status and biodiversity status, are presented in Table 17.3.

Table 17.3 Regional ecosystems in the study area and their status

Regional Ecosystem	Regional Ecosystem Description	Vegetation Management Status	Biodiversity Status
11.3.4	*Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Of concern	Of concern
11.3.29	*Eucalyptus crebra*, *Eucalyptus exserta*, *Melaleuca* spp. woodland on alluvial plains.	Least concern	No concern at present
11.11.15	*Eucalyptus crebra* woodland on deformed and metamorphosed sediments and interbedded volcanics.	Least concern	No concern at present
11.11.18	Semi-evergreen vine thicket on old sedimentary rocks with varying degrees of metamorphism and folding.	Endangered	Endangered
12.1.2	Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	Least concern	No concern at present
12.1.3	Mangrove shrubland to low closed forest on marine clay plains and estuaries.	Least concern	No concern at present
12.2.2	Microphyll/notophyll vine forest on beach ridges.	Of concern	Endangered
12.3.3	*Eucalyptus tereticornis* woodland to open forest on alluvial plains.	Endangered	Endangered
12.3.6	*Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains.	Least concern	No concern at Present
12.3.7	*Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	Least concern	No concern at present
12.3.11	*Eucaplyptus tereticornis*, *Eucalyptus siderophloia*, *Corymbia intermedia* open forest on alluvial plains near coast.	Of concern	Of concern
12.11.4	Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	Of concern	Of concern
12.11.6	*Corymbia citriodora*, *Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Least concern	No concern at present
12.11.14	*Eucalyptus crebra*, *Eucaplyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Of concern	Of concern

Notes: ± = with or without.

Field Validated Vegetation – Commonwealth and State

Field surveys identified vegetation communities inconsistent with those mapped at Commonwealth and state level. Following field validation, vegetation communities within the study area classified as critically endangered or endangered under Commonwealth legislation, or endangered under state legislation are as follows:

- RE 12.2.2 (microphyll/notophyll vine forest on beach ridges) – this vegetation community has a vegetation management status as of concern and a biodiversity status of endangered. A small patch of vine forest, located on a sand dune on the eastern side of Hamilton Point, was representative of the EPBC-listed critically endangered ecological community (littoral rainforest

and coastal vine thickets of eastern Australia). The community was flanked by similarly composed vine forest; however, as these occurred on metamorphic colluviums, they were more representative of the of concern RE 12.11.4.

Two other areas of DERM-mapped RE 12.2.2 within the study area were either dominated by sclerophyllous woodland species or representative of fragmented generalist vine species on metamorphic colluviums. These areas were not compatible with the DERM or EPBC mapped vegetation community.

- RE12.3.3 (*Eucalyptus tereticornis* woodland to open forest on alluvial plains) – this vegetation community has a vegetation management status of endangered and a biodiversity status of endangered. Overland drainage basins on Curtis Island, north of Boatshed Point on the LNG plant site, met the criteria of this RE type and supported a moderately intact distribution of forest red gum (*Eucalyptus tereticornis*) with a variable shrub and groundcover layer.

Elements of RE 11.11.5 and/or 11.12.4, which have a vegetation management status of least concern and a biodiversity status of no concern at present were identified within the Targinie Creek corridor at the TWAF 8 site. These elements represented a mesic shift or opportunistic establishment due to the absence of historic fire regimes and were mostly too small to be considered mappable entities. The broader vegetation type and the aforementioned elements were found to be more representative of RE 11.3.4.

Field validated vegetation communities within the study area are shown in Figures 17.3 and 17.4.

17.3.4 Flora Species of Conservation Significance

Field surveys identified 293 native terrestrial flora species and 56 introduced flora species.

Database searches identified a further 21 species that have a conservation status under the EPBC Act or Nature Conservation (Wildlife) Regulation 2006 (Qld). None of these species were detected during the targeted field surveys, and none were found during field surveys carried out for other LNG proponents (URS, 2009d; QGC, 2009; APLNG, 2010). The likelihood of these 21 species being present in the study area are given in Section 4.3 of the terrestrial ecology assessment (Appendix 9, Terrestrial Ecology Impact Assessment), and are not considered further in this report. None of these species were assessed as having a likelihood of occurrence within the study area above low to moderate.

One species, *Cycas megacarpa*, identified in the database searches is also listed as vulnerable on the IUCN Red List (2010). It was not recorded during field surveys and, although moderately suitable habitat is present within the study area, the species was considered to have a low to moderate likelihood of occurrence. This species is usually associated with sloping country, such as Mount Larcom to the west of the study area.

Specimens of an unidentified species of *Cupaniopsis*, thought to be closely related to the threatened flora species *Cupaniopsis shirleyana*, were identified within the study area during early field surveys. The recorded specimens were identified by the Queensland Herbarium as *C. shirleyana*, which is currently listed as vulnerable under both the EPBC Act and Nature Conservation (Wildlife) Regulation. These specimens were recorded within an area of semi-evergreen vine thicket located on the southern extent of Boatshed Point.

This area was revisited and assessed in detail during later surveys. The previously identified specimens of *Cupaniopsis* displayed vegetative and reproductive characteristics that were not entirely characteristic of *C.shirleyana*. The same specimens were sampled when in flower and were resubmitted to the Queensland Herbarium for additional analysis. Initial assessment by the

Queensland Herbarium in August 2010 indicated that the sampled species, herein referred to as *Cupaniopsis sp.* indet., is potentially a new taxon. The species is shown in Plate 17.1 and Plate 17.2.

17.3.5 Other Significant Plants

A number of plant species at the limit of their distributional range are of local significance. None of these species were listed as threatened under the EPBC Act or Nature Conservation (Wildlife) Regulation 2006 (Qld) and include:

- *Capparis ornans, Crotalaria brevis, Durabaculum undulatum, Ehretia grahamii, Melaleuca fluviatilis* and *Rhamnella viensis* - all at the southern limit of their distribution.
- *Graptophyllum spinigerum* and *Rhysotoechia bifoliata* - at the northern limit of their distribution.
- *Macrozamia miquellii* - endemic to the Port Curtis pastoral district.

No commercial crops occur within the study area except for several small-scale mango orchards in the vicinity of TWAF 8. The mangrove communities may be significant for recreation for the role they play as a fish and crustacean nursery. Species are likely to be present in the study area that are culturally significant for their use as food, fuel and building materials.

17.3.6 Noxious Weeds

The field surveys recorded 56 introduced plant species. Desktop review of the HERBRECS database (DERM, 2011i) identified three exotic flora species, recognised as weeds of national significance, as likely to occur within the study area:

- Rubber vine (*Cryptostegia grandiflora*) – a vigorous climbing species, which smothers native vegetation and forms dense thickets. Commonly distributed in central Queensland, it is readily spread by wind and water.
- Common lantana (*Lantana camara var. camara*) – a dense shrub that smothers native vegetation and forms dense thickets and, in some flowering forms, is poisonous to stock. Widely distributed along the east coast of Australia, this species is spread by human activity, and fruit eating birds.
- Salvinia (*Salvinia molesta*) – an aquatic weed, this species is assessed in Chapter 18, Freshwater Ecology.

Both rubber vine and common lantana are declared plants under the Land Protection (Pest and Stock Route Management) Act and are recognised as potentially having significant environmental, social or economic impacts. Field surveys confirmed the presence of these weeds and declared plants at many locations within the study area.

Rubber vine was found in REs 12.3.3, 12.11.6 and 12.11.14 as isolated individuals or small infestations, in woodland on undulating low rises, alluvial plains and watercourses on Hamilton Point and the LNG plant site on Curtis Island and it is likely to occur on the mainland at the tunnel entry shaft and tunnel spoil disposal area.

Common lantana was found in REs 11.3.4, 12.2.2, 12.3.3 and 12.11.4 as isolated individuals or small thickets in a variety of vegetation types. In some cases, this species dominated the shrub layer and formed impenetrable thickets. The species was widespread on Curtis Island and was found at TWAF 8 and the mainland tunnel entry shaft and at tunnel spoil disposal area.

Source: Coffey

Plate 17.1
Cupaniopsis sp. indet

Source: Coffey

Plate 17.2
Cupaniopsis sp. indet leaves

Another declared plant under the Land Protection (Pest and Stock Route Management) Act, the common prickly pear (*Opuntia stricta*), was also recorded in the field surveys and found in RE 12.11.14 on Curtis Island, at Boatshed Point and at the LNG plant site.

The occurrence of pest flora species within the project area is shown on Figure 2 within the pest management plan for the project (Appendix 10, Pest Management Plan).

Many other declared pest plants were observed in the wider region, outside the study area. Species may spread throughout the region and be introduced into the study area.

17.3.7 Fauna Species of Conservation Significance

Field surveys recorded 162 terrestrial fauna species (18 mammal, 15 reptile, 9 frog and 120 bird species). The study area was described as a landscape shaped by widespread disturbance and modification of fauna values as a result of grazing, bushfire and past clearing for industry. Notable weed invasion throughout the study area, especially by dense exotic grass species, has reduced the native flora and fauna diversity. Small remnant patches of vegetation remain, providing fauna habitat for a range of conservation significant species.

The database searches identified 54 species that are afforded a conservation status under the EPBC Act or Nature Conservation (Wildlife) Regulation 2006 (Qld), and which are known to occur, or may occur within the study area. Table 17.4 identifies whether the field surveys for the project or other studies identified the species within the study area, or if the species was not found, and the likelihood of the species occurring within the study area.

Species shown are assessed as being a moderate likelihood or higher of being present within the study area. The full list of EPBC/Nature Conservation Act listed fauna identified in the database searches as possibly present within the study area are detailed in Appendix 9, Terrestrial Ecology Impact Assessment.

Three of the species of conservation significance identified in the database searches were recorded as present within the study area during either the project surveys or other studies undertaken in the area.

Eastern curlews (*Numenius madagascariensis*) were recorded on tidal mudflats on the mainland adjacent to the mainland tunnel launch shaft and tunnel spoil disposal site, and at various locations around Curtis Island, in both the project surveys and surveys undertaken for other studies. The species is likely to utilise shorelines throughout the study area and the wider area of Port Curtis.

A single beach stone curlew (*Esacus neglectus*) was found during the project surveys north of the study area near the mouth of Graham Creek on Curtis Island. Other studies found this species on both Hamilton and Boatshed points, and at the mainland tunnel launch shaft and tunnel spoil disposal site. The species (Plate 17.3) is likely to range widely around Port Curtis, although all sightings may relate to a single ranging bird, or pair.

Squatter pigeons (*Geophaps scripta scripta*) (Plate 17.4) were recorded at a number of locations on the mainland during the project surveys and within 5 km of the study area. Areas of similar habitat present within the study area, especially around TWAF 8 makes the presence of the species likely. Other surveys (URS, 2009d; QGC, 2009; GAWB, 2008) have confirmed this to be the case, locating the species within or adjacent to the study area.

Table 17.4 Likelihood of threatened fauna species occurring in the study area

Common Name	Scientific Name	NC Regulation Status[1]	EPBC Act Status[2]	Species Information and Occurrence Notes	Assessment of Likelihood within Study Area
Amphibians					
Tusked frog	*Adelotus brevis*	V	-	At northern extent of its range in central Queensland, found under logs and hollows, beside watercourses in range of habitats, including forest, grassland and urban areas.	Moderate. Suitable habitat throughout the study area.
Birds					
Yellow chat (Capricorn subspecies)	*Epthianura crocea macgregori*	E	CE	Endemic subspecies to central Queensland coast between Rockhampton and Gladstone, and Curtis Island. Inhabits wetland and wet grassland areas, under marine influence.	Moderate. Degraded intertidal habitat on mainland coast and parts of Curtis Island.
Squatter pigeon (southern subspecies)	*Geophaps scripta scripta*	V	V	Favours grassy woodlands, often near water. Occurs in central Queensland, with isolated populations in southeast Queensland.	Recorded. Noted adjacent to study area on mainland, on numerous occasions during Arrow LNG Plant field surveys. Other studies have recorded this species within the study area around the mainland tunnel launch shaft and tunnel spoil disposal site. Suitable habitat present within study area on mainland, especially around TWAF 8.
Little tern	*Sterna albifrons*	E	-	Favours coastal areas of south and east Australia, including tidal estuaries such as Port Curtis.	Moderate to high. Suitable habitat on the mainland section of the study area and on the southern coast of Curtis Island.
Australian swiftlet	*Aerodramus terraereginae*	NT	-	Aerial feeding species over a range of habitat types in northern Queensland south to Mackay, although occasionally further south.	Moderate. Potential visitor over the study area, in a variety of habitats.
Black-chinned honeyeater	*Melithreptus gularis*	NT	-	Occurs throughout eastern Australia, favouring dry eucalypt woodlands and scrubland areas.	High. Suitable habitat present in the study area, and recorded in suitable habitat nearby.
Black-necked stork	*Ephippiorrhynchus asiaticus*	NT	-	Found in freshwater wetland habitats, and coastal mangroves and mudflats in eastern and northern Australia.	Moderate. Suitable habitat occurs on the mainland coastal section of the study area.

Table 17.4 Likelihood of threatened fauna species occurring in the study area (cont'd)

Common Name	Scientific Name	NC Regulation Status[1]	EPBC Act Status[2]	Species Information and Occurrence Notes	Assessment of Likelihood within Study Area
Birds (cont'd)					
Eastern curlew	*Numenius madagascariensis*	NT	-	Migratory wader, to coastal regions of Australia in the summer months, although smaller numbers overwinter. Occurs mainly on tidal mudflats, but utilises a range of coastal habitats.	Recorded. Present during surveys on mudflats along mainland coastline of the study area, and at Hamilton Point. Suitable habitat throughout coastlines of study area.
Grey goshawk	*Accipiter novaehollandiae*	NT	-	Raptor present in a variety of woodland habitats in eastern and northern Australia.	High. Noted during surveys along ridge of Ship Hill, Curtis Island, north of the study area. Suitable habitat present throughout the study area.
Lewin's rail	*Rallus pectoralis*	NT	-	Wetland species, found in eastern Australia, although sparse in distribution.	Moderate. Small farm dams and streams present throughout study area may hold this species.
Radjah shelduck	*Tadorna rajah*	NT	-	Wetland species in northern Australia, although scarce on eastern Queensland coast.	Moderate. Suitable habitat within study area, and recorded in another study 15 km to the north.
Cotton pygmy goose	*Nettapus coromandelianus*	NT	-	Wetland species of eastern Queensland, favouring freshwater lakes and swamps.	Moderate. Suitable habitat within study area, and recorded in another study 15 km to the north.
Sooty oyster-catcher	*Haemotopus fuliginosus*	NT	-	Patchily distributed along Australian coasts, favouring rocky intertidal areas, although can be found in other marine habitats.	High. Recorded on rocky island off Curtis Island during field surveys. Suitable habitat present at Hamilton Point and Boatshed Point.
Square-tailed kite	*Lophoictinia isura*	NT	-	Present in open forest and woodland throughout Australia.	High. Observed near Targinie State Forest, north of TWAF 8, adjacent to the study area. Suitable habitat occurs throughout study area.
Beach stone curlew	*Esacus neglectus*	V	-	Patchily distributed along shorelines of northern and eastern Australia favouring undisturbed islands, beaches and sandbanks.	Recorded. Found on mudflats at the mouth of Graham Creek, Curtis Island during Arrow LNG Plant surveys. Suitable habitat present on southern side of Curtis Island, and other studies recorded this species in North China Bay and on Boatshed Point. Suitable habitat also along coastal margins of the mainland study area.
Glossy black cockatoo	*Calyptorhynchus lathami*	V	-	Found in southeastern Australia, favouring woodlands where it feeds on cones of she-oaks.	High. Recorded north of the study area on Curtis Island, and near Yarwun on the mainland in other studies. Suitable habitat present within the study area on both the mainland and Curtis Island.

Table 17.4 Likelihood of threatened fauna species occurring in the study area (cont'd)

Common Name	Scientific Name	NC Regulation Status[1]	EPBC Act Status[2]	Species Information and Occurrence Notes	Assessment of Likelihood within Study Area
Birds (cont'd)					
Powerful owl	*Ninox strenua*	V	-	Occurs in variety of woodland types in eastern Australia, often near water.	High. Recorded on Curtis Island during other studies, near Graham Creek and below Ship Hill, north of the study area. Likely nesting pair on Curtis Island, in the vicinity of these sightings, and similar habitat present throughout the study area on Curtis Island. Similar habitat also present in mainland sections of the study area, particularly around TWAF 8.
Mammals					
Northern quoll	*Dasyurus hallucatus*	-	E	Fragmented populations found in northern Australia in variety of open woodland and forest types.	Moderate. Patches of vine thicket and open forest present in western margins of mainland study area and parts of Curtis Island.
Water mouse	*Xeromys myoides*	V	V	Found in fringing mangroves in the high intertidal zone, predominantly from central Queensland south to the New South Wales border, but also with populations in the Northern Territory.	High. Suitable habitat occurs on the southern section of the Curtis Island coastline, and on mainland study area coasts, particularly around the Calliope River (launch site 1 location) and mangroves adjacent to the mainland tunnel launch shaft and tunnel spoil disposal site. Water mouse has been observed in surveys at the Australia Pacific LNG project site.
Grey-headed flying-fox	*Pteropus poliocephalus*	-	V	Megabat found in eastern coastal Australia, in a variety of woodland habitats, and also in more open areas where suitable food trees are present.	High. Recorded north of the study area just south of Graham Creek, and likely to be present in study area within similar habitat both on Curtis Island and the mainland.
Golden-tipped bat	*Phoniscus papuensis*	NT	-	Microbat found in coastal eastern Queensland, predominantly in rainforest but also present in other forest types.	High. Suitable forest occurs throughout study area, and a suspected call of this species was recorded from Anabat analysis 3 km north of the mainland study area.
Little pied bat	*Chalinolobus picatus*	NT	-	Microbat patchily distributed along Queensland coast, preferring riverine open forest, but present in other forest types.	Moderate. Suitable habitat present throughout study area.

Table 17.4 Likelihood of threatened fauna species occurring in the study area (cont'd)

Common Name	Scientific Name	NC Regulation Status[1]	EPBC Act Status[2]	Species Information and Occurrence Notes	Assessment of Likelihood within Study Area
Mammals (cont'd)					
Coastal sheathtail bat	*Taphozous australis*	V	-	Microbat present in coastal woodland and mangrove swamps, north from Yeppoon in central Queensland.	Moderate. Suitable habitat present throughout study area.
Ghost bat	*Macroderma gigas*	V	-	Microbat present mainly in northern Australia, but south to circa Rockhampton on central Queensland coast. Favours variety of habitats, such as rainforest and grasslands, and roosts in caves.	Moderate. Suitable habitat present throughout study area.
Koala	*Phascolarctos cinereus*	V	-	Arboreal species, favouring sclerophyll woodlands. Located on both sides of Great Dividing Range from Chillagoe to South Australia.	Moderate. Not found during field surveys although suitable habitat is present, with species recorded 15 km north of study area in similar habitat during other studies.
Reptiles					
Brigalow scaly-foot	*Paradelma orientalis*	V	V	Favours sandstone areas in woodlands, vine thickets and scrub, and found under logs, leaf litter and rocks. Found in the brigalow belt bioregion of central and south Queensland.	Moderate. Suitable habitat present, and found in similar habitat 12 km to southeast of study area on Boyne Island.
Yakka skink	*Egernia rugosa*	V	V	Found in eastern Queensland, in dry woodland, often under timber and in rock crevices.	Moderate. Suitable habitat present throughout study area.
Collared delma	*Delma torquata*	V	V	Fragmented distribution across southeast Queensland, north to Gladstone region. Favours rocky slopes in sclerophyll woodland, and found under rocks and leaf litter or in crevices.	Moderate. Patches of suitable habitat present throughout study area.

Table 17.4 Likelihood of threatened fauna species occurring in the study area (cont'd)

Common Name	Scientific Name	NC Regulation Status[1]	EPBC Act Status[2]	Species Information and Occurrence Notes	Assessment of Likelihood within Study Area
Reptiles (cont'd)					
Common death adder	*Acanthopsis antarcticus*	NT	-	Present in a variety of woodland habitats in eastern and southern Australia.	Moderate. Patches of suitable habitat present throughout study area.
Saltwater crocodile	*Crocodylus porosus*	V	-	Inhabits rivers, swamps, estuaries and open sea in northern Australia, south to central Queensland.	Low. Although suitable habitat is present in marine sections of study area, this species has not been reported in the study area in recent years.

[1] E = endangered, V = vulnerable, NT = near threatened, - = least concern/not listed (Nature Conservation Act).

[2] CE = critically endangered, E = endangered, V = vulnerable, - = Not listed (EPBC Act).

NC Regulation - Nature Conservation (Wildlife) Regulation 2006 (Qld).

Likelihood of occurrence within the study area:

Very Low = The study area is outside the species' normal range and habitat, or underlying geology does not exist (no further impact assessment required).

Low = Database searches indicate the species could potentially occur in the study area; however, previous records are likely to be historic or invalid, the study area is outside the species normal range, habitat does not exist or the species is considered locally extinct (no further impact assessment required).

Moderate = Habitat exists for the species; however, it is either marginal or not particularly abundant. The species is known from the wider region and could potentially occur (further impact assessment required).

High = The species is known to occur in the local area and core habitat exists in the study area (further impact assessment required).

Recorded = The species was recorded in the study area as part of field surveys (further impact assessment required).

Ten species were assessed with a high likelihood of occurrence within the study area, either due to the presence of large areas of suitable habitat the species presence adjacent to the study area in similar areas of habitat during project surveys or surveys for other studies. Species assessed as a high likelihood of occurrence include grey-headed flying-fox and water mouse (*Xeromys myoides*), the former in areas of woodland such as the Arrow LNG plant site, and the latter in fringing mangroves on Curtis Island (Plate 17.5), at launch site 1 and at the mainland tunnel launch shaft and tunnel spoil disposal site.

Fauna species of conservation significance within or adjacent to the study area found during surveys for the project or other studies are shown in Figure 17.5.

Fifty-two species classed as migratory under the EPBC Act were identified in the database searches as possibly occurring within the study area. Ten of these species were identified within the study area by other studies (URS, 2009d; QGC, 2009; GAWB, 2008), while surveys for the project located an additional ten migratory species within the study area.

The majority of these species are wetland birds (terns, egrets and waders) found in various intertidal areas around Port Curtis, including the mudflats adjacent to the mainland tunnel entry shaft and tunnel spoil disposal area. Other species included white-bellied sea-eagle (*Haliaeetus leucogaster*) recorded in several locations, including a likely nest on the western side of Hamilton Point, and rainbow bee-eater (*Merops ornatus*) recorded in a variety of habitat settings. The locations at which EPBC listed migratory species were recorded are detailed in Appendix 9, Terrestrial Ecology Impact Assessment.

Two species identified in the database searches are also listed as vulnerable under the IUCN Red List (2010). Neither collared delma (*Delma torquata*) or ghost bat (*Macroderma gigas*) were recorded during field surveys, although both were rated as having a moderate likelihood of occurrence within the study area due to the presence of suitable habitat.

17.3.8 Essential Habitat for Fauna

Essential habitat for fauna within the study area falls under the following categories.

Areas of Biodiversity Significance (Biodiversity Planning Assessments)

Essential habitat for fauna is mapped under the biodiversity planning assessments regulated by DERM. This is considered a support tool for decision making processes. The study area contains biodiversity values, which are identified under biodiversity planning assessments for the Southeast Queensland, Brigalow Belt South and Brigalow Belt North bioregions.

Essential habitat is designated for an area in which a species of conservation significance is known to be present, or there is indication that the area is an important resource for the species. Areas of essential habitat for koala occur within the study area, including in Targinie State Forest to the east of TWAF 8, areas of woodland adjacent to the mainland tunnel entry shaft and tunnel spoil disposal area, and parts of Curtis Island. These areas were also marked as essential habitat for the coastal sheathtail bat.

The study area also contains state and regionally significant wildlife corridors, providing important routes for movement of flora and fauna species. A state significant wildlife corridor runs from Burnett Heads to the north of Gladstone, and links vegetation tracts along the coast. A regionally significant wildlife corridor runs along the Calliope River.

Source: Coffey

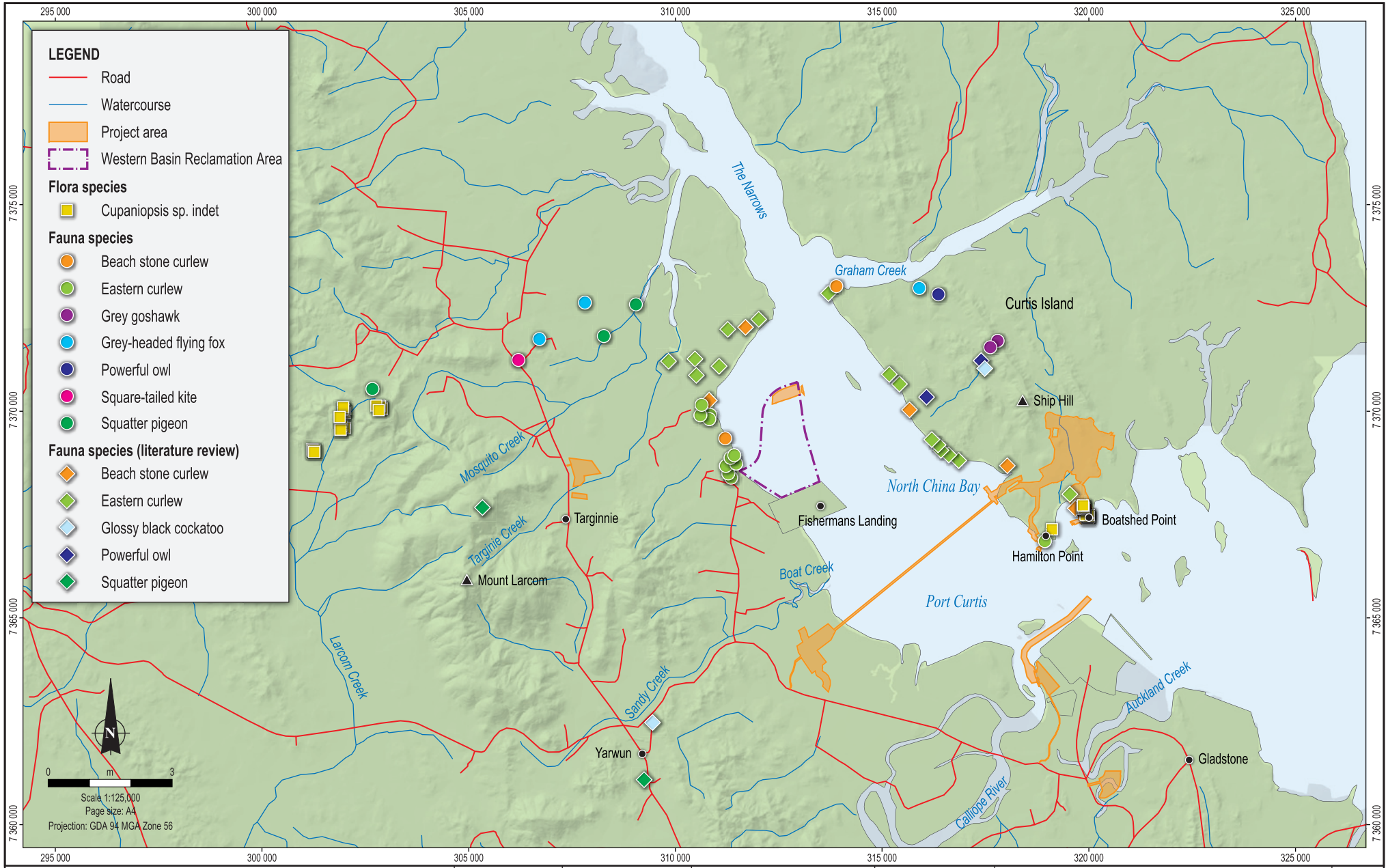
Plate 17.3
Beach stone curlew

Source: Coffey

Plate 17.4
Squatter pigeon

Source: Coffey

Plate 17.5
Water mouse habitat, Curtis Island



Source:
Place names, roads and watercourses from DME.
Project area and digital elevation model from Coffey Environments.
Flora and fauna species from Ecosure.
Western Basin Reclamation Area from Gladstone Ports Corporation.

coffey environments

Date: 17.11.2011
MXD: 7033CA_07_GIS146_v1_5
File Name: 7033_07_F17.05_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Flora and fauna species of conservation significance within or adjacent to the study area

Figure No: **17.5**

Other areas of biodiversity significance, identified within the biodiversity planning assessments, include areas mapped as having state-significant biodiversity value. Large sections of the mainland study area and all of Curtis Island fall into this category.

Areas of essential habitat, wildlife corridors and state significant biodiversity values are shown in Figure 17.6.

Directory of Important Wetlands

Port Curtis is listed as a nationally important wetland under the Directory of Important Wetlands of Australia. Port Curtis meets five of the six criteria for inclusion in the directory (Criteria 1-3, 5 and 6) (DSEWPC, 2011b).

A number of birds listed under the China–Australia Migratory Bird Agreement (CAMBA), Japan–Australia Migratory Bird Agreement (JAMBA) and Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA) are found within Port Curtis. These birds feed on the intertidal mudflats at low tide and roost at several locations around Port Curtis at high tide. The mudflats at the mainland tunnel entry shaft and tunnel spoil disposal area (Plate 17.6) are adjacent to one such key feeding area (DSEWPC, 2011b). This area is likely to support 15 species or more of migratory shorebird, and is a significant shorebird habitat.

17.3.9 Pest Fauna Species

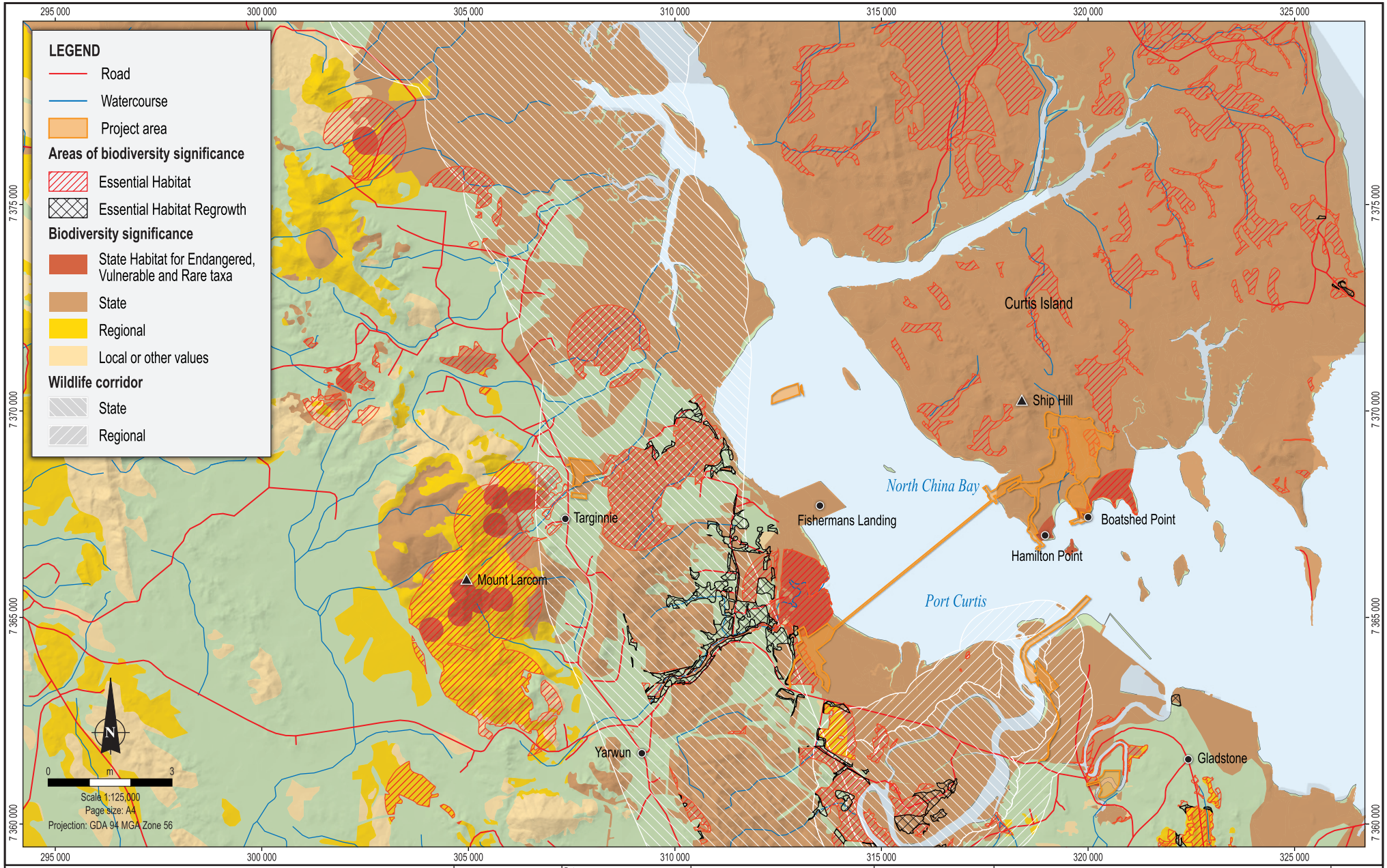
Ecological surveys undertaken for the project located two declared pest fauna species under the Land Protection (Pest and Stock Route Management) Act, or species declared as a key threatening process under the EPBC Act:

- Cane toad (*Rhinella marina*) is not declared under the Land Protection (Pest and Stock Route Management) Act but a key threatening process under the EPBC Act due to biological effects to native species including lethal toxic ingestion. This species was widely recorded on Curtis Island, with other sightings on the mainland just outside the study area. It is likely to be widespread.
- Wild dog (*Canis familiaris*) is declared as a Class 2 species under the Land Protection (Pest and Stock Route Management) Act, and a threat to native fauna species as a result of predation. The species was recorded at two locations on the western margins of the study area on the mainland, and adjacent to the mainland tunnel entry shaft and tunnel spoil disposal area.

The wild horse (*Equus caballus*) was also recorded in field surveys. It is a non-declared species under the Land Protection Act, but with impacts on native flora through trampling, grazing and increased erosion. The wild horse is widespread throughout the LNG plant site on Curtis Island, though was not recorded on the mainland part of the study area during field surveys.

Evidence of feral pig (*Sus scrofa*) (a Class 2 species and a threatening process as a result of predation, habitat degradation and disease transmission) was also noted on Curtis Island during field surveys. Feral pigs are common throughout Queensland and are a major pest species on Curtis Island.

The red fox (*Vulpes vulpes*), black rat (*Rattus rattus*) and European hare (*Lepus capensis*) were recorded in suitable habitat outside the study area and are likely to occur within the study area in similar habitat. Desktop searches also indicated that feral cat (*Felis catus*) and European rabbit (*Oryctolagus cuniculus*) are known to occur within the study area. Both are Class 2 species.



Source:
Place names, roads and watercourses from DME.
Project area and digital elevation model from Coffey Environments.
Essential habitat from DERM.
Biodiversity significance and wildlife corridors from EPA.

coffey environments

Date: 15.11.2011
MXD: 7033CA_07_GIS147_v1_4
File Name: 7033_07_F17.06_GIS_GL

Arrow Energy

Arrow LNG Plant

arrow energy go further

Areas of biodiversity significance

Figure No: 17.6

Source: Coffey

Plate 17.6

Mudflats at mainland tunnel entry shaft and tunnel spoil disposal area

17.3.10 Sensitivity of Ecological Assets

A summary of the ecological assets and their sensitivity is presented in Table 17.5, under discrete subdivisions of the study area. Twelve assets were identified as having high or very high sensitivity.

Ecological assets found within the study area with a sensitivity of high or very high are discussed below. REs have been defined by the Vegetation Management Regulation 2000.

Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Area

Asset 1 (RE 12.1.2). Although this RE type is listed as least concern, the saltpans on the mainland coast of the study area adjacent to the mainland tunnel entry shaft and tunnel spoil disposal area are shorebird feeding habitat and are known to support EPBC Act listed migratory species. Protected marine plants are present in this area and the leeward side of the mangroves and the fringes of Boat Creek support saltwater couch fields. The area forms part of the state significant wetland of Port Curtis and is listed under the EPBC Act and under international agreements (CAMBA, JAMBA, ROKAMBA). This asset has a high sensitivity rating. The area is relatively intact, although endures some disturbance from a variety of origins, including four-wheel driving, kite flying and illegal dumping.

Asset 2 (RE 12.1.3). This RE is listed as least concern and supports a variety of mangrove species, although dominated by stilted mangrove (*Rhizophora stylosa*). There are patches of mangrove dieback on the seaward side. The ecosystem has a high sensitivity despite being relatively resilient and moderately easy to replace.

Mangroves provide a roosting site for shorebirds, with one identified at the southern edge of Asset 2 (APLNG, 2010). The mangrove habitat possesses a low, closed canopy cover with abundant fallen woody debris and hollow logs that provide habitat for the EPBC listed water mouse. It forms part of the state significant wetland of Port Curtis.

Asset 8 (RE 12.3.3). This RE is listed as endangered. Its sensitivity is considered very high because of the essential habitat for koala and coastal sheathtail bat. This area was considered to be a moderately intact ecosystem and moderately difficult to replace. These areas support forest red gum woodland with associated narrow-leaved ironbark (*Eucalyptus crebra*) and Moreton Bay ash (*Corymbia tesselaris*), with varied shrub and ground cover layers (Plate 17.7).

Curtis Island Saltpans and Fringing Mangroves

Asset 12 (RE 12.1.2). Although this RE is of least concern, the saltpans on Curtis Island between Boatshed Point and Hamilton Point (Plate 17.8) are shorebird feeding habitat (included in the state significant wetland of Port Curtis) and likely to support EPBC Act listed migratory species. The Nature Conservation Act listed beach stone curlew has been observed in this area. The sensitivity is rated as high.

Asset 13 (RE 12.1.3). This RE of least concern supports a variety of mangrove species although is dominated by stilted mangrove (*Rhizophora stylosa*). Because the ecosystem is intact, it has a high sensitivity conservation status. The mangrove habitat possesses a low, closed canopy cover with abundant fallen woody debris and hollow logs providing potential habitat for the EPBC Act listed water mouse.

Hamilton Point

Asset 14 (RE 12.2.2). A critically endangered RE with a very high conservation status provides habitat for threatened species including coastal sheathtail bat and grey-headed flying-fox. This small patch of vine forest on the eastern side of Hamilton Point was attributed a very high

sensitivity as it possesses high intactness, uniqueness, non resilience to change and a very high difficulty in replacing.

Assets 15 and 16 (RE 12.11.4). This RE, listed as of concern, has a high conservation status. Large areas of this RE are heavily degraded and in poor condition as a result of recent and historic high intensity fuel reduction burns, and pest flora and fauna infestations. Assets 15 and 16 were attributed an overall sensitivity of high due to the high degree of non-resilience to change and a high difficulty of replacement.

Curtis Island LNG Plant Site

Assets 27 and 31 (RE 12.3.3). Both assets are REs listed as endangered with a very high sensitivity. Both have essential habitat for koala and coastal sheathtail bat. This area was considered to be a highly intact ecosystem and difficult to replace. These areas support forest red gum woodland with associated narrow-leaved ironbark, Moreton Bay ash and varied shrub and ground cover layers, plus abundant faunal habitat (hollow bearing trees, fallen woody material) (Plate 17.9 and 17.10).

Boatshed Point

Asset 38 (RE 12.11.14). An of concern-listed RE with a high sensitivity and conservation status, the asset is only moderately intact. It was assigned a uniqueness rating due to the presence of the *Cupaniopsis sp*. indet in the vine thicket (Plate 17.11). The asset also provides habitat for threatened species, which include coastal sheathtail bat and grey-headed flying-fox. The coastal fringe of the asset (Plate 17.12) was also part of the state significant wetland of Port Curtis.

TWAF 8

Asset 41 (RE 11.3.4). This is an RE listed as of concern with vegetation associated with forest red gum woodland and associated narrow-leaved ironbark and Moreton Bay ash (Plate 17.13). The shrub layer contains species such as ironbark wattle (*Acacia disparrima*) and paperbark (*Melaleuca nervosa*) with vine thicket generalists also found. Ground cover is dominated by native grasses. Large areas to the east and west of the asset are mapped as essential habitat for coastal sheathtail bat and koala, and the site could act as a corridor connecting these areas. TWAF 8 also has the potential to support other conservation-listed species such as powerful owl (*Ninox strenua*), square-tailed kite (*Lophoictinia isura*) and black-chinned honeyeater (*Melithreptus gularis*). Habitat features present include arboreal termitaria and large habitat trees with hollows. There is evidence of weed invasion around the watercourse at TWAF 8, specifically common lantana.

The site is part of a state wildlife corridor. With its high conservation status and intactness, it is afforded an overall high sensitivity.

Table 17.5 Sensitivity of ecological assets in the study area

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status) [1]	Threatened Fauna Species Known to Occur (including EPBC Migratory Species)[2]	Conservation Areas/Other Ecological Features[3]	Sensitivity of Asset
Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Site				
1	RE 12.1.2 (LC, -) Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	Y	SH, MP, SSW, TSH, EH	High
2	RE 12.1.3 (LC, -) Mangrove shrubland to low closed forest on marine clays and estuaries.	Y	SH, MP, SSW, TSH, EH	High
3	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	-	EH	Medium
4	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	-	SC	Medium
5	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Y	EH, SC	Medium
6	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	-	SC	Medium
7	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	-	SC	Medium
8	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	-	SC	High
9	RE 12.3.7 (LC, -) *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	-	SC	Medium
10	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	SC	Medium
11	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	SC	Medium
Curtis Island Saltpans and Fringing Mangroves				
12	RE 12.1.2 (LC, -) Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	Y	SH, MP, SSW, TSH, EH, WHA	High
13	RE 12.1.3 (LC, -) Mangrove shrubland to low closed forest on marine clays and estuaries.	Y	MP, SSW, TSH, EH, WHA	High

Table 17.5 Sensitivity of ecological assets in the study area (cont'd)

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)	Threatened Fauna Species Known to Occur (including EPBC Migratory Species)	Conservation Areas/Other Ecological Features	Sensitivity of Asset
Hamilton Point				
14	RE 12.2.2 (OC, CE) Microphyll/notophyll vine forest on beach ridges.	-	TSH, WHA	Very High
15	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	Y	TSH, WHA	High
16	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	-	TSH, WHA	High
17	RE 12.3.6 (LC, -) *Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains.	-	TSH, WHA	Medium
18	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
19	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
20	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	TSH, WHA	Medium
21	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	TSH, WHA	Medium
22	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	TSH, WHA	Medium
LNG Plant Site				
23	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	TSH, WHA	Medium
24	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Y	TSH, WHA	Medium
25	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
26	RE 12.3.7 (LC, -) *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	-	TSH, WHA	Medium

Table 17.5 Sensitivity of ecological assets in the study area (cont'd)

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)	Threatened Fauna Species Known to Occur (including EPBC Migratory Species)	Conservation Areas/Other Ecological Features	Sensitivity of Asset
LNG Plant Site (cont'd)				
27	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	-	EH, TSH, WHA	High
28	RE 12.3.6 (LC, -) *Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains.	-	TSH, WHA	Medium
29	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
30	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Y	TSH, WHA	Medium
31	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	-	EH, TSH, WHA	High
32	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	SSW, TSH, WHA	Medium
33	RE 12.3.7 (LC, -) *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	-	EH, TSH, WHA	Medium
34	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
35	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
36	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	-	TSH, WHA	Medium
Boatshed Point				
37	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	SSW, TSH, WHA	Medium
38	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	Y	SSW, TSH, WHA	High
39	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Y	SSW, TSH, WHA	Medium

Table 17.5 Sensitivity of ecological assets in the study area (cont'd)

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)	Threatened Fauna Species Known to Occur (Including EPBC Migratory Species)	Conservation Areas/Other Ecological Features	Sensitivity of Asset
TWAF 7				
40	Non-remnant vegetation at TWAF 7.	-	WC, EH	Low
TWAF 8				
41	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Y	WC, ASF	High
42	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	-	WC	Medium
43	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	-	WC	Medium
Launch Site 1				
44	RE 12.1.2 (LC, -) Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	-	SSW, WC	Medium
45	RE 12.1.3 (LC, -) Mangrove shrubland to low closed forest on marine clays and estuaries.	-	SSW, WC	Medium
Non-remnant Vegetation				
46	Non-remnant vegetation at mainland tunnel entry site.	-	SC	Very Low
47	Non-remnant vegetation at LNG plant site (within footprint).	-	Areas characteristic of REs 12.11.6, 12.11.14 and 12.3.3	Low
48	Non-remnant vegetation at LNG plant site (outside footprint).	-	Areas characteristic of REs 12.11.6, 12.11.14 and 12.3.3	Low
49	Non-remnant vegetation at TWAF 8.	-	SC	Very Low

[1] CE = critically endangered, E = endangered, OC = of concern, LC = least concern. ± = with or without

[2] Y = present. - = unknown.

[3] SH = shorebird habitat, MP = marine plants, SSW = state-significant wetland, TSH = threatened species habitat, EH = essential habitat, SC = state corridor, WHA = World Heritage area, ASF = adjacent to state forest.

Source: Coffey

Plate 17.7
Woodland behind mainland tunnel entry shaft and tunnel spoil disposal area

Source: Coffey

Plate 17.8
Claypan between Hamilton Point and Boatshed Point, Curtis Island

Source: Coffey

Plate 17.9
Woodland at LNG plant site, Curtis Island

Source: Coffey

Plate 17.10
Ephemeral stream, Arrow LNG plant site, Curtis Island

Source: Coffey

Plate 17.11
Vine thicket, Boatshed Point, Curtis Island

Source: Coffey

Plate 17.12
Rocky shoreline of Boatshed Point, Curtis Island

Source: Coffey

Plate 17.13
Vegetation at TWAF 8

17.4 Issues and Potential Impacts

This section describes the issues and potential impacts on terrestrial ecology arising from project construction, operation and decommissioning. The assessment describes direct and indirect impacts on environmentally sensitive areas or nationally and state listed communities and species. Impacts are also categorised by project area.

The assessment considers species of conservation significance with a moderate or greater likelihood of being present within the study area. These species are either known to be present or likely to be present within certain ecological communities. Conservation listed species with a low likelihood of being present, either due to a lack of suitable habitat or the project area being outside the species normal range, are not considered further in this assessment. Should a species with low likelihood of being present be found within the project area during preclearance surveys, mitigation measures will be developed for that species.

Impacts on the terrestrial ecology assets will occur largely due to:

- Habitat loss and fragmentation.
- Disturbance and direct mortality.
- Introduction and spread of pest species.
- Pollution events.

17.4.1 Potential Issues and Impacts across the Project Area

Key potential impacts and threatening processes resulting from project activities are summarised below. These impacts are applicable throughout the project area.

Vegetation Clearance and Ground Disturbance

Site access and construction activities will remove vegetation and cause ground disturbance. Areas of vegetation within the region and bioregion will decrease with resulting impacts on vegetation communities and flora species of conservation significance. Impacts include:

- Loss of native vegetation, in some cases permanent (where hardstanding areas are constructed).
- Removal of approximately 25.7 ha of endangered RE, 171.6 ha of concern RE and 8 ha of high-value regrowth vegetation listed under the Vegetation Management Act (Table 17.6).
- Loss of individuals of flora and fauna species of conservation significance.
- Loss of scattered remnant trees, including hollow-bearing trees utilised by terrestrial fauna species for roosting and nesting (including arboreal mammals, microbats, parrots and owls).
- Unearthing of burrowing fauna species.
- Loss of foraging areas, breeding sites and shelter, which may result in lower faunal diversity in an area.
- Loss of coastal mangrove vegetation, which supports threatened fauna species, including the water mouse and migratory shorebirds.
- Erosion and sediment mobilisation, leading to decrease in habitat condition.

Habitat Fragmentation and Impacts on Wildlife Corridors

Site access and construction activities will clear vegetation used by wildlife as corridors resulting in a loss of connectivity between habitats. Impacts include:

- The creation of smaller, often disconnected patches of vegetation.
- Isolation of flora and fauna populations leading to increased vulnerability to local extinction due to stochastic events (such as fire) and decreased genetic diversity in the long term.
- Changes in species composition of the community in that certain species may become locally extinct, especially fauna with large territories such as birds of prey and owls. These species may be unable to persist in smaller patches of habitat and their prey species may increase in numbers.
- Increased barrier to movement, further isolating populations from roads and other project infrastructure and preventing species moving from one area of habitat to another (e.g., movement of shorebirds between feeding and roosting sites).
- Displacement of species from cleared areas into neighbouring habitat, with increased competition for resources within remaining areas of habitat.
- Increased edge effects as habitats become smaller including:
  - Loss of vegetation integrity, particularly along the margins of remaining areas of vegetation as a result of increased light penetration, disease occurrence, altered water flows and weed invasion.
  - Increased predation along habitat edges and in dominant species, which displace less aggressive species.
  - Access into previously inaccessible habitats for pest fauna predator species such as cats and dogs, as well as damaging herbivorous pest species such as pigs and wild horses.

Introduced Flora and Fauna

Introduced flora and fauna could be brought into the area by vehicle and vessel movements, during the establishment of construction camps and through vegetation/ground clearance for access and construction. Vehicles, vessels and people may be vectors for pest flora, transporting seeds in tyre treads, through mud attached to vehicles or on footwear or stuck to clothing. Food waste may attract pest fauna.

Vegetation clearing may open up the canopy and cause habitat fragmentation, with increased weed establishment and access for fauna species to colonise the area. Ground clearance will disturb the soil, remove competing vegetation and allow light into new areas, facilitating the establishment of weed species.

Impacts include:

- Colonisation by pest flora and fauna species (already established in the Gladstone region) to new areas or the introduction of new species not found within the region.
- Reduction of ecological values through competition, predation, habitat degradation and introduction of disease.
- Impacts upon primary production areas through colonisation by pest flora species and reduced productivity of cropland.
- Displacement of native flora and fauna of conservation significance, and potential reduction of quality of designated areas.

Hydrology and Pollution

Hydrological impacts and pollution can arise through earthworks, establishing spoil stockpiles, redirection of the watercourse on Curtis Island and establishing new hardstanding areas. Vegetation clearance, earthworks and spoil stockpiling can cause acid sulfate soils issues, sediment mobilisation (airborne and waterborne), reduced infiltration and increased runoff. Hardstanding areas can channel stormwater runoff and decrease infiltration. Creation of the diversion channels on Curtis Island around the LNG plant site may increase flows in areas downstream of the diversion channels, with potential scour and deposition issues. Loss of riparian habitat may lead to instability in the banks of watercourses.

Impacts include:

- Reduced water quality in downstream areas through sedimentation and pollution from petroleum-based products from vehicles, plant and equipment, or poor waste management procedures, impacting on vegetation health in these areas.
- Release of leachates (as a result of acid sulfate soil mobilisation) affecting flora and fauna, particularly at the mainland tunnel entry shaft and tunnel spoil disposal site.
- Loss of transfer mechanism for water borne seeds where the watercourse is removed at the Arrow LNG plant site.
- Altered feeding patterns for fauna using the ephemeral stream to be diverted around the LNG plant site.

Direct Disturbance of Fauna

Lighting and noise from construction and operational activities can have direct and indirect impacts on fauna species, and result in ongoing disturbance to local fauna populations. Increased vehicle movements may cause direct mortality or injury.

Impacts include:

- Roadkill or injury to native fauna due to increased traffic around construction sites.
- Disturbance of fauna species in areas immediately adjacent to work sites, through noise and vibration, personnel and vehicle movements, flaring, dust and artificial lighting.
- Positive impacts on fauna from artificial lighting as lighting attracts insects, which, in turn, encourage insectivorous species such as frogs and reptiles, microbats and some birds such as frogmouths (*Podargus* sp.) and bush stone curlew (*Burhinus grallarius*) to feed on increased prey concentrations. However, species assemblages may change in an area with less adaptable species being out competed by more adaptable ones.
- Alteration of bird and frog species mating and nesting behaviours through increased lighting. Increased activity by these species depletes energy resources and lighting often disorientates bird species, including nocturnal migratory species.
- Displacement of migratory birds from mudflat areas adjacent to construction sites through increased noise. Birds will be prevented from foraging in areas immediately adjacent to worksites, thus impacting on the fuel reserves of these migratory species.

Altered Fire Regimes

Vegetation clearance for access, construction and clearance of firebreaks around project infrastructure may decrease the likelihood of burns required for germination of certain species.

This may increase the risk of ingress from pest flora (i.e., grasses), which may increase the fuel load. Accidental ignition is more likely with more people/activity around the worksites. Impacts include:

- Increased weed invasion from species such as exotic grasses and colonisation of cleared areas by pioneer species, thereby increasing the fuel load and potential for more severe and frequent fires.
- Reduction of fuel load in other areas due to permanent clearing with resulting altered fire regime.
- Reduced competition from species requiring fire events to germinate seed (as a result of increased fire controls in areas adjacent to project infrastructure).
- Loss of mid strata vegetation complexity in favour of grass cover and pioneer shrubs (if fire frequency is greater in any areas).

Trenchfall

Stringing, laying of pipelines, and construction of the watercourse diversion channel on Curtis Island will require trenching in several locations. Trenches can act as a barrier to movement for ground dwelling fauna species and they can entrap species within the trench, leading to mortality.

17.4.2 Environmentally Sensitive Areas

Impacts to ESAs from the construction and operation of the project include:

- Vegetation clearance at the LNG plant site on Curtis Island within the Great Barrier Reef World Heritage Area.
- Habitat fragmentation, barrier and edge effects (barriers to fauna movement, loss of vegetation integrity and increased predation along habitat edges, etc.) within the Great Barrier Reef World Heritage Area.
- Disturbance to values associated with the state significant wetland of Port Curtis (such as EPBC Act-listed migratory shorebirds) through construction activities adjacent to mudflat areas.
- Establishment of pest flora and fauna species in new areas of Curtis Island through the spread of existing species and introduction of new species.
- Displacement of species from the Arrow LNG plant site and adjacent areas into undisturbed areas of Curtis Island including the Garden Island Conservation Park and Curtis Island National Park. This may result in increased competition for resources in these areas. The entire Curtis Island Industry Precinct (including this project and three other LNG proponents) covers less than 3% of the overall area of Curtis Island.

The sensitivity of ESAs is very high, although within a regional context the magnitude of the impacts upon ESAs as a result of the project is medium. The overall significance of the impacts of the project on ESAs is **moderate**.

17.4.3 Regulated Vegetation Clearance

The vegetation areas shown in Table 17.6 will be cleared across the study area (although the areas below include base and alternative case options considered for the project). The proportions of these areas compared to the study area as a whole, Gladstone Regional Council area and Queensland are also shown.

Table 17.6 Regulated vegetation to be cleared within the study area

Regional Ecosystem (RE)	Total Remnant Vegetation in Study Area (High Value Regrowth in Parentheses) (ha)	Area to be Cleared (High Value Regrowth in Parentheses) (ha)	RE in Study Area to be Cleared (%)	RE in Gladstone Regional Council Area to be Cleared (%)	RE in Queensland to be Cleared (%)
11.3.4 *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	285.1 (57.5)	46.4 (8)	15.9	0.9	<0.1
12.1.2 Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains*.	521.8	59.4	11.4	0.4	0.2
12.1.3 Mangrove shrubland to low closed forest on marine clays and estuaries*.	552.2	5.8	1.1	<0.1	<0.1
12.11.14 *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	244.6 (4.6)	123.4	49.5	3.5	0.4
12.11.4 Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	7.5	3.9	51.8	0.1	0.1
12.11.6 *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	142.9	71.5	50	0.1	<0.1
12.3.3 *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	32.5	25.7	79.1	0.1	0.1
12.3.6 *Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains.	5.2	3.6	68.1	0.1	<0.1

Table 17.6 Regulated vegetation to be cleared within the study area (cont'd)

Regional Ecosystem (RE)	Total Remnant Vegetation in Study Area (High Value Regrowth in Parentheses) (ha)	Area to be Cleared (High Value Regrowth in Parentheses) (ha)	RE in Study Area to be Cleared (%)	RE in Gladstone Regional Council Area to be Cleared (%)	RE in Queensland to be Cleared (%)
12.3.7 *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	9.1	4.2	46.4	0.1	<0.1

* Regional ecosystem areas RE 12.1.2 and RE 12.1.3 differ slightly from figures for saltmarsh vegetation and mangrove habitat detailed in Chapter 19, Marine and Estuarine Ecology, which are based upon a DEEDI dataset for habitat types around Port Curtis and on different criteria for defining habitat type than RE mapping. The difference in area is approximately 1 ha or less in both cases.

As a proportion of the study area, there will be substantial clearance of areas of several REs including RE 12.11.14, RE 12.11.4 and RE 12.11.6. As a proportion of the Gladstone Regional Council area, clearance is relatively minor (less than 1% of the RE type) with the exception of RE 12.11.14 (3.5% of the RE within the area). The overall proportion compared to the extent within the state is less than 0.5% and the sensitivity of the assets containing this RE were typically rating medium, with a low degree of difficulty of replacement by offsets.

17.4.4 Potential Impacts to Endangered, Vulnerable and Near Threatened Fauna

Potential impacts on endangered, vulnerable and near threatened fauna as a result of the project are summarised under sub headings by class.

Amphibians

There is a moderate potential for the tusked frog (*Adelotus brevis*) to occur in a range of habitats throughout the study area. This species could be impacted by vegetation clearance and earthworks, particularly around the ephemeral stream at the LNG plant site. The species may also be impacted by increased lighting around the facility and through the potential increase in pest fauna species, such as the cane toad. The tusked frog was not found during field surveys. There are large areas of suitable habitat adjacent to the project area that will be unaffected.

Birds

Birds such as grey goshawk (*Accipiter novaehollandiae*), powerful owl, square-tailed kite and glossy black cockatoo (*Calyptorhynchus lathami*) have large territories and are likely to have a sparse distribution in the study area. The area lost is considered to be similar to areas of habitat to the north of the LNG plant site within the Curtis Island Environmental Management Precinct and the rest of Curtis Island, and areas to the west of the study area on the mainland.

The extent of remaining available habitat on the island means that the impacts on these species are not significant. There are no areas of casuarinas, which is the favoured food species for glossy black cockatoo, within the project area although it does contain suitable hollow bearing trees for nesting. The area of habitat lost is similar to areas within the Curtis Island Environmental Management Precinct and, if the species is present within the project area, it is likely to be displaced to this area.

Shorebirds such as sooty oystercatcher (*Haemotopus fuliginosus*), eastern curlew, beach stone curlew, and the little tern (*Sterna albifrons*), which favour coastal areas and tidal margins, may be

displaced from the coastal fringe of Boatshed Point and Hamilton Point by marine infrastructure. This area is small compared to the overall available habitat of Port Curtis, and the habitat at these sites is sub optimal for shorebirds so is unlikely to be of significance for any of these species. The area on the mainland around the mainland tunnel entry shaft and tunnel spoil disposal area is likely to support eastern curlew and beach stone curlew periodically, although as part of a wider network of foraging and roosting sites around Port Curtis.

Waterbirds, and species dependent on wetland habitats such as Lewin's rail (*Rallus pectoralis*), Radjah shelduck (*Tadorna radjah*), cotton pygmy goose (*Nettapus coromandelianus*) and black-necked stork (*Ephippiorhynchus asiaticus*) are unlikely to be impacted by the project. The cotton pygmy goose and Lewin's rail typically favour freshwater wetlands, none of which will be removed or affected by the project. Radjah shelduck is likely to be scarce in the area, as its stronghold is further north in Queensland and northern Australia. The only area of wetland impacted by the project is at the mainland tunnel entry shaft and tunnel spoil disposal area, which is unlikely to provide core habitat for this species. The saltmarsh and mudflats could provide foraging habitat for black-necked stork. This species will range widely over a variety of habitats and the loss of a small area of habitat here is unlikely to be significant.

The Capricorn race of yellow chat is endemic to the central Queensland coast. It is known only on Curtis Island and the adjacent mainland coast, where its range is estimated to be 25 km^2. It inhabits wetlands and associated grasslands on seasonally inundated plains under marine influence. Areas of wet grassland or saltmarsh in the study area, are generally small and heavily degraded. If the species does occur here, it is likely to be on a transitory basis, as the habitat is not of sufficient quality to retain the species for long, in terms of feeding or breeding resources. The stronghold of this species is further north around northern Curtis Island, the Fitzroy Delta and Torilla Plain, well away from the study area.

Black-chinned honeyeater is a highly mobile and nomadic species, moving around a large territory in response to blossom flowering. Relatively small areas of vegetation are being cleared when compared to adjacent available habitat. The honeyeater is unlikely to be significantly impacted by the project.

Squatter pigeon is known to occur on the mainland and is likely to be present in the vicinity of TWAF 8. Construction of the workers accommodation at this site and the operation of the camp could lead to displacement of the species in the immediate area of the camp. Large tracts of suitable habitat are present in the area and the pigeon will not be significantly impacted.

Australian swiftlet (*Aerodramus terraereginae*) is likely to be a scarce visitor to the project area, typically only coming as far south as Mackay. The species is an aerial feeder over a variety of habitats, is a wide ranging species and will not be significantly impacted by the project.

Mammals

The project area is potentially within the foraging range of the coastal sheathtail bat, grey-headed flying-fox, golden tipped bat (*Phoniscus papuensis*), little pied bat (*Chalinolobus picatus*) and ghost bat. No roost sites for megabat species were noted within the project area. Roosts for microbat species could occur within tree hollows in the project area (excluding the ghost bat, which roots in caves and old mine sites). Project activities could remove such roosts. The impact on these species is considered to be minimal as similar habitat is relatively common within the study area and the species have extensive foraging ranges.

There is moderate potential for koala to be present throughout the study area, with areas marked as essential habitat for this species. Field surveys for the project and other studies did not record

the species in the region. Koala could be present on Curtis Island and may also be present within the study area on the mainland. If present, the species could be impacted by vegetation clearance and habitat fragmentation. Koalas, if present, are likely to be in low densities and suitable available habitat adjacent to the project area means that any impacts are likely to be minimal.

Northern quoll could be present in woodland habitats across the project area although the species was not recorded in the field surveys. The species is likely to be uncommon in the area, if present, and range widely over a large territory. Northern quolls in Northern Territory's Kakadu National Park have been shown to have a territory of about 35 ha (with males holding territories up to 100 ha by overlapping female territories during the breeding season) (DNREA, 2006). TWAF 8 has been identified as potential habitat for this species. The area of clearance at this site is approximately 38 ha. The site is adjacent to Targinie State Forest, which will hold large areas of potential habitat for this species. Northern quoll could be impacted by habitat loss, fragmentation and edge effects such as the spread and increase in cane toad infestations.

Water mouse is likely to be present in mangrove habitat across the study area. Loss of areas of mangrove ecosystem, with abundant fallen woody debris and hollow logs, is likely to result in loss of habitat for the water mouse. The extent of habitat lost as a proportion of habitat available within the region is small. It is estimated the project will result in a loss of approximately 6 ha of mangrove habitat or 1% of the available habitat within the study area.

Reptiles

There is a moderate potential for brigalow scaly-foot (*Paradelma orientalis*), yakka skink (*Egernia rugosa*), collared delma and common death adder (*Acanthopsis antarcticus*) to be present within the study area in dry woodland habitats favouring leaf litter, hollow logs, crevices in rocks and fallen timber.

None of these species were found during field surveys. If present, they are likely to be impacted through unearthing during construction activities, loss of foraging and resting habitat including hollow logs, rocks and leaf litter, and edge effects such as changed hydrological regimes and increase in pests such as cane toads. The habitat within the study area is unlikely to be core habitat for any of these species.

17.4.5 Arrow LNG Plant

Ecological assets 23 to 36, and 47 and 48 (see Figure 17.1) are within the LNG plant footprint (approximately 250 ha), which will be largely cleared of vegetation and replaced with areas of hardstanding for plant facilities, access roads and other infrastructure. Work will also include the stream diversions around the site perimeter. The general project wide impacts all have the potential to occur within the area of project infrastructure. Specific potential impacts on the ecological assets at the LNG plant are:

- Loss of endangered RE 12.3.3 (*Eucalyptus tereticornis* woodland to open forest on alluvial plains) in ecological assets 27 and 31. These areas are considered to be highly intact ecosystems and difficult to replace. The vegetation community consists of red gum woodland with narrow leaved ironbark and Moreton Bay ash. These areas are considered essential habitat for endangered, vulnerable and rare species, namely the coastal sheathtail bat and the koala.
- Loss of mature hollow bearing trees, arboreal termitaria and fallen woody material (faunal habitat).

- Sediment runoff from the diversion channels for the watercourse created along the eastern and western margins of the site leading to increased sediment transport and reduced water quality in downstream areas of the channels, impacting upon vegetation health in these areas.

During desktop and field surveys within the LNG plant footprint (including ancillary facilities), no flora species of conservation significance were identified as being present or as likely to be present.

A number of fauna species of conservation significance have the potential to be present within the Arrow LNG plant footprint. These include the grey-headed flying-fox, square-tailed kite, grey goshawk, powerful owl, brigalow scaly-foot, yakka skink, collared delma, coastal sheathtail bat and black-chinned honeyeater. None of these species were recorded in field surveys and the area is not considered to be core habitat for any of these species. Small areas of the site (assets 27 and 31) are listed as essential habitat for the coastal sheathtail bat. This species was not recorded in surveys for other projects on Curtis Island and is distributed north from Shoalwater Bay, approximately 100 km northwest of Yeppoon and well away from the study area (DERM, 2011j).

All fauna species will be susceptible to the loss of habitat from vegetation clearance and groundworks that remove habitat features such as leaf litter, fallen wood and large rocks. Certain species, such as the square-tailed kite, grey goshawk and powerful owl, have large territories. The area lost is considered to be similar to areas of habitat to the north of the site within the Curtis Island Environmental Management Precinct and the rest of Curtis Island.

The impacts on these species are not considered significant due to the extent of remaining available habitat on the island.

Construction and operational activities will result in almost complete clearance of the ecological assets, a loss of areas of critical habitat for fauna species and degradation and disturbance to important habitat areas that support endangered, vulnerable and rare species.

As the endangered RE 12.3.3 (assets 27 and 31) at the LNG plant site will be cleared prior to construction, the significance of the impact on these assets has been assessed as **high**. These assets are essential habitat for koala and coastal sheathtail bat. Clearance will result in direct habitat loss and fragmentation of existing areas of contiguous habitat. All other impacts at the LNG plant site were assessed as **moderate**.

17.4.6 Curtis Island Saltpans and Fringing Mangroves

Ecological assets 12 and 13 (see Figure 17.1) will be impacted by the project through the reclamation of small areas of saltpan and mangrove habitat for the construction of a haul road along the northern shore of Hamilton Point, the laying of the pipeline and construction of the LNG jetty. Specific impacts on the ecological assets in this area are:

- Loss of a small area of mangrove ecosystem, dominated by stilted mangrove. This area includes abundant fallen woody debris and hollow logs and is likely to support the EPBC listed water mouse.
- Loss of a small area of intertidal saltpan and associated protected marine plants. This area is shorebird feeding habitat and part of the state significant wetland of Port Curtis, and likely to support EPBC Act listed migratory bird species. Disturbance to this area will occur during construction of the project infrastructure, with displacement of shorebirds from the immediate area adjacent to works. During operation, shorebird species are likely to return to use the

intertidal areas for foraging as habituation takes place, although some may be displaced from a small area immediately adjacent to project infrastructure.

From desktop and field surveys, no flora species of conservation significance were identified as being present or as likely to be present in this area.

A number of fauna species of conservation significance could be present within the saltpan and mangrove habitat. Beach stone curlew and eastern curlew were recorded during field surveys for other studies in the area. Other listed migratory waders are also likely to occur in this area. Fringing mangroves could hold populations of water mouse.

The LNG plant footprint is not core habitat for any of these species. The saltpan is a small proportion of a large network of shorebird feeding and roosting sites around Port Curtis (Port Curtis covers an area of approximately 200 km^2). The area of saltpan to be lost is of low value and a small proportion of that present in the study area (less than 1%). A small area of mangrove habitat will be lost although larger areas adjacent to the site will be retained and the clearance in relation to the available mangrove vegetation within the study area is less than 1%. It is expected that any water mouse present will move into these adjacent areas because the species has been observed to travel relatively large distances of up to 3 km a night (the species is believed to be totally nocturnal) while criss-crossing home ranges averaging 0.7 ha.

Impacts on fauna species are not considered to be significant due to the extent of suitable habitat on the island and in the wider region of Port Curtis.

Overall, the geographical extent of impacts on saltpan and mangrove habitat is small compared to the total locally available habitat. The impacts have been assessed as being of **moderate** significance, as clearance will be restricted to a small proportion of the overall extents of saltpan and mangrove vegetation within the study area (less than 1% in each case).

17.4.7 Boatshed Point

Boatshed Point is the site of the potential workforce accommodation camp and an option for a materials offloading facility (MOF) and personnel jetty on the southern tip of the point. This option includes a haul road, which will run from the MOF to the LNG plant. The majority of vegetation on Boatshed Point will be removed as part of ground preparation and ecological assets 37 to 39 (see Figure 17.1) will be directly impacted.

Specific potential impacts on the ecological assets on Boatshed Point are:

- Loss of a small area of coastal fringe of Boatshed Point for a MOF and personnel jetty, with a small loss of an area of the state significant wetland of Port Curtis.
- Loss of essential habitat for endangered, vulnerable and rare species, namely the coastal sheathtail bat and the grey-headed flying-fox.
- Disturbance of the vine thicket on the southern tip of Boatshed Point from construction activities (dust, noise and vibration, personnel and vehicle movements and artificial lighting). The vine thicket contains the currently unidentified *Cupaniopsis* sp. indet.
- Increased edge effects on the retained area of vegetation.
- Isolation of the small patch of vine thicket and creation of a barrier to movement, thereby isolating fauna populations. Some bird species are able to move to and from isolated pockets of habitat, although most mammals and reptiles are less able to make such movements.

From desktop and field surveys, no flora species of conservation significance were identified as being present or as likely to be present. The vine thicket on Boatshed Point contains the species of *Cupaniopsis* sp. indet.

Beach stone curlew and eastern curlew were recorded from field surveys for other studies in the area. Other listed migratory waders are also likely to occur in this area, predominantly during the southern hemisphere summer when these species migrate from their Siberian breeding grounds. (in Australia between September and April). Small numbers of many species overwinter in the area. The shoreline substrate at Boatshed Point largely consists of rocky boulders and rock platform and is not optimal foraging habitat for many shorebirds. Sooty oystercatcher favours rocky shorelines and, although not recorded during any of the field work, this species is likely to use the area as a feeding and roosting resource, as part of a series of sites around Port Curtis.

There is a large network of shorebird feeding and roosting sites around Port Curtis. The area of shoreline lost to shorebirds due to project infrastructure or displacement on Boatshed Point is of low value, being predominantly rocky substrate and not intertidal mudflats. The impact on migratory shorebird species is not considered to be significant at Boatshed Point due to the extent of remaining available habitat on the island and in the wider region of Port Curtis.

The majority of vegetation and habitat on Boatshed Point will be cleared except for a small area of vine thicket, which contains the *Cupaniopsis* sp. indet. The impacts have been assessed as being of **moderate** significance with the exception of the area of *Cupaniopsis* sp. indet. (asset 38). While the majority of this area will be retained, impacts will still be of **high** significance. This is due to the clearance of some areas, habitat fragmentation and disturbance of remaining areas of the asset, plus potential impacts from introduced flora and fauna.

17.4.8 Hamilton Point

Hamilton Point is an option for a MOF on the southern tip of the point. A haul road will run from the MOF into the LNG plant should this option be pursued. Ecological assets 14 to 22 (see Figure 17.1) will be impacted by the project through vegetation clearance. The majority of vegetation on Hamilton Point will be retained.

Specific impacts on the ecological assets at Hamilton Point are:

- Loss of a small area of coastal fringe at Hamilton Point from construction of the MOF, with the loss of a small area (less than 1 ha) of the state significant wetland at Port Curtis.
- Loss of essential habitat for endangered, vulnerable and rare species including coastal sheathtail bat, koala and the grey-headed flying-fox.
- Asset 14 (RE 12.2.2 microphyll/notophyll vine forest on beach ridges) has a very high conservation status. It is a critically endangered RE and considered as having habitat for threatened species. Although roads and other infrastructure avoid this area, the asset could be vulnerable to weed infestation, trampling from increased personnel movement and potentially increased fire frequency.
- Increased edge effects on the remaining vegetation.

Large areas of RE 12.11.4 on Hamilton Point are heavily degraded and in poor condition due to recent and historic, high intensity fuel reduction burns and pest infestations.

From desktop and field surveys, no flora species of conservation significance were identified as being present or as likely to be present.

A number of fauna species of conservation significance have the potential to be present within the woodland habitat of Hamilton Point. Species are similar to those at the LNG plant site. Impacts on these species are not significant given the considerable extent of remaining available habitat on the island.

Listed migratory waders are likely to occur on the foreshore of Hamilton Point. The substrate of the shoreline at this location largely consists of rocky boulders and rock platform and is not optimal foraging habitat for many shorebird species. Sooty oystercatcher favours rocky shorelines and, although not recorded during any of the field work, this species is likely to use the area as a feeding and roosting resource, as part of a series of sites around Port Curtis.

There is a large network of shorebird feeding and roosting sites around Port Curtis. The area of shoreline lost to shorebirds due to project infrastructure or displacement on Hamilton Point is of low value. Impacts on migratory shorebird species are not significant at Hamilton Point due to the extent of remaining available habitat on the island and the wider region of Port Curtis.

The proposed construction and operational activities will result in the clearance of areas of vegetation and habitat on Hamilton Point. Impacts were assessed as being **moderate** (or lower) significance for all assets on Hamilton Point, with the exception of asset 14. This small area of vine forest on the eastern side of Hamilton Point is critically endangered RE 12.2.2 with habitat for threatened species including coastal sheathtail bat and grey-headed flying-fox. Although not within the construction/clearing footprint, the asset could be significantly impacted without careful management of weeds and other threats and, as such, the significance of impacts was assessed as being **high**.

17.4.9 Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Area

Ecological assets in this area will be impacted by the project through the construction of the feed gas pipeline and tunnel shaft across Port Curtis, as well as the tunnel spoil deposition site and access routes (through areas of native vegetation) to the construction sites.

Specific impacts on the ecological assets in the area are:

- Loss of mudflats and associated protected marine plants. This area is shorebird feeding habitat and part of the state significant wetland of Port Curtis and is likely to support EPBC Act-listed migratory birds. During construction, displacement of birds is likely from the immediate area adjacent to the works. This may disrupt foraging and jeopardise the ability of birds to lay down fat reserves for the northward migration or to refuel after their southern migration.

  During operation, shorebird species are likely to return to use the intertidal areas for foraging as habituation takes place. Some birds may be displaced from a small area immediately adjacent to project infrastructure (due to personnel and vehicle movements, and construction noise), and fragmentation from other areas of the mudflats may take place. The area is listed under the EPBC Act and under international migratory bird agreements.

  An area of key shorebird foraging habitat in the Curtis Coast Regional Coastal Management Plan (EPA, 2003) is located on the eastern side of the mangroves adjacent to the mainland tunnel launch shaft. The mudflats on which the tunnel launch shaft is located are not part of this site.

  The mangroves will act as a visual buffer between this area of key shorebird foraging habitat and construction and operational works at the mainland tunnel launch shaft. There may be a temporary displacement of birds from the area of mudflat closest to the works for less tolerant

shorebird species, as a result of construction noise. Areas to the north and southeast of these mudflats will be relatively undisturbed and will still provide foraging habitat for species disturbed from the areas closest to the works.

- A shorebird roost site is present at the southern edge of asset 1, at Flying Fox Creek, as identified in the Curtis Coast Regional Coastal Management Plan. This site is unlikely to be disturbed by project construction and operation as it is located over 1 km to the southeast of the tunnel entry shaft and tunnel spoil disposal area.
- The area of mudflats is relatively intact although four-wheel driving, kite flying and illegal dumping may cause some disturbance to this area. Shorebirds foraging in this area are already likely to be subjected to low to moderate disturbance.
- The mangrove habitat adjacent to the mudflats will not be removed as a result of the project. It is likely the impact upon this habitat, and associated species, such as water mouse, will be minimal due to the distance (approximately 60 m) from the nearest construction works.
- Loss of woodland vegetation (asset 3 (RE11.3.4)) and increased edge effects under the feed gas pipeline corridor and access tracks. Woodland on the landward side of the site will be largely unaffected.

From desktop and field surveys, no flora species of conservation significance were identified as being present or as likely to be present.

A number of fauna species of conservation significance may be present at the area of mudflats on which the tunnel launch site will be constructed. The site is considered likely to hold more than 15 species of migratory shorebirds and is a significant shorebird habitat. The wider area of mudflats on which the mainland tunnel entry shaft and tunnel spoil disposal area is located is likely to provide habitat for migratory waders between October and April, with a peak in November to March. Smaller numbers may also be present during winter.

These mudflats are one site in a large network of shorebird feeding and roosting sites around Port Curtis (APLNG, 2010).

A number of fauna species of conservation significance have the potential to be present within the woodland habitat adjacent to the tunnel entry shaft and tunnel spoil disposal area. These species are similar to those at the LNG plant site. Impacts on these species are not significant due to the extent of remaining available habitat adjacent to the small corridor cleared for the feed gas pipeline.

The proposed construction and operational activities will result in the removal and reclamation of areas of mudflat and native woodland. Much of the value of these areas will be retained and the geographical extent of the impacts is small. Eight of the assets at this site were assessed as having a **negligible** significance of impacts, and one a **minor** significance of impacts.

Asset 8 (RE 12.3.3 *Eucalyptus tereticornis* woodland to open forest on alluvial plains) was attributed a high sensitivity as a result of being endangered RE. It is essential habitat for koala and coastal sheathtail bat. Impacts on this asset are considered to be **negligible** as the project does not directly impact upon this area as the nearest works are approximately 1 km to the southeast. The area is already subject to disturbance from neighbouring industrial activity.

Two of the assets have a **moderate** significance of impacts. This includes asset 2 (RE 12.1.3 mangrove shrubland to low closed forest on marine clay plains and estuaries), which is rated as having high sensitivity largely due to the mangroves providing potential shorebird roosting habitat

and likely habitat for water mouse. The magnitude of the impacts on this asset is assessed as medium, due to the project not requiring clearance of any of the asset and the mangroves being approximately 60 m from the nearest project area, thereby reducing direct disturbance to the asset.

Asset 1, relating to the saltpans of the mainland tunnel entry shaft and tunnel spoil disposal area (RE 12.1.2) is assessed as having a **high** significance of impacts. Construction at this site will cover approximately 70 ha, the majority of which is mudflat and saltpan vegetation. This represents less than 0.5% of the vegetation type within the Gladstone Regional Council area. In addition to direct habitat loss, there will be indirect disturbance to adjacent shorebird foraging habitat.

17.4.10 Launch Site 1

Construction at launch site 1 will involve the removal of a small area of mangrove vegetation and shrubland on the adjacent landward side as well as a small intertidal area of mudflats at the mouth of the Calliope River. This latter area is assessed within Chapter 19, Marine and Estuarine Ecology, although the impacts on shorebird species and water mouse are assessed here.

Assets 44 and 45 (see Figure 17.1) will be impacted by the project through vegetation clearance.

Specific impacts on the ecological assets at launch site 1 are:

- Loss of mangrove habitat, which may support water mouse. Impacts on this species are not considered to be significant due to the extent of remaining available habitat on the mainland and within the wider region of Port Curtis.
- Increased loss of mangrove habitat for water mouse in the Calliope River through erosion and loss of bank material as a result of navigation dredging carried out for the project.

Construction and operational activities will result in the clearance of the majority of vegetation and habitat at launch site 1. The magnitude of the impacts on the ecological asset of launch site 1 and the overall significance of the impacts on this ecological asset are assessed as being **moderate**.

17.4.11 TWAF 8

Ecological assets 41 to 43 (see Figure 17.1) will be impacted by the project through vegetation clearance at TWAF 8. These assets include RE 11.3.4 (of concern). The site includes three distinct areas of this ecosystem with non-remnant patches.

Construction at TWAF 8 will involve the removal of asset 41 and the partial removal of asset 43 (cleared in the north, retained in the south). Asset 42 will be largely retained along an ephemeral creek. Asset 49 along the southern perimeter of TWAF 8 will also be removed.

Specific potential impacts on the ecological assets at TWAF 8 are:

- Loss of RE 11.3.4 (of concern). These areas are highly intact ecosystems. Large areas to the east and west of the asset are mapped as essential habitat for coastal sheathtail bat and koala, and the site could act as a corridor connecting these areas. TWAF 8 also has the potential to support other conservation listed species such as powerful owl, square-tailed kite and black-chinned honeyeater. There is evidence of weed invasion around the margins of TWAF 8, which may reduce the value of this area as habitat for these species.
- Loss of mature, hollow bearing trees, arboreal termitaria and fallen woody material (faunal habitat).

- Loss of vegetation forming part of a state wildlife corridor. The removal of vegetation could impact upon the integrity of this corridor although large areas surrounding the site are still well vegetated and as such the impact is considered to be minimal. A connective corridor along the creek will be retained.
- Fragmentation of remaining habitat and increased edge effects including loss of vegetation integrity.
- Increased sediment transport and reduced water quality in the ephemeral creek (caused by sediment runoff from construction activities), impacting upon vegetation health in adjacent areas.
- Increased disturbance of native wildlife by the operation of the workers construction camp from noise, personnel movement and lighting, increased risk of roadkill from vehicle movements, increased likelihood of pest fauna species from inadequate waste management, and potential spread of plant pests.

From desktop and field surveys, no flora species of conservation significance were identified as being present or as likely to be present.

A number of fauna species of conservation significance have the potential to be present within the woodland habitat of TWAF 8. These species are grey-headed flying-fox, square-tailed kite, grey goshawk, powerful owl, koala, brigalow scaly-foot, coastal sheathtail bat, black-chinned honeyeater, squatter pigeon, yakka skink and Dunmall's snake. None of these species were found in targeted field surveys, although squatter pigeon was noted nearby during field surveys for other studies in the area. All species will be susceptible to the loss of habitat from vegetation clearance and groundworks that remove habitat features such as leaf litter, fallen wood and rocks.

The square-tailed kite, grey goshawk and powerful owl have large territories, and the area lost is similar to areas of habitat within the Gladstone region. Impacts on these species are not considered to be significant due to the large extent of suitable available habitat nearby, such as Targinie State Forest adjacent to TWAF 8.

Construction and operation activities will result in the clearance of the majority of vegetation and habitat at TWAF 8. The ecological asset along the ephemeral creek will be retained and subject to increased edge effects. Impacts at this site are assessed as having **moderate** significance with the exception of those at asset 49 which are assessed as being of **minor** significance, and at asset 41 (RE 11.3.4 *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains), which are assessed as being **high**. This asset is an of concern RE and will be almost completely cleared for workers' accommodation, access roads and laydown areas.

17.4.12 TWAF 7

Construction at TWAF 7 will involve the removal of vegetation over most of the site. TWAF 7 is dominated by regrowth vegetation on an old ash pond. The asset consists largely of non-remnant vegetation. TWAF 7 is within a regional wildlife corridor and, as such, plays a role in the connectivity of habitats in the Gladstone region. The field survey found the area was previously cleared and is in the early stages of regeneration; therefore, it is of limited ecological value and has low connectivity to adjacent habitats.

Specific impacts on the ecological assets at TWAF 7 are:

- Loss of a small area of saltmarsh (less than 2 ha) for the construction of the access causeway to TWAF 7. Fringing intertidal areas such as this could support foraging shorebirds although

the area is not of sufficient quality to support large numbers. These areas are not key shorebird foraging or roosting habitat.

- Loss of a small area of fringing mangroves (less than 2 ha) that may support water mouse. This area is a small proportion of the overall habitat available in Auckland Creek and the study area (over 550 ha of RE 12.1.3 mapped within the study area).
- Increased disturbance of native wildlife from the operation of the workers' construction camp.

Construction and operational activities will result in the clearance of the majority of vegetation and habitat at TWAF 7. The magnitude of the impacts on the ecological asset of TWAF 7 and the overall significance of the impacts on this ecological asset are assessed as being **minor**.

17.4.13 Impact Significance Summary

A summary of the significance of impacts across the project area is presented in Table 17.7.

Overall, six assets have impacts of high significance as follows:

- Asset 1 (Mainland tunnel entry shaft and tunnel spoil disposal site).
- Asset 14 (Hamilton Point).
- Asset 27 (LNG plant site).
- Asset 31 (LNG plant site).
- Asset 38 (LNG plant site).
- Asset 41 (TWAF 8).

Mitigation and management measures focus on reducing the significance of the residual impacts on these assets.

Table 17.7 Significance of impacts on ecological assets across the project area

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)[1]	Sensitivity of Asset	Magnitude of Impacts	Significance of Impacts
Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Site				
1	RE 12.1.2 (LC, -) Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	High	High	High
2	RE 12.1.3 (LC, -) Mangrove shrubland to low closed forest on marine clays and estuaries.	High	Medium	Moderate
3	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	High	Moderate
4	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	Negligible	Negligible
5	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	Negligible	Negligible
6	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	Negligible	Negligible
7	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	Negligible	Negligible
8	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	High	Negligible	Minor
9	RE 12.3.7 (LC, -) *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	Medium	Negligible	Negligible

Table 17.7 Significance of impacts on ecological assets across the project area (cont'd)

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)[1]	Sensitivity of Asset	Magnitude of Impacts	Significance of Impacts
10	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	Negligible	Negligible
11	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	Negligible	Negligible
Curtis Island Saltpans and Fringing Mangroves				
12	RE 12.1.2 (LC, -) Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	High	Medium	Moderate
13	RE 12.1.3 (LC, -) Mangrove shrubland to low closed forest on marine clays and estuaries.	High	Medium	Moderate
Hamilton Point				
14	RE 12.2.2 (OC, CE) Microphyll/notophyll vine forest on beach ridges.	Very high	Medium	High
15	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	High	Negligible	Minor
16	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	High	Medium	Moderate
17	RE 12.3.6 (LC, -) *Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains.	Medium	Negligible	Negligible
18	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
19	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Medium	Medium	Moderate
20	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	Medium	Moderate
21	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
22	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
LNG Plant Site				
23	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
24	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Medium	High	Moderate
25	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate

Table 17.7 Significance of impacts on ecological assets across the project area (cont'd)

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)[1]	Sensitivity of Asset	Magnitude of Impacts	Significance of Impacts
26	RE 12.3.7 (LC, -) *Eucalyptus tereticornis*, *Melaleuca viminalis*, *Casuarina cunninghamiana* fringing forest.	Medium	High	Moderate
27	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	High	High	High
28	RE 12.3.6 (LC, -) *Melaleuca quinquenervia, Eucalyptus tereticornis, Lophostemon suaveolens* woodland on coastal alluvial plains.	Medium	High	Moderate
29	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
30	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Medium	High	Moderate
31	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	High	High	High
32	RE 12.11.14 (OC, -) Eucalyptus crebra, Eucalyptus tereticornis woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
33	RE 12.3.7 (LC, -) Eucalyptus tereticornis, Melaleuca viminalis, Casuarina cunninghamiana fringing forest.	Medium	High	Moderate
34	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
35	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
36	RE 12.11.6 (LC, -) *Corymbia citriodora, Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics.	Medium	High	Moderate
Boatshed Point				
37	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
38	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	High	High	High
39	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	Medium	High	Moderate
TWAF 7				
40	n/a	Low	High	Minor
TWAF 8				
41	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	High	High	High
42	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	Medium	Moderate
43	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	Medium	Medium	Moderate

Table 17.7 Significance of impacts on ecological assets across the project area (cont'd)

Asset	Vegetation Community (Vegetation Management Act Status, EPBC Act Status)[1]	Sensitivity of Asset	Magnitude of Impacts	Significance of Impacts
Launch Site 1				
44	RE 12.1.2 (LC, -) Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains.	Medium	Medium	Moderate
45	RE 12.1.3 (LC, -) Mangrove shrubland to low closed forest on marine clays and estuaries.	Medium	Medium	Moderate
Non-remnant Vegetation				
46	Non-remnant vegetation at mainland tunnel entry shaft and tunnel spoil disposal site.	Very low	Negligible	Negligible
47	Non-remnant vegetation at LNG plant site (within footprint).	Low	High	Minor
48	Non-remnant vegetation at LNG plant site (outside footprint).	Low	Negligible	Negligible
49	Non-remnant vegetation at TWAF 8.	Very low	High	Minor

[1] CE = critically endangered, E = endangered, OC = of concern, LC = least concern.

17.5 Avoidance, Mitigation and Management Measures

This section describes measures to address the potential impacts on terrestrial ecology. Mitigation measures follow a hierarchy of avoiding the impact if possible (through project design), then reducing the impact through mitigation and management. Offsets are considered for any residual impacts once it has been demonstrated that all attempts have been made to avoid or reduce the significance of an impact to acceptable levels.

Terrestrial ecology management measures for project activities (including environmental objectives, performance criteria, implementation strategies, monitoring and reporting are presented in Attachment 6, Environmental Management Plan.

All activities will be undertaken in compliance with project permits and approvals.

17.5.1 Design and Planning

The avoidance and reduction of project impacts on terrestrial ecology is integral to design development. The following measures will be incorporated into the design:

- An area of semi-evergreen vine thicket community (containing the *Cupaniopsis* vegetation community) will be retained by the project on Boatshed Point. This area will be demarcated prior to the commencement of construction and workers and machinery will be prohibited from accessing the area. The boundary of the semi-evergreen vine thicket community will be fenced off with a 20 m buffer between the semi-evergreen vine thicket community (including the *Cupaniopsis* vegetation community) and the fence and area of disturbance. The retained vine thicket area is designed to protect a viable semi-evergreen vine thicket vegetation community and a viable population of *Cupaniopsis* sp. indet. on Boatshed Point. Do not develop within the fenced area of the retained semi-evergreen vine thicket community. Establish roles and responsibilities for the management of the retained semi-evergreen vine thicket community. [C17.03]

- A wildlife corridor of 20 m will be established on the eastern side of Boatshed Point to maintain connectivity between the semi-evergreen vine thicket community and the environmental management precinct. [C17.04]
- Route the haul road for the Hamilton Point MOF option away from the eastern margin of the headland to avoid the critically endangered RE 12.2.2 (microphyll/notophyll vine forest on beach ridges). [C17.05]
- TWAF 8 will be constructed to minimise disturbance to the of concern RE 11.3.4 ('*Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains') to maintain connectivity of habitat along the Targinie Creek riparian zone. [C13.04]
- Where practical, align the perimeter fence at TWAF 8 to adopt the alignment of the existing fence where it crosses Targinie Creek. [C13.05]
- Design any intra-site access road crossing of Targinie Creek at TWAF 8 to include box culverts (or similar) to enable fauna movement under the road and along the wildlife corridor. [C13.06]

The following measures will be implemented during the planning phases for the project:

- Prepare construction and operations environmental management plans. These documents are to include detailed information about significant flora and fauna species and their management and ongoing conservation. Include site-specific mitigation, and details of monitoring and inspection to be undertaken consistent with advice provided by government. [C17.01]
- Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works. [C17.06]
- Induct all personnel prior to entering a project site, including on measures for managing the impacts on flora and fauna likely to be present. [C17.22]

17.5.2 Mitigation by Project Impacts

The following mitigation measures aim to reduce impacts of the project on terrestrial flora and fauna throughout the project footprint.

Vegetation Clearance and Ground Disturbance

- Clearly mark no go zones, where required, including the *Cupaniopsis* fenced area and the critically endangered RE 12.2.2 on Hamilton Point (if the Hamilton Point South MOF is selected). [C17.23]
- Conduct preclearance surveys across project areas to be cleared of vegetation. The surveys will aim to determine whether any threatened species are present at each site. Appropriate mitigation measures will be implemented if threatened species are confirmed within the area. [C17.25]
- Reduce vegetation clearing where practical and only after all other options such as selective clearing and trimming of vegetation have been considered. [C17.27]
- Prior to initiation of works, clearly mark access tracks to prevent secondary tracks becoming established. Use existing access tracks where practical. Where practical, the location and design of access tracks should avoid sites of high ecological value. [C17.14]
- Rehabilitate construction access tracks not required for operations. [C17.39]

- Locate construction equipment, laydown areas, turn-around areas, stockpiles and working areas within areas of existing disturbance where practical. [C17.15]
- Clearly mark trees for retention to avoid accidental clearing and develop clearance procedures prior to construction. The root zone should be adequately protected. [C17.28]
- In areas where trees are planned to be left in place, take care to minimise damage to surrounding trees when felling trees into cleared areas or in natural slots between retained trees. [C17.29]
- Identify areas to be rehabilitated and develop procedures for restoration and maintenance. [C17.38]

Introduced Flora and Fauna

Pest management mitigation measures are set out in the pest management plan for the project (Appendix 10, Pest Management Plan). The following general measures will be implemented:

- Develop weed management measures prior to initiation of construction activities in accordance with local and regional management guidelines and best practice advice prescribed in DERM's pest control factsheet series. [C17.09]
- Develop and implement washdown strategies and procedures to prevent the spread of weeds. [C17.12]
- Adopt waste control measures to avoid introducing new external seed sources for exotic flora. [C17.32]
- Prohibit pets of staff and contractors from entering the project area (unless assistance animals). [C1731]
- Inspect plants, soil, fill and any other such materials to be used in construction/rehabilitation works prior to entry to site. If supplied from within the fire-ant restricted area, these materials must be accompanied by a movement certificate or fire-ant declaration form. This also applies for the yellow crazy ant. [C17.30]
- Develop and implement a mosquito management plan prior to construction that includes measures to control the occurrence of stagnant pools of water on the site especially after rainfall. [C17.11]
- Liaise with Biosecurity Queensland and Gladstone Regional Council on project biosecurity and pest management programs. Notify the Gladstone Regional Council of any new declared or notifiable species. These programs should particularly focus on the boundaries of the project site with the Environmental Management Precinct. [C17.10]

Direct Disturbance of Fauna

- Prepare a fauna management plan for the project. [C17.08]
- Prohibit hunting or trapping unless required for pest management. [C17.33]
- Undertake all handling and management of fauna in compliance with permits issued by DERM. [C17.34]
- Develop fauna relocation protocols as part of the fauna management measures including procedures if fauna is found during clearing activities, including in hollows of trees to be felled. [C17.07]

- Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including:
  - Shield/direct the light source onto work areas where practical. [C17.16]
  - Use long-wavelength lights, where practicable, including use of red, orange or yellow lights. [C17.17]
  - Lower the height of the light sources as far as practicable. [C17.18]
  - Avoid planned routine maintenance flaring at night during sensitive turtle-reproductive periods (where practicable). [C17.19]
- Develop measures to prevent fauna entrapment and implement prior to construction where practical (e.g., the use of pipe caps if piping if stored at ground level, string pipes with gaps for wildlife access). [C17.35]
- Develop trench inspection procedures to remove trapped fauna, establish protection and refuge areas for wildlife trapped in the trench and methods to assist trapped fauna left in the trench. [C17.36]

Altered Fire Regimes

- Prohibit construction and operation activities within 'field' areas that are outside of the construction area of disturbance, i.e., areas exposed to bushfire fuels, during days of total fire ban. [C17.37]

17.5.3 Mitigation by Project Location

Mitigation measures relevant to specific areas of project infrastructure are detailed below. These measures target impacts of a moderate or high significance.

Arrow LNG Plant, Boatshed Point, Hamilton Point

- Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones, where practical. [C17.20]
- Inspect the likely white-bellied sea-eagle nest on Hamilton Point for activity during the breeding season prior to site clearance. If active, formulate appropriate management measures, should the Hamilton Point MOF option be pursued. [C17.26]

Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Area

- Design construction lighting on the causeway at the mainland tunnel entry shaft and tunnel spoil disposal area to minimise impacts on roosting shorebirds. The lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal areas, where practical. [C17.21]
- Prohibit access to the saltpans and fringing mangroves (RE 12.1.2 and 12.1.3) outside the planned area of disturbance of the mainland tunnel entry shaft and tunnel spoil disposal area. [C17.24]
- Include measures in the pest management plan to control invasive plant species that may colonise the mudflats and degrade remaining habitat. [C17.13]

17.5.4 Offsets

The Queensland Biodiversity Offset Policy 2011 aims to increase the long-term protection and viability of the state's biodiversity where residual impacts from a development, on an area possessing state significant biodiversity values cannot be avoided. The policy provides the framework to ensure that there is no net loss of biodiversity.

Table 17.8 describes those terrestrial ecological values, which may require an offset, and the likely difficulty of finding a suitable offset receiving site.

Table 17.8 Potential offset requirements and degree of difficulty of replacement

Value	Regional Ecosystem and Status[1]	Area to be Cleared (ha)	Likely Offset Policy Trigger	Degree of Difficulty in Replacing
Regional ecosystem	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	46.4	Policy for vegetation management offsets	Low
Regional ecosystem	RE 12.11.14 (OC, -) *Eucalyptus crebra*, *Eucalyptus tereticornis* woodland on metamorphics ± interbedded volcanics.	123.38	Policy for vegetation management offsets	Low/medium
Regional ecosystem	RE 12.11.4 (OC, -) Semi-evergreen vine thicket on metamorphics ± interbedded volcanics.	3.91	Policy for vegetation management offsets	Medium/high
Regional ecosystem	RE 12.3.3 (E, -) *Eucalyptus tereticornis* woodland to open forest on alluvial plains.	25.69	Policy for vegetation management offsets	Medium/high
High-value regrowth	RE 11.3.4 (OC, -) *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains.	8.03	Regrowth vegetation code	Low
Essential habitat	For koala/coastal sheathtail bat.	46.4	Policy for vegetation management offsets	Low
Cupaniopsis sp. indet	Status pending.		Biodiversity offsets policy (Qld) and/or EPBC Act	High

[1]E = endangered, OC = of concern (Vegetation Management Act).

Offsets could be direct, indirect, or both. Direct offsets are preferred under the majority of offset policies as they are more likely to deliver conservation outcomes.

Direct offsets may encompass securing in perpetuity existing habitat, restoring and securing degraded habitat or re-establishing habitat. Indirect offsets might include contributions to research programs, implementing recovery plan actions, removing threatening processes or contributing to trust funds for consolidated purchase and restoration of strategic habitat.

This impact assessment does not stipulate the level of offsets required for the project, and indicates areas where offsets may be required.

Determination of areas (if any) requiring to be offset will be further defined in consultation with DERM and DSEWPC and other government stakeholders prior to commencement of construction. This is likely to include the two areas of endangered (Vegetation Management Act) remnant vegetation (RE 12.3.3; assets 27 and 31) within the LNG plant site, and the *Cupaniopsis* sp.indet population. [C17.02]

17.6 Residual Impacts

The assessment of residual impacts on terrestrial ecology assets assumes that all mitigation measures are implemented. With effective implementation of the measures, the magnitude of impact on the ecological assets defined across the project area will be reduced in many cases, which will in turn reduce the overall impact significance of the project on terrestrial ecology.

Of the 49 ecological assets assessed, 21 have either insignificant or minor impact significance once mitigation is applied. Twenty five have a moderate residual significance.

Three ecological assets remain with a high significance of impacts due to the high sensitivity of these assets and the long term duration of the impacts.

These three assets are:

- Asset 1 (RE 12.1.2 Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains) at the mainland tunnel entry shaft and tunnel spoil disposal area. The RE type at this location is of least concern but the impacts to the saltpans and shorebird habitat of some of the project area at this location will be permanent and are considered difficult to offset like for like, despite large areas of similar habitat retained at the site and within the region.
- Assets 27 and 31 at the LNG plant site are endangered (RE 12.3.3 *Eucalyptus tereticornis* woodland to open forest on alluvial plains). Considered essential habitat for koala and coastal sheathtail bat, this highly intact ecosystem will be permanently cleared for the project. Offsets may be required and will be further developed in consultation with DERM and DSEWPC.

Assets where premitigation significance was high and have been reduced to moderate include:

- Asset 38. The residual impact will be of moderate significance assuming minimal clearing of *Cupaniopsis* sp. indet. and that this species will be adequately protected within the proposed *Cupaniopsis* fenced area.
- Asset 41 (RE 11.3.4 *Eucalyptus tereticornis* and/or *Eucalyptus* spp. tall woodland on alluvial plains) The residual impact will be of moderate significance assuming disturbance is reduced and a suitable offset can be found.

The significance of residual impacts across the project area are displayed in Figures 17.7 and 17.8 and summarised in Table 17.9.

Table 17.9 Significance of residual impacts on ecological assets

Asset	Sensitivity	Impacts	Significance of Impacts Premitigation	Relevant Proposed Mitigation	Significance of Residual Impacts
Mainland Tunnel Entry Shaft and Tunnel Spoil Disposal Site					
1	High	VC, HF, IFF, H&P, DD, T	High	Design construction lighting on the causeway at the mainland tunnel entry shaft and tunnel spoil disposal area to minimise impacts on roosting shorebirds. The lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal areas, where practical. Prohibit access to the saltpans and fringing mangroves (RE 12.1.2 and 12.1.3) outside the footprint of the mainland tunnel entry shaft and tunnel spoil disposal area. Include measures in the pest management plan to control invasive plant species that may colonise the mudflats and degrade remaining habitat.	High
2	High	VC, HF, IFF, H&P, DD, T	Moderate		Moderate
3	Medium	VC, HF, IFF, H&P, AF, T	Moderate		Moderate
4	Medium	IFF	Negligible	Standard environmental controls.	Negligible
5	Medium	IFF	Negligible		Negligible
6	Medium	IFF	Negligible		Negligible
7	Medium	IFF	Negligible		Negligible
8	High	IFF	Minor		Minor
9	Medium	IFF	Negligible		Negligible
10	Medium	IFF	Negligible		Negligible
11	Medium	IFF	Negligible		Negligible
Curtis Island Saltpans and Fringing Mangroves					
12	High	VC, HF, IFF, H&P, DD	Moderate	Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones	Moderate
13	High	VC, HF, IFF, H&P, DD	Moderate		Moderate

Table 17.9 Significance of residual impacts on ecological assets (cont'd)

Asset	Sensitivity	Impacts	Significance of Impacts Premitigation	Relevant Proposed Mitigation	Significance of Residual Impacts
Hamilton Point					
14	Very high	IFF	High	Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones	Moderate
15	High	VC, IFF	Minor	As for assets 12 and 13.	Minor
16	High	IFF	Moderate		Minor
17	Medium	IFF	Negligible		Negligible
18	Medium	VC, HF, IFF, H&P, DD	Moderate	Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones Inspect the likely white-bellied sea-eagle nest on Hamilton Point for activity during the breeding season prior to site clearance. If active, formulate appropriate management measures, should the Hamilton Point MOF option be pursued	Moderate
19	Medium	VC, HF, IFF, H&P, DD	Moderate	As for asset 18.	Minor
20	Medium	VC, HF, IFF, H&P, DD	Moderate		Minor
21	Medium	VC, HF, IFF, H&P, DD	Moderate		Moderate
22	Medium	VC, HF, IFF, H&P, DD	Moderate		Moderate
LNG Plant Site					
23	Medium	VC, HF, IFF, H&P, DD	Moderate	As for assets 12 and 13.	Moderate
24	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
25	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
26	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate

Table 17.9 Significance of residual impacts on ecological assets (cont'd)

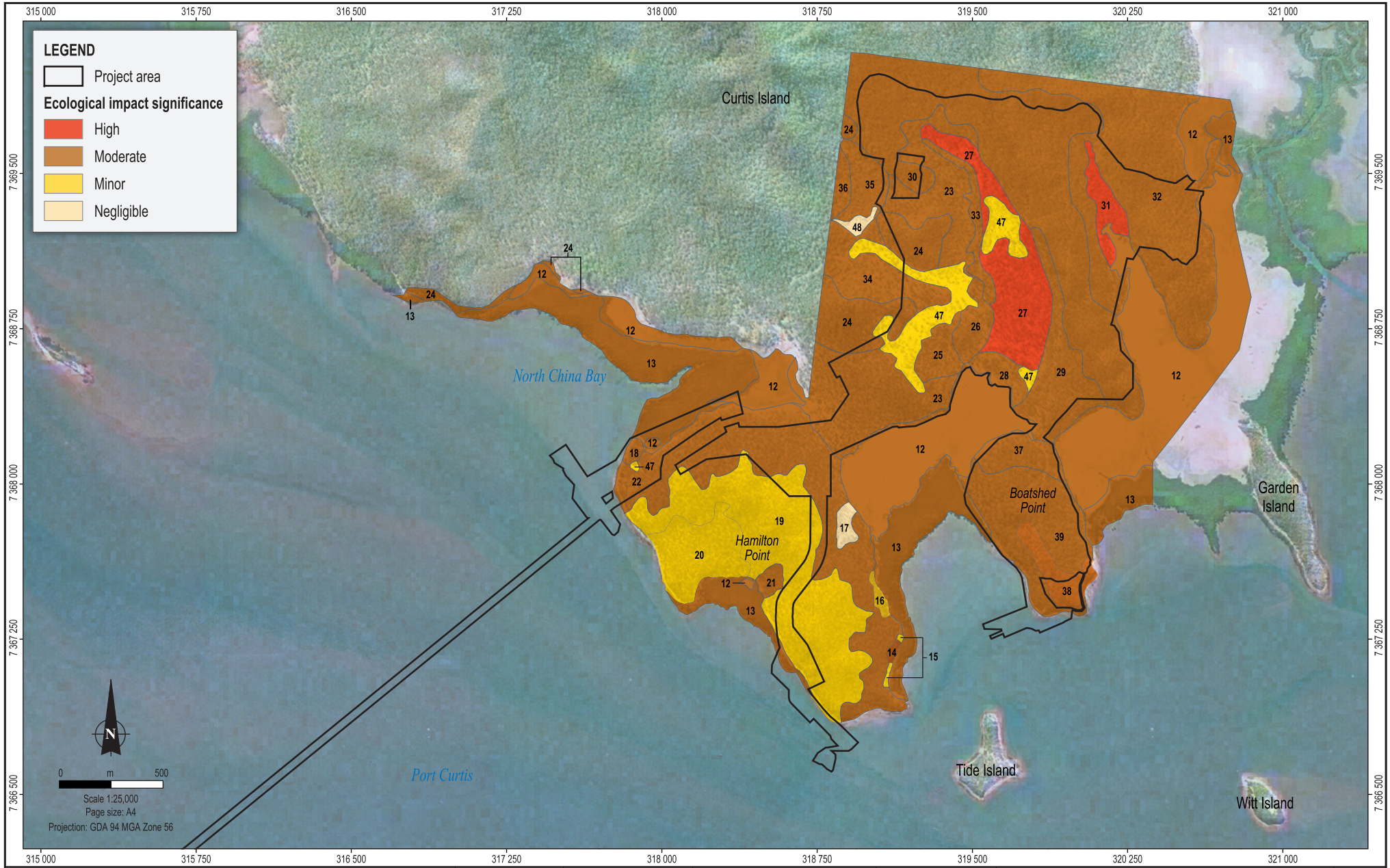
Asset	Sensitivity	Impacts	Significance of Impacts Premitigation	Relevant Proposed Mitigation	Significance of Residual Impacts
LNG Plant Site (cont'd)					
27	High	VC, HF, IFF, H&P, DD, AF	High	Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones.	High
28	Medium	VC, HF, IFF, H&P, DD, AF	Moderate	As for assets 12 and 13.	Moderate
29	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
30	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
31	High	VC, HF, IFF, H&P, DD, AF	High	As for asset 27.	High
32	Medium	VC, HF, IFF, H&P, DD, AF	Moderate	As for assets 12 and 13.	Moderate
33	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
34	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
35	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
36	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
Boatshed Point					
37	Medium	VC, HF, IFF, H&P, DD, AF	Moderate	As for assets 12 and 13.	Moderate
38	High	HF, IFF, H&P, DD, AF	High	Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones.	Moderate
39	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate
TWAF 7					
40	Low	VC, HF, IFF, H&P, AF	Minor	Standard environmental controls	Minor
TWAF 8					
41	High	VC, HF, IFF, H&P, DD, AF	High	Standard environmental controls	Moderate
42	Medium	IFF, DD	Moderate		Minor
43	Medium	VC, HF, IFF, H&P, DD, AF	Moderate		Moderate

Table 17.9 Significance of residual impacts on ecological assets (cont'd)

Asset	Sensitivity	Impacts	Significance of Impacts Premitigation	Relevant Proposed Mitigation	Significance of Residual Impacts
Launch Site 1					
44	Medium	VC, HF, IFF, H&P, DD	Moderate	Standard environmental controls	Minor
45	Medium	VC, HF, IFF, H&P, DD	Moderate		Minor
Non-remnant Vegetation					
46	Very Low	IFF	Negligible	Standard environmental controls	Negligible
47	Low	VC, HF, IFF, H&P, DD	Minor		Minor
48	Low	FF, H&P, DD	Negligible		Negligible
49	Very Low	VC, HF, IFF, H&P, DD	Minor		Minor

Notes: All general project mitigation applies to all assets, only specific project location mitigation (Section 17.5.3) shown.

Impacts: VC = vegetation clearing and disturbance; HF = habitat fragmentation and impacts on wildlife corridors; IFF = introduced flora and fauna; H&P = hydrology and pollution; DD = direct disturbance to fauna; AF= altered fire regimes; T = trenchfall (possible).



Source:
Place names from DME.
Project area from Coffey Environments.
Ecological impact significance from Ecosure.
Imagery from SPOT (2004-2007).

Note:
Numbering represents unique identification number allocation to ecological assets mapped by Ecosure

coffey environments

Date: 25.11.2011
MXD: 7033CA_07_GIS149_v1_7
File Name: 7033_07_F17.07_GIS_GL

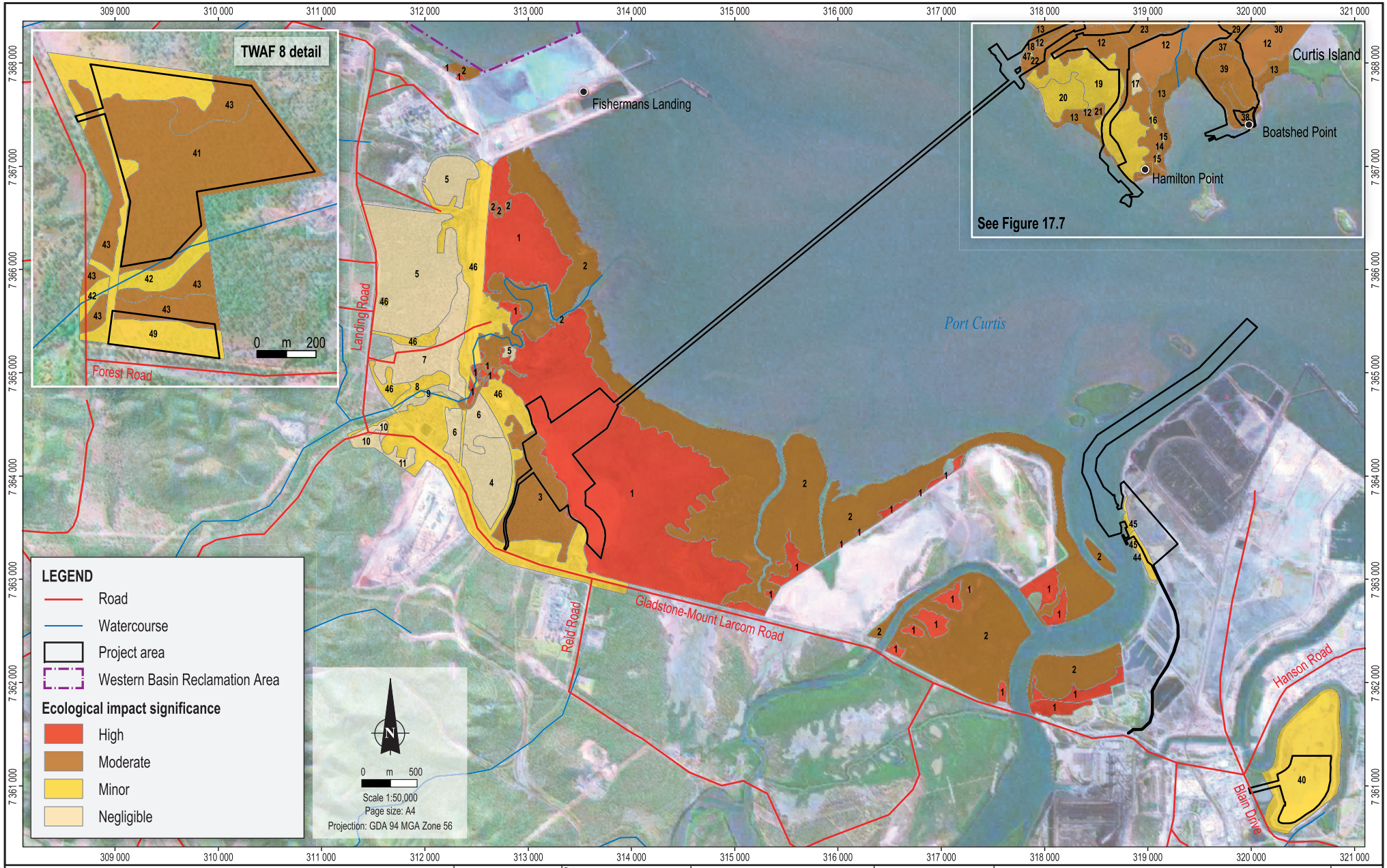
Arrow Energy

Arrow LNG Plant

arrow energy go further

Post mitigation assessment of terrestrial ecology impacts - LNG plant site

Figure No: 17.7



Source:
Place names, roads and watercourses from DME.
Project area from Coffey Environments.
Ecological impact significance from Ecosure.
Western Basin Reclamation Area from Gladstone Ports Corporation.
Imagery from SPOT (2004-2007).

Note:
Numbering represents unique identification number allocation to ecological assets mapped by Ecosure

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Date: 25.11.2011
MXD: 7033CA_07_GIS191_v1_4
File Name: 7033_07_F17.08_GIS_FT

Arrow Energy

Arrow LNG Plant

arrow energy go further

Post mitigation assessment of terrestrial ecology impacts - mainland infrastructure

Figure No: 17.8

17.7 Inspection and Monitoring

This section outlines inspection and monitoring measures for the project.

17.7.1 Preclearance Inspections

Preclearance inspections will be conducted by a qualified ecologist to identify potential key sites for conservation significant species, including nesting or roosting sites. Where practical, clearing will be timed to avoid the breeding season of the identified species found.

17.7.2 Monitoring and Inspection

The environmental management plan for the project will include details of the inspection and monitoring requirements related to impacts on terrestrial ecology. Likely inspection and monitoring activities include:

- Undertake a monitoring regime for the retained area of semi-evergreen vine thicket community (*Cupaniopsis*) on Boatshed Point and the RE 12.2.2 community on Hamilton Point (if the Hamilton Point South MOF is selected) to provide early indication of any degradation in these areas. Monitoring may not be required at RE 12.2.2 if the western haul road option is taken forward. Requirements may change and will be dependent upon the outcomes of *Cupaniopsis* sp. indet identification.
- Undertake a monitoring program at sites where impacts to migratory shorebird habitat have been identified. Requirements for further monitoring will be determined after an initial study to establish usage of project areas by migratory shorebirds and, if required, appropriate management measures formulated.
- Inspect areas of cleared vegetation that have been restored post construction to establish the success of rehabilitation.
- Develop a detailed site environmental monitoring program to assess the effectiveness of rehabilitation efforts at the site as part of the decommissioning and rehabilitation management plan.
- Undertake a trapping program (live traps where the mouse is released unharmed) to determine the presence or absence of water mouse at project sites on Curtis Island with mangrove habitat and at launch site 1. Requirements for further monitoring will be determined after the initial study.
- Develop trench inspection procedures to remove trapped fauna. For pipelines and other activities requiring excavation of long trenches, establish protection and refuge areas for wildlife trapped in the trench.

17.8 Commitments

The measures (commitments) that Arrow Energy will implement to manage impacts on terrestrial ecology are set out in Table 17.10.

Table 17.10 Commitments: Terrestrial ecology

No.	Commitment
C17.01	Prepare construction and operations environmental management plans. These documents are to include detailed information about significant flora and fauna species and their management and ongoing conservation. Include site-specific mitigation and details of monitoring and inspection to be undertaken, in the environmental management plans consistent with advice provided by government.
C17.02	Determine areas (if any) requiring to be offset in consultation with DERM and DSEWPC and other government stakeholders prior to commencement of construction. This is likely to include the two areas of endangered (Vegetation Management Act) remnant vegetation (RE 12.3.3; Assets 27 and 31) within the LNG plant site, and the *Cupaniopsis* sp.indet population.
C17.03	An area of semi-evergreen vine thicket community (containing the *Cupaniopsis* vegetation community) will be retained by the project on Boatshed Point. This area will be demarcated prior to the commencement of construction and workers and machinery will be prohibited from accessing the area. The boundary of the semi-evergreen vine thicket community will be fenced off with a 20-m buffer between the semi-evergreen vine thicket community (including the *Cupaniopsis* vegetation community) and the fence and area of disturbance. The retained vine thicket area is designed to protect a viable semi-evergreen vine thicket vegetation community and a viable population of *Cupaniopsis* sp. indet. on Boatshed Point. Do not develop within the fenced area of the retained semi-evergreen vine thicket community. Establish roles and responsibilities for the management of the retained semi-evergreen vine thicket community.
C17.04	A wildlife corridor of 20 m will be established on the eastern side of Boatshed Point to maintain connectivity between the semi-evergreen vine thicket community and the environmental management precinct.
C17.05	Route the haul road for the Hamilton Point MOF option away from the eastern margin of the headland to avoid the Critically Endangered' RE 12.2.2 (Microphyll/notophyll vine forest) on beach ridges.
C13.04	Design TWAF 8 to minimise disturbance to the Of Concern' RE 11.3.4 ('*Eucalyptus tereticornis* and/or Eucalyptus spp. tall woodland on alluvial plains') to maintain connectivity of habitat along the Targinie Creek riparian zone. Common with Chapter 13, Surface Water, Hydrology and Water Quality, and Chapter 18, Freshwater Ecology.
C13.05	Where practical, align the perimeter fence at TWAF 8 to adopt the alignment of the existing fence where it crosses Targinie Creek. Common with Chapter 13, Surface Water, Hydrology and Water Quality, and Chapter 18, Freshwater Ecology.
C13.06	Design any intra-site access road crossing of Targinie Creek at TWAF 8 to include box culverts (or similar) to enable fauna movement under the road and along the wildlife corridor. Common with Chapter 13, Surface Water, Hydrology and Water Quality, and Chapter 18, Freshwater Ecology.
C17.06	Develop requirements for ecological watching briefs/wildlife spotter-catchers as well as procedures for addressing ecological issues as they arise during construction, operation and rehabilitation works.
C17.07	Develop fauna relocation protocols as part of fauna management measures including procedures if fauna is found during clearing activities, including in hollows of trees to be felled.
C17.08	Prepare a fauna management plan for the project.
C17.09	Develop weed management measures prior to initiation of construction activities in accordance with local and regional management guidelines and best practice advice prescribed in DERM's pest control factsheet series.
C17.10	Liaise with Biosecurity Queensland and Gladstone Regional Council on project biosecurity and pest management programs. Notify Gladstone Regional Council of any new declared or notifiable pest species. These programs should particularly focus on the boundaries of the project site with the Environmental Management Precinct.
C17.11	Develop and implement a mosquito management plan prior to construction that includes measures to control the occurrence of stagnant pools of water on the site especially after rainfall.
C17.12	Develop and implement washdown strategies and procedures to prevent the spread of weeds.

Table 17.10 Commitments: Terrestrial ecology (cont'd)

No.	Commitment
C17.13	Include measures in the pest management plan to control invasive plant species that may colonise the mudflats and degrade remaining habitat.
C17.14	Prior to initiation of works, clearly mark access tracks to prevent secondary tracks becoming established. Use existing access tracks where practical. Where practical, the location and design of access tracks should avoid sites of high ecological value.
C17.15	Locate construction equipment, laydown areas, turn-around areas, stockpiles and working areas within areas of existing disturbance where practical. Implement measures to reduce the impacts of light from the LNG plant and ancillary facilities including:
C17.16	Shield/direct the light source onto work areas where practical. Common with Chapter 19, Marine and Estuarine Ecology, and Chapter 23, Landscape and Visual.
C17.17	Use long-wavelength lights, where practicable, including use of red, orange or yellow lights. Common with Chapter 19, Marine and Estuarine Ecology.
C17.18	Lower the height of the light sources as far as practical. Common with Chapter 19, Marine and Estuarine Ecology.
C17.19	Avoid planned routine maintenance flaring at night during sensitive turtle reproductive periods (where practicable). Common with Chapter 19, Marine and Estuarine Ecology.
C17.20	Design lighting around the perimeter of the LNG plant to minimise impacts on roosting shorebirds, where practical. Lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal zones, where practical.
C17.21	Design construction lighting on the causeway at the mainland tunnel entry shaft and tunnel spoil disposal area to minimise impacts on roosting shorebirds. The lowest possible luminescent globes should be used in sensitive areas, particularly around intertidal areas, where practical.
C17.22	Induct all personnel prior to entering a project site, including on measures for managing the impacts on flora and fauna likely to be present.
C17.23	Clearly mark no go zones, where required, including the semi-evergreen vine thicket (*Cupaniopsis*) fenced area on Boatshed Point and the 'Critically Endangered' RE 12.2.2 on Hamilton Point (if the Hamilton Point South MOF is selected).
C17.24	Prohibit access to the saltpans and fringing mangroves (RE 12.1.2 and 12.1.3) outside the planned area of disturbance of the mainland tunnel entry shaft and tunnel spoil disposal area.
C17.25	Conduct preclearance surveys across project areas to be cleared of vegetation. The surveys will aim to determine whether any threatened species are present at each site. Appropriate mitigation measures will be implemented if threatened species are confirmed within the area.
C17.26	Inspect the likely white-bellied sea-eagle nest on Hamilton Point for activity during breeding season prior to clearance, if this option is pursued. If active, formulate appropriate management measures, should the Hamilton Point MOF option be pursued.
C17.27	Reduce vegetation clearing where practical and only after all other options such as selective clearing and trimming of vegetation have been considered.
C17.28	Clearly mark trees for retention to avoid accidental clearing and develop clearance procedures prior to construction. The root zone should be adequately protected.
C17.29	In areas where trees are planned to be left in place, take care to minimise damage to surrounding trees when felling trees into cleared areas or in natural slots between retained trees.
C17.30	Inspect plants, soil, fill and any other such materials to be used in construction/rehabilitation works prior to entry to site. If supplied from within the fire-ant restricted area, these materials must be accompanied by a movement certificate or fire-ant declaration form. This also applies for the yellow crazy ant.
C17.31	Prohibit pets of staff and contractors from entering the project area (unless assistance animals).
C17.32	Adopt waste control measures to avoid introducing new external seed sources for exotic flora.
C17.33	Prohibit hunting and trapping unless required for pest management.

Table 17.10 Commitments: Terrestrial ecology (cont'd)

No.	Commitment
C17.34	Undertake all handling and management of fauna in compliance with permits issued by DERM.
C17.35	Develop measures to prevent fauna entrapment and implement prior to construction where practical (e.g., the use of pipe caps if piping stored at ground level, string pipes with gaps for wildlife access).
C17.36	Develop trench inspection procedures to remove trapped fauna, establish protection and refuge areas for wildlife trapped in the trench and methods to assist trapped fauna left in the trench.
C17.37	Prohibit construction and operation activities within 'field' areas that are outside of the construction area of disturbance, i.e., areas exposed to bushfire fuels, during days of total fire ban.
C17.38	Identify areas to be rehabilitated and develop procedures for restoration and maintenance.
C17.39	Rehabilitate construction access tracks not required for operations.