TERRESTRIAL ECOLOGY ASSESSMENT

TOONDAH HARBOUR PRIORITY DEVELOPMENT AREA, REDLAND CITY

Prepared for
Walker Corporation

Biodiversity Assessment and Management Pty Ltd
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Date: 05/04/2017

Managing Director

EXECUTIVE SUMMARY

PURPOSE OF THE REPORT

This report provides an assessment of the terrestrial ecology values present within the Toondah Harbour Priority Development Area (PDA) in Redland City, south-east Queensland, the potential impacts on these values of the Walker Group's proposal for the development of the PDA, and potential impact mitigation and management measures. The development proposal (the Project) includes residential, retail, marina, hotel, port facilities and tourism infrastructure to be developed within the PDA.

STUDY APPROACH

The report integrates the results of a number of previous terrestrial ecology studies that have been undertaken to inform the Toondah Harbour PDA development proposal with a revised review of publically available databases, including extensive shorebird survey data collected by the Queensland Wader Study Group, and published literature relevant to the terrestrial ecology values within the study area. Previous studies included a 1-day general ecological survey and at least four summer surveys and one winter survey for migratory shorebirds during both low-tide and high-tide phases of the tide cycle.

MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

Matters of national environmental significance (MNES) regulated under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that occur within the PDA boundary include:

- a small portion of the Moreton Bay wetlands, listed as internationally significant wetlands under the *Convention on Wetlands of International Importance 1971* (Ramsar Convention);
- intertidal mudflats and sandflats that are recognised as important feeding habitat (due to them being part of the Moreton Bay shorebird area that is recognised as internationally important for migratory shorebirds) for migratory shorebirds at low tide (average of 101 and maximum of 158 birds use the habitats in summer, representing 0.33% and 0.53% respectively of the estimated total of 30,000 migratory shorebirds that use Moreton Bay), including known feeding habitat for the critically endangered Eastern Curlew *Numenius madagascariensis* (average of 5 and maximum of 7 birds), the critically endangered Great Knot *Calidris tenuirostris* (a single bird on a single survey) and the vulnerable Bar-tailed Godwit (Western Alaskan) *Limosa lapponica baueri* (average of 25 and maximum of 36 birds);
- several individuals of the vulnerable Koala *Phascolarctos cinereus* regularly utilise food trees that are scattered across the western portion of the PDA as a component of the urban environment; while these trees, which include primary Koala food trees, are used regularly by several Koalas, the urban habitat is not identified as 'habitat critical to the survival of Koala' in accordance with the referral guidelines habitat assessment tool; and
- a small patch of Subtropical and Temperate Coastal Saltmarsh threatened ecological community, listed as vulnerable, is present in the south-western corner of the PDA.

Two shorebird roost sites (Nandeebie Claypan and Cassim Island) recognised as important roosting habitat (due to them being part of the Moreton Bay shorebird area that is recognised as internationally important for migratory shorebirds) for migratory shorebirds are located immediately adjacent to the PDA boundary, and a third important roost site, Oyster Point, is located 600 m south of the PDA.

The Nandeebie Claypan roost is used regularly by migratory shorebirds, particularly on spring high tides. During the summer months late September to March over the period 1995 to 2015,

an average of 474 and maximum of 2,560 migratory shorebirds were recorded on the 83% of surveys when migratory shorebirds were present; however over the past ten years (since 2007) the average and maximum numbers were 397 and 1,406 respectively. Migratory shorebirds recorded using Nandeebie Claypan include the critically endangered Eastern Curlew (an average of 25 and maximum of 180 birds recorded on the 67% of summer surveys when the species was present over the period 1995-2015, reducing to an average of 22 and maximum of 60 birds over the past ten years since 2007), the critically endangered Great Knot (an average of 27 and maximum of 90 birds recorded on the 15% of summer surveys when the species was present), the critically endangered Curlew Sandpiper *Calidris ferruginea* (very rarely present; only 1-2 birds recorded in 2 of 114 summer surveys) and the vulnerable Bar-tailed Godwit (an average of 609 and maximum of 2,300 birds recorded on the 56% of summer surveys when the species was present over the period 1995-2015, reducing to an average of 556 and maximum of 1,400 birds over the past ten years since 2007). Birds using the Nandeebie Claypan also use the nearby Oyster Point shoreline roost, moving between the two roost sites depending on the height of the tide and extent of disturbance at Oyster Point.

The Cassim Island mangroves, located 30 m from the PDA boundary, are used daily as a high-tide roost during the summer months by four migratory shorebird species that can roost in mangrove trees; an average of 699 and maximum of 920 migratory shorebirds were recorded roosting during four summer high-tide surveys.

MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

Matters of state environmental significance (MSES) regulated under the Queensland *Nature Conservation Act 1992* (NC Act) or *Vegetation Management Act 1999* (VM Act) that occur within the PDA boundary include:

- patches of remnant vegetation of two regional ecosystems (REs) that have a 'least concern' status under the VM Act: RE 12.1.2 (Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains); and RE 12.1.3 (Mangrove shrubland to low closed forest on marine clay plains and estuaries);
- feeding habitat used by two species listed as vulnerable under the NC Act, namely Eastern Curlew and Koala;
- a total of 286 non-juvenile Koala habitat trees, including 58 within areas mapped as 'medium value rehabilitation' within a priority koala assessable development area under the South East Queensland Koala Conservation State Planning Regulatory Provisions (SPRP);
- High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- Wildlife habitat for threatened wildlife and special least concern animals under the NC Act.

POTENTIAL IMPACTS OF THE PROJECT

As the Project is still at the planning stage of development, potential impacts are identified in general terms.

Potential impacts on matters of national environmental significance

The potential impacts of the Project on matters of national environmental significance include the following:

- Direct and indirect impacts on a small portion of the Moreton Bay Ramsar wetlands;
- Direct impact on an area of intertidal mudflats and sandflats that is recognised as important feeding habitat for migratory shorebirds, including known feeding habitat for two critically endangered and one vulnerable species;

- Indirect impacts on mudflats and sandflats adjacent to the PDA that are recognised as important feeding habitat for migratory shorebirds, including known and likely feeding habitat for three critically endangered, two endangered and one vulnerable species; indirect impacts relate to reduced food availability for migratory shorebirds in intertidal mudflats and sandflats adjacent to the PDA in the event that altered water quality or hydrodynamics affects benthic invertebrate abundance in intertidal mudflats and sandflats adjacent to the PDA;
- Increased disturbance to migratory shorebirds roosting at three important roost sites for migratory shorebirds located close to the Project, including roosts known to be used by three critically endangered and one vulnerable species; increased disturbance has potential to lead to a substantial reduction in the use of the roost sites by migratory shorebirds;
- Increased disturbance to migratory shorebirds feeding on intertidal mudflats and sandflats adjacent to the PDA in the event that the Project facilitates greater pedestrian access to these areas at low tide, particularly the areas to the east of the Cassim Island mangroves that might be attractive to recreational walkers with dogs;
- Loss of food trees used by several individuals of the vulnerable Koala in an urban area that is not recognised as 'habitat critical to the survival of Koala';
- Mortality of Koalas during clearing of Koala habitat trees prior to construction;
- Increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation; and
- Direct or indirect impacts on a small area of the vulnerable Temperate Coastal Saltmarsh threatened ecological community.

Potential direct impacts relate to the clearing of habitat or vegetation for infrastructure, marina basin or reclamation.

Potential impacts on matters of state environmental significance

The potential impacts of the Project on matters of state environmental significance include the following:

- direct impact on small areas of remnant regional ecosystems listed as having least concern status under the VM Act;
- loss of food trees used by several individuals of the vulnerable Koala in an urban area, including non-juvenile Koala habitat trees within areas mapped as medium value rehabilitation under the SPRP;
- increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation;
- direct and indirect impacts on High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- direct and indirect impacts on wildlife habitat for threatened and special least concern fauna species.

POTENTIAL IMPACT MITIGATION AND MANAGEMENT MEASURES

The direct impact of the Project on loss of feeding habitat for migratory shorebirds can be mitigated by minimising the area of intertidal feeding habitat in the development footprint of the Project design.

Potential impacts of disturbance on migratory shorebirds can be mitigated through the implementation of the following measures:

- buffer zones around important areas for migratory shorebirds, particularly important roost sites; ideally there should be no Project activities or public access within the buffer zones;
- construction of appropriate barriers, such as fences around important habitat to restrict access; ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds;
- landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and
- increased community education through mechanisms such as interpretive signs at access points to shorebird habitats.

The potential impacts of the Project on Koalas that currently utilise feed trees within the PDA can be mitigated by:

- adopting a landscape and urban design that retains as many of the primary food trees as possible;
- adopting a landscape and urban design that includes a linear strip of public open space to serve as a corridor connecting retained Koala food trees with bushland habitat in Nandeebie Park to the south of the PDA;
- planting additional primary Koala food trees both within the PDA and surrounding areas where possible, to mitigate the likely loss of some Koala food trees within the PDA, noting that it will take years for the plantings to reach a size that they begin to provide food for Koalas;
- including traffic calming designs for roads crossing the open space corridor, and implementing a maximum speed limit of 40 km/hr;
- ensuring that the clearing of any trees during Project construction is performed under the guidance of a licenced fauna spotter; and
- using Koala exclusion fencing to fence off areas that may pose a risk of injury to Koala during construction e.g. deep pits that Koala may fall into.

TERRESTRIAL ECOLOGY ASSESSMENT

TOONDAH HARBOUR PRIORITY DEVELOPMENT AREA, REDLAND CITY

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Table of Terms and Abbreviations

BAAM	Biodiversity Assessment and Management Pty Ltd
DERM	Queensland Department of Resource Management (now EHP)
DoEE	Commonwealth Department of the Environment and Energy
ED Act	Queensland *Economic Development Act 2012*
EDQ	Economic Development Queensland
EHP	Queensland Department of Environment and Heritage Protection
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
MNES	Matters of National Environmental Significance (under the EPBC Act)
MSES	Matters of State Environmental Significance (under the SPP)
NC Act	Queensland *Nature Conservation Act 1992*
PDA	Priority Development Area
QWSG	Queensland Wader Study Group
Ramsar Convention	*Convention on Wetlands of International Importance 1971*
RCC	Redland City Council
RE	Regional Ecosystem
SPP	Queensland State Planning Policy

SPRP	South East Queensland Koala Conservation State Planning Regulatory Provisions
TEC	Threatened Ecological Community (under the EPBC Act)
VM Act	Queensland *Vegetation Management Act 1999*

1.0 INTRODUCTION

1.1 BACKGROUND

Toondah Harbour was declared as Priority Development Areas (PDA) in Redland City by the State Government under the *Economic Development Act 2012* (ED Act) on 21 June 2013. Redland City Council (RCC) has identified the potential for Toondah Harbour PDA to revitalise the waterfront site through mixed-use development to deliver long-term, sustainable economic growth for Redland City in a number of ways, including but not limited to:

- the generation of employment in a range of sectors across the economy;
- providing much needed infrastructure that will generate economic activity and improved public amenity both for the mainland and as a regional gateway to North Stradbroke Island and Moreton Bay; and
- working towards Council's goal of employment containment within the City through the generation of increased economic activity and industry growth.

Planning for the area was undertaken by the Queensland Government, in partnership with Redland City Council, and a final development scheme was approved on 29 May 2014. The development scheme includes mixed-use, low and medium density residential development as well as tourism and retail-based development, dedicated ferry terminals, public open space and the potential for a private berth marina.

In late 2014, following a rigorous expression of interest process, Walker Group Holdings was selected by the Queensland State Government and Redland City Council as the preferred development partner for Toondah Harbour PDA. The Walker Group's proposal includes residential, retail, marina development, hotel, port facilities and tourism infrastructure.

1.2 OBJECTIVES OF THE REPORT

This technical report has been prepared for Walker Corporation for the purpose of providing an independent assessment of:

- the terrestrial ecology values within the Toondah Harbour PDA, particularly in relation to:
  - matters of national environmental significance (MNES) reflecting those protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act); and
  - matters of state environmental significance (MSES) reflecting those natural values and areas protected under Queensland's *Nature Conservation Act 1992* (NC Act) and *Vegetation Management Act 2009* (VM Act).
- potential impacts on these terrestrial ecology values from the proposed development of the PDA; and
- potential impact mitigation and management measures.

Since the declaration of the Toondah Harbour PDA in June 2013, several terrestrial ecology studies have been undertaken to inform the development scheme and Walker Group's proposal. This technical report reviews and integrates the results of these previous studies into a single report that interprets the results in relation to the current statutory framework.

1.3 STUDY AREA

Toondah Harbour PDA is located on the southern shores of Moreton Bay in Cleveland, approximately 33 km east of the Brisbane city centre. It is a recognised boat landing and acts as the point of departure and arrival for vehicular ferry and water taxi services between the mainland and North Stradbroke Island. The area is also comprised of residential and open space lands. The PDA covers landholdings located at Middle Street, Cleveland, and incorporates both land and sea areas with a total area of approximately 67 hectares (17.5 hectares over land, and 49.5 hectares within Moreton Bay).

Cleveland and its water transport facilities at Toondah Harbour are recognised as the main regional gateway to North Stradbroke Island. The harbour serves as the principal base for water taxi, passenger and vehicular ferry services to and from the island. The harbour is also utilised for the launch of recreational boats and trailers. Continuing growth of user numbers at Toondah Harbour will increase demand and place pressure on the existing small scale harbour facilities, which may have an impact on the environment.

For the purposes of this report, the study area for assessment comprises the area within the mapped extent of the PDA, as well an area of mangroves (known as Cassim Island) east of the PDA boundary and an area of mangroves and saltmarsh (known as Nandeebie Claypan) to the south of the PDA boundary (see **Figure 3.1**).

1.4 STATUTORY FRAMEWORK

Statutory instruments relevant to this ecological assessment cover Commonwealth and State Government legislation and other instruments.

1.4.1 Commonwealth legislation

The Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) protects matters of national environmental significance (MNES), which include the following with potential relevance to the study area:

- listed threatened species and ecological communities;
- migratory species protected under international agreements;
- Ramsar wetlands of international importance;
- World Heritage properties; and
- National Heritage places.

Should a project propose to take an action that will have, or is likely to have, a significant impact on a matter of national environmental significance, the proponent must refer that action to the Commonwealth Department of the Environment and Energy (DoEE) for assessment as to whether the action is a 'controlled action' requiring Commonwealth approval for the project or proposed action. A 'significant impact' is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Commonwealth of Australia 2009).

1.4.2 State legislation

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NC Act) is the principal legislation for the conservation and management of the State's native flora and fauna species and is administered by the Queensland Department of Environment and Heritage Protection (EHP). The key goal of the NC Act is the protection of endangered, vulnerable and near threatened (EVNT) species of flora and fauna as listed under the *Nature Conservation (Wildlife) Regulation 1994*.

Under section 253 of the *Nature Conservation (Wildlife) Regulation 1994*, a flora survey must be undertaken in accordance with the Flora Survey Guidelines - Protected Plants.

Under section 332 of the *Nature Conservation (Wildlife) Regulation 1994*, an approved species management program is required for tampering with an animal breeding place that is being used by a protected animal (including least concern native species) to incubate or rear the animal's offspring.

Vegetation Management Act 1999

The purpose of the *Vegetation Management Act 1999* (VM Act) is to regulate the clearing of native remnant vegetation mapped as Endangered, Of Concern and Not of Concern Regional Ecosystems (REs) to maintain ecological processes, ensure there is no loss of biodiversity or increase in land degradation from vegetation clearing, and manage the effects of clearing. In addition, some areas of remnant vegetation are further classified as Essential Habitat under the VM Act with specific reference to significant species listed under the NC Act.

2.0 PROJECT APPROACH AND METHODS

This report integrates the results of a number of previous terrestrial ecology studies that have been undertaken to inform the Toondah Harbour PDA development proposal with a revised review of publically available databases and published literature relevant to the terrestrial ecology values within the study area.

2.1 DESKTOP REVIEW

2.1.1 Previous studies

The following previous studies that reported on the terrestrial ecology of the Toondah Harbour PDA were reviewed for integration in this terrestrial ecology assessment:

- BAAM and frc environmental (2014). Expert advice in ecology (marine and terrestrial) and coastal processes for input to the preparation of a structure plan and development scheme for Toondah Harbour and Weinam Creek Priority Development Areas. Report prepared for Redland City Council.
- BAAM (2014). Migratory shorebird assessment, Toondah Harbour and Weinam Creek Priority Development Areas. Report prepared for Walker Corporation.
- BAAM (2015). Toondah Harbour and Weinam Creek Priority Development Area migratory shorebird survey results. Technical memorandum prepared for Walker Corporation.

2.1.2 Published literature and databases

The following publically available databases were reviewed to identify MNES and MSES that are known or predicted to occur in the study area or immediate environs:

- the EPBC Act Protected Matters Search Tool online database;
- the Atlas of Living Australia online database;
- the Queensland Government's Regional Ecosystem and Essential Habitat mapping;
- the Queensland Government's Koala Habitat mapping;
- the Queensland Government's Wildlife Online database;

Data on migratory shorebird use of shorebird habitats in or adjoining the study area were also sourced from the Queensland Wader Study Group (QWSG) for review and analysis. The QWSG is a special interest group within Birds Queensland that monitors shorebird populations in Queensland and conducts regular shorebird surveys of different parts of the Queensland coast that have large shorebird populations.

The published literature, particularly that dealing with the population ecology, habitat requirements and sensitivity to habitat change and disturbance of conservation significant species assessed as known or likely to occur in the study area was reviewed to inform the assessment.

2.2 FIELD SURVEYS

The previous studies listed under **Section 2.1.1** above conducted several field surveys to assess terrestrial ecology values within the study area. The approaches adopted during these field surveys are outlined in the following sections.

2.2.1 General terrestrial ecology survey

A general terrestrial ecology field survey was undertaken by a team of three terrestrial ecologists in fine, sunny weather on 5th July 2013, and involved ground-truthing of existing habitat mapping within the study area, including:

- verification of regional ecosystem (RE) mapping;
- assessment of the actual or likely presence of significant terrestrial species and associated habitat;
- verification of habitat boundaries (using GPS plotters) and characterisation of the quality, condition and connectivity of the habitats present; and
- obtaining a photographic record of each of the habitat types present.

A particular focus of the terrestrial fauna survey was surveying all non-juvenile habitat trees for Koala within the study area; i.e. food trees of the *Eucalyptus*, *Corymbia*, *Melaleuca* or *Lophostemon* genera, or preferred shelter species such as *Angophora* species, with a height of more than four metres, or a trunk with a circumference of more than 31.5 centimetres at 1.3 metres above the ground (Queensland Government 2015). This involved identifying and taking a GPS point at each non-juvenile habitat tree (or group of clustered trees), estimating the tree height and searching the base of the tree for Koala scats as confirmation of recent Koala activity.

2.2.2 Migratory shorebird surveys

Five summer surveys and one winter survey for migratory shorebirds were conducted within the study area between October 2014 and June 2015 by Dr Penn Lloyd (Principal Ecologist) in accordance with the survey guidelines outlined in the Commonwealth's EPBC Act *Policy Statement 3.21: Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species* (Commonwealth of Australia 2015a). Specifically:

- the surveys for foraging shorebirds were conducted as close to the time of low tide as practicable and at a maximum of no more than two hours either side of low tide;
- the surveys for roosting shorebirds were conducted as close to the time of high tide as practicable and at a maximum of no more than two hours either side of high tide;
- the surveys were not undertaken during periods of high rainfall or strong winds, or when activities that cause disturbance to the birds were taking place;
- the surveys determined the total number of individuals of each species present, to enable assessment of site and habitat importance; and
- the surveys collected spatial data of the area used by shorebirds for roosting and feeding to facilitate mapping of roosting and foraging habitat.

During the low tide surveys, shorebirds feeding on intertidal mudflats were surveyed using a high-powered Swarovski spotting telescope mounted on a sturdy tripod. Habitat areas were surveyed from suitable vantage points that provided an unobstructed view of the entire area, without causing disturbance to the shorebirds.

A known migratory shorebird roost site in an offshore area of mangroves located immediately east of Toondah Harbour (referred to as Cassim Island) was surveyed from a boat (first survey) or kayak (subsequent surveys). During the first survey, the boat was driven slowly around the perimeter of the mangroves. Birds roosting in the mangrove trees were counted using Leica 10x42 binoculars; this count was facilitated by the fortuitous overflight of a White-bellied Sea-eagle

(*Haliaeetus leucogaster*) during the survey that caused most migratory shorebirds to take flight and circle the roost site (when they could be counted in the air) before settling again. During the kayak surveys, the kayak was paddled around the fringe of the mangroves to flush roosting birds, which were then counted in flight. A further known migratory shorebird roost site on saltmarsh/claypan adjoining Nandeebie Park, immediately to the south of the Toondah Harbour PDA boundary, was surveyed using a Swarovski spotting telescope and/or Leica 10x42 binoculars.

The total number of people, dogs and boats present on the on-land portions of the study area during each survey were also recorded as a measure of the potential level of disturbance to roosting and foraging shorebirds.

3.0 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The desktop review identified a number of matters of national environmental significance (MNES) relevant to terrestrial ecology that are known or predicted to occur within or adjoining the Toondah Harbour PDA. These matters are summarised in **Table 3.1** and discussed in further detail in the following sections.

Table 3.1 Matters of national environmental significance identified as known or predicted to occur within or adjoining the Toondah Harbour PDA.

Matter of National Environmental Significance	Number identified
Wetlands of international importance (Ramsar)	1
Listed threatened ecological communities	3
Listed threatened terrestrial flora species	12
Listed threatened terrestrial fauna species	40
Listed migratory terrestrial fauna species	51

3.1 WETLANDS OF INTERNATIONAL IMPORTANCE

A portion of the intertidal area of Toondah Harbour PDA occurs within the bounds of the Moreton Bay wetland of international importance, listed under the *Convention on Wetlands of International Importance 1971* (Ramsar Convention) (**Appendices 1** and **2**). The existing channel of the harbour and some intertidal areas immediately adjoining the channel are mapped as being outside of the Ramsar area, with the remainder of the intertidal area occurring within the Ramsar area (**Figure 3.1**).

The Moreton Bay Ramsar site wetlands are nationally and internationally significant as one of the largest estuarine bays in Australia, enclosed by barrier islands of vegetated dunes, which together with the permanent lakes of the sand island components provide a diverse and rich suite of wetland habitats. Moreton Bay contains a complex system of intertidal flats totalling 23,000 ha at low tide (Blackman and Craven 1999).In relation to terrestrial fauna species, the wetlands are particularly significant as habitat for wetland birds, particularly migratory shorebirds (see **Section 3.5**), regularly supporting more than 50,000 waterbirds. The Moreton Bay shorebird area, which stretches 130 km from Caloundra in the north to Southport in the south and incorporates approximately 23,000 ha of intertidal mudflat/sandflat at low tide (Blackman & Craven 1999 cited in Finn et al. 2001), has been reported to support over 40,000 migratory shorebirds during the summer months (Driscoll et al. 1993, Watkins 1993) and over 3,500 resident shorebirds (Driscoll 1997). However, the total populations of at least 11 migratory shorebird species have undergone significant declines in Moreton Bay over the 15 year period 1992-2008, declining an average 62% over this period, largely as a consequence of the loss of feeding habitat at critical migration stopover sites in the Yellow Sea (Wilson *et al*. 2011; Yang *et al*. 2011). Consequently, Moreton Bay currently supports an estimated total of around 30,000 migratory shorebirds during summer (David Milton, QWSG, personal communication).

BAAM ECOLOGICAL CONSULTANTS

Client: Walker Corporation

Project: Terrestrial Ecology Assessment Toondah Harbour PDA

Design	BAAM	16.03.2017
Drawn	Bentline | MP	16.03.2017
Scale	1:7500	# 0107-005
Cad File	BAAM_Toondah01.dwg	NTP 74

Title: Matters of National Environmental Significance

FIGURE: 3.1

3.2 THREATENED ECOLOGICAL COMMUNITIES

Three threatened ecological communities (TEC) were identified from the database search results as having potential to occur within the Toondah Harbour PDA (**Appendix 1**), namely:

- Lowland Rainforest of Subtropical Australia (EPBC Act: Critically Endangered);
- Littoral Rainforest and Coastal Vine Thickets of Eastern Australia (EPBC Act: Critically Endangered); and
- Subtropical and Temperate Coastal Saltmarsh (EPBC Act: Vulnerable).

The field survey confirmed that a small patch of Subtropical and Temperate Coastal Saltmarsh TEC, which corresponds with RE 12.1.2 (saltpan vegetation including grassland, herbland and sedgeland on marine clay plains), occurs within the south-western corner of the Toondah Harbour PDA (**Figure 3.1**). The field survey also confirmed that neither the Lowland Rainforest of Subtropical Australia TEC nor the Littoral Rainforest and Coastal Vine Thickets of Eastern Australia TEC occur within or adjacent to the PDA.

3.3 THREATENED FLORA SPECIES

The EBPC Act Protected Matters Search Tool database search (see **Appendix 1**) identified 12 threatened flora species that may or are likely to occur within the study area. However, no threatened flora species have been recorded within a 1 km radius of the study area on the databases that were searched (see **Appendix 2**), none were detected during the field survey of the study area, and the study area does not contain habitat suitable for any of the 12 threatened flora species that may occur (see likelihood of occurrence assessment presented in **Appendix 3**). It should be noted that the EPBC Online Protected Matters Search Tool, whilst based on some species records, relies on modelling of suitable habitats and is largely predictive.

3.4 THREATENED FAUNA SPECIES

The database searches (**Appendices 1** and **2**) identified a total of 40 terrestrial fauna species listed as threatened species under the EPBC Act that may occur within the study area or environs. Five of these species (three critically endangered and two vulnerable) were recorded within or immediately adjacent to the study area during field surveys, and a further four species (two endangered and two vulnerable) were assessed as having potential to occur based on database records for the local area, field observations of the species in areas adjacent to the study area and presence of suitable habitat (**Table 3.2**). The remaining 31 species were assessed as unlikely to occur (see **Appendix 3** for details). Profiles for the nine species that are known to occur or have potential to occur are provided below. Additional information on the seven migratory shorebird species included in **Table 3.2** is provided in **Section 3.5** dealing with migratory shorebirds.

Table 3.2. Terrestrial fauna species listed as threatened species under the EPBC Act that are known or have potential to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
Numenius madagascariensis	Eastern Curlew	CE, M	V	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	V, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris	Great Knot	CE, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
tenuirostris				the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris ferruginea	Curlew Sandpiper	CE, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Phascolarctos cinereus	Koala	V	V	**Known**. Feeds on food trees (*species of Eucalyptus, Corymbia, Lophostemon* and *Melaleuca*) growing in the urban environment within and adjacent to the study area.
Calidris canutus	Red Knot	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to occur within 1 km of the study area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius mongolus	Lesser Sand Plover	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius leschenaultii	Greater Sand Plover	V, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Pteropus poliocephalus	Grey-headed Flying-fox	V	LC	**Potential**. While it has not been recorded within the study area, the species is known from the local area and it has potential to be a regular seasonal visitor to feed on flowing trees within the study area.

[1] Status under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): CE = critically endangered; E = endangered; M = migratory; V = vulnerable.
[2] Status under the *Nature Conservation Act 1992* (NC Act): LC = least concern, S = special least concern (migratory), V = vulnerable.

3.4.1 Eastern Curlew (Numenius madagascariensis)

Status: EPBC Act: Critically Endangered; NC Act: Vulnerable.

Distribution: The Eastern Curlew is the world's largest migratory shorebird and it is endemic to the East Asian-Australasian Flyway (EAAF). It breeds in north-eastern Asia during the northern summer and migrates through eastern Asia to spend the non-breeding season in the Philippines, Indonesia and Papua New Guinea (25% of the population), Australia (73% of the population) or New Zealand (2% of the population) during the austral summer.

Habitat and ecology: In Australia, Eastern Curlew feeds during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments with or without seagrass, and usually within 50 m of the low-water mark (Finn et al. 2007). In Moreton Bay, the average summer density of feeding Eastern Curlews ranges between 3.7 and 71.9 birds per 100 ha of mudflat (Finn 2010) and is most strongly related to substrate resistance, with the birds preferring areas with softer sediments that they can more easily probe into to capture prey (Finn et al. 2007, 2008). In Moreton Bay, Eastern Curlews feed primarily on crustaceans, particularly Mictyridae (soldier crabs), Brachyura (other crabs), Caridea (shrimp) and Thalassinidea (yabbies), which made up 15.4%, 9.8%, 4.7% and 2.8% of food items consumed respectively, and small molluscs (Finn et al. 2008). During the high tide phase of the tidal cycle, Eastern Curlews roost in small to large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans near the high-water mark.

Migrating Eastern Curlews leave Moreton Bay over a period of about one month in March, but arrive back over a more extended period from August through to December (Driscoll and Ueta 2002); however 25% of Eastern Curlews in Moreton Bay do not migrate and remain through the austral winter (Finn et al. 2001). Most Eastern Curlews appear to migrate along the east coast of China (Driscoll and Ueta 2002) and the Yellow Sea provides extremely important stopover feeding habitat for about 80% of the flyway population to replenish their fat reserves before continuing their migration (TSSC 2015).

Threats: Threats to Eastern Curlew in Australia include ongoing human disturbance at feeding and roost sites, habitat loss, habitat degradation from pollution, changes to the water regime and invasive plants (Milton et al. 2011, TSSC 2015). Key threats along their migration route are feeding habitat loss resulting from large land reclamation projects and habitat degradation resulting from aquaculture, gross pollution and invasion of salt marshes by exotic *Spartina* grass, particularly at key stopover migration staging sites in the Yellow Sea (Yang et al. 2011, Murray et al. 2014, Melville et al. 2016, Moores et al. 2016).

Population trend: The estimated population size of Eastern Curlew within the 20-year period 1986-2006 was 28,000 birds spending the non-breeding season in Australia, making up 74% of the total flyway population estimate of 38,000 (Bamford et al. 2008). However the flyway population has experienced a substantial decline since this estimate. Over the 19 years 1996-2014, the rate of decline has been greater in southern Australia (6.95% per year) than in northern Australia (2.91% per year), with an overall rate of decline of 3.2% nationally (Clemens et al. 2016). The annual rate of decline of the Eastern Curlew population using Moreton Bay over the 15 year period 1992-2008 was estimated at 2.4% per year (Wilson et al. 2011). The most recent analysis suggests the population of Eastern Curlew migrating to Australia has undergone a severe population decline of 66.8% over 20 years (5.8% per year) and 81.4 % over 30 years, which for this species is equal to three generations (TSSC 2015). This decline is thought to be largely due to ongoing loss of intertidal feeding habitat at key migration staging sites in the Yellow Sea (see **Section 3.5.2** for more details).

Occurrence in the Toondah Harbour PDA: During the summer months October 2014 to February 2015, an average of 4.8 and maximum of 7 Eastern Curlew were recorded feeding on the approximately 40 ha mudflats within the study area (see **Section 3.5.4** for further details). The observed average summer density of Eastern Curlews feeding in the Toondah Harbour PDA (average 12.0 birds per 100 ha) is greater than the average density of 4.0 birds per 100 ha recorded over 223 ha of mudflats in the Cleveland area in 2000, but less than the maximum of 71.9 birds per 100 ha recorded in the highest quality feeding area for the species in Moreton Bay at Moreton Island (Finn 2010). Eastern Curlews were recorded roosting at the Nandeebie Claypan roost site on 67% of 114 surveys between late September and March over the period 1995 to 2015, with an average of 25 and maximum of 180 birds recorded on surveys when the species was present, reducing to an average and maximum of 22 and 60 birds respectively over the past ten years since 2007 (see **Section 3.5.4** for more details). These data confirm that Nandeebie Claypan is a moderately important roost site for Eastern Curlew in the vicinity of the Toondah Harbour PDA.

3.4.2 Great Knot (Calidris tenuirostris)

Status: EPBC Act: Critically Endangered; NC Act: Special Least Concern.

Distribution: The Great Knot is a migratory shorebird that breeds in north-eastern Siberia during the northern summer and migrates through eastern Asia to spend the non-breeding season in Australia (most of the population) or south-east Asia during the austral summer.

Habitat and ecology: In Australia, Great Knots feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, often feeding in flocks in shallow water at the mudflat/sandflat edge. Great Knots feed mostly on bivalve and gastropod molluscs, polychaete worms and Brachyura and Ostracoda crabs (Tulp and Goeij 1994, Zhang et al. 2011). During the high tide phase of the tidal cycle, Great Knots roost in often large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans, often at the water's edge or in shallow water near the high-water mark.

Most migrating Great Knots leave Australia from the north coast in March-April, flying directly to the Yellow Sea region of China and Korea, with a few to Japan, where they stage and spend time feeding to replenish their fat reserves before continuing their migration north to the breeding grounds. After the breeding season, most adults congregate in the western and southern Sea of Okhotsk in south-eastern Russia, then fly direct to northern Australia, while some others move south to Korea before flying direct to Australia from there, arriving in late August to September (TSSC 2016).

Threats: The greatest threat facing the Great Knot is habitat loss and degradation at key staging areas in the Yellow Sea (see **Section 3.5.2** for more details), which support about 80% of the East Asian-Australasian Flyway population on the northward migration. Great Knot is considered more vulnerable to reclamation activities than most other waders due to the very specific species and sizes of shellfish that they eat. Other threats include disturbance at feeding and roosting sites and the longer-term impact of climate change that is expected to reduce the area of intertidal feeding habitat (TSSC 2016).

Population trend: The estimated population size of Great Knot within the 20-year period 1986-2006 was 360,000 birds spending the non-breeding season in Australia, making up 95% of the total flyway population estimate of 380,000 (Bamford et al. 2008). However, the flyway population has experienced a substantial decline since this estimate. The maximum and average abundance of Great Knot within Moreton Bay over the 28-year period 1978-2006 was reported as 1,975 and 831 birds respectively (Clemens et al. 2008). However, a more recent analysis over the 15 year period 1992-2008 found a significant decline in abundance in Moreton Bay estimated at 4.4% per year, from estimates of up to 2,750 birds in the 1990s to estimates of around 1,250 in the mid- to late-2000s (Wilson et al. 2011). Over the 19 years 1996-2014, the rate of decline has been greater in southern Australia (11.15% per year) than in northern Australia (0.98% per year), with an overall rate of decline of 3.2% nationally (Clemens et al. 2016). This decline is thought to be largely due to ongoing loss of intertidal feeding habitat due to a long history of ongoing land reclamation at key migration staging sites in the Yellow Sea (see **Section 3.5.2** for more details). At one of the largest land reclamation projects at Saemangeum in the South Korean Yellow Sea, approximately 104,000 Great Knots were lost from the flyway population, presumed to have died, following the reclamation of 29,000 ha of tidal flats in 2006 (Moores et al. 2016). The most recent analysis suggests that the Australian population of Great Knot has declined 83% over the past 25 years (TSSC 2016).

Occurrence in the Toondah Harbour PDA: During the low tide surveys, only a single Great Knot was recorded feeding on intertidal mudflats within the Toondah Harbour PDA on a single survey (see **Section 3.5.4** for more details). Furthermore, only small numbers of Great Knots appear to use nearby mudflats. This suggests that feeding habitat within the PDA and nearby mudflats is of marginal importance to Great Knot. The high tide survey results suggest that Great Knot occasionally roosts in relatively small numbers at the Nandeebie Claypan roost site (an average of 27 and maximum of 90 birds recorded on the 15% of summer surveys when the species was present) as well as at the nearby Oyster Point roost site (see **Section 3.5.4** for more details).

3.4.3 Curlew Sandpiper (Calidris ferruginea)

Status: EPBC Act: Critically Endangered; NC Act: Special Least Concern.

Distribution: The Curlew Sandpiper is a migratory shorebird that breeds across the Russian Arctic during the northern summer and migrates through Europe, North Africa and Asia to spend the non-breeding season in Africa, southern Asia and Australasia during the austral summer. Approximately 13% of the global population occurs in the East Asian-Australasian Flyway (TSSC 2015b).

Habitat and ecology: Curlew Sandpipers feed in both tidal and non-tidal wetlands. In tidal wetlands they forage on muflats, sandflats and nearby shallow water. In non-tidal wetlands they usually feed while wading through shallow water. In Australia, Curlew Sandpipers have a varied diet, but feed mostly on annelid worms, gastropod molluscs, crustaceans and insects. During the high tide phase of the tidal cycle, they roost in open areas with a damp substrate, including on sandy beaches, sandspits and islets in coastal lagoons and other wetlands (TSSC 2015b).

Curlew Sandpipers start migrating north from their non-breeding sites in Australia between mid-January and mid-April, most of them migrating through southern China, where Bahai Bay is an important staging site, before they begin arriving on the breeding grounds in late May to early June. After the breeding season, returning birds reach the northern shores of Australia in late August and early September. However, substantial numbers of Curlew Sandpipers remain in northern Australia throughout the nonbreeding season (TSSC 2015b).

Threats: Threats in Australia include ongoing human disturbance, habitat loss and degradation from pollution, changes to the water regime and invasive plants (TSSC 2015b).

Population trend: The estimated population size of Curlew Sandpiper within the 20-year period 1986-2006 was 118,000 birds spending the non-breeding season in Australia, making up 65% of the total flyway population estimate of 180,000 (Bamford et al. 2008). However, the flyway population has experienced a substantial decline since this estimate. The maximum and average abundance of Curlew Sandpiper within Moreton Bay over the 28-year period 1978-2006 was reported as 5,229 and 1,087 birds respectively (Clemens et al. 2008). An analysis over the 15 year period 1992-2008 found a significant decline in abundance in Moreton Bay estimated at 4.0% per year (Wilson et al. 2011). Over the 19 years 1996-2014, the rate of decline has been greater in southern Australia (11.15% per year) than in northern Australia (0.98% per year), with an overall rate of decline of 6.1% nationally (Clemens et al. 2016). The national Curlew Sandpiper population is estimated to have declined 76% over 20 years (TSSC 2015b).

Occurrence in the Toondah Harbour PDA: During the low tide surveys, Curlew Sandpiper was never recorded feeding on intertidal mudflats within the Toondah Harbour PDA (see **Section 3.5.4** for more details). Furthermore, very few, if any, Curlew Sandpipers appear to use nearby mudflats. This suggests that feeding habitat within the PDA and nearby mudflats is of marginal importance to Curlew Sandpiper. The high tide survey results suggest that Curlew Sandpiper very rarely roosts at the Nandeebie Claypan roost site (only 1-2 birds recorded in 2 of 114 summer surveys) or at the nearby Oyster Point roost site (see **Section 3.5.4** for more details).

3.4.4 Bar-tailed Godwit (western Alaskan) (Limosa lapponica baueri)

Status: EPBC Act: Vulnerable; NC Act: Special Least Concern.

Distribution: The Bar-tailed Godwit is a relatively large migratory shorebird with a variety of subspecies that together occupy a large global range. The subspecies *L. l. baueri* breeds in north-

east Siberia and west Alaska in the northern summer and migrates down the East Asian-Australasian Flyway to spend the non-breeding season in northern and eastern Australia and New Zealand during the austral summer (TSSC 2016b).

Habitat and ecology: In Australia, Bar-tailed Godwits feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, usually foraging near the edge of the water or in shallow water. They feed on polychaete worms, molluscs, crustaceans and insects (TSSC 2016b). In the highest quality feeding habitats on the eastern side of Moreton Bay, Bar-tailed Godwit feeding densities ranged between 3 and 8 birds per hectare of sandflat (Zharikov and Skilleter 2003). During the high tide phase of the tidal cycle they roost in large flocks on sandy beaches, sandbars, spits and in near-coastal saltmarsh (TSSC 2016b). Bar-tailed Godwits have high fidelity to feeding and roosting sites in Moreton Bay, returning to the same feeding areas and roost sites both within and between seasons (Coleman and Milton 2012).

Satellite tracking has shown that migrating Bar-tailed Godwits (western Alaska) leave Australia and New Zealand in March, making long flights (average 10,060 km) to staging sites in the Yellow Sea, where they stage for an average of 41 days to replenish their fat reserves before flying an average of 6,770 km to their breeding grounds. After completion of breeding, the birds stage for several weeks in southwest Alaska before either making non-stop flights across the Pacific Ocean to New Zealand (11,690 km in a complete track) or stopovers on islands in the south-western Pacific en route to New Zealand and eastern Australia. One satellite tracked bird made a non-stop flight of around 10,200 km in about eight days. After making these flights, the birds arrive starving on the staging sites; this highlights the critical importance of conserving sufficient intertidal feeding habitat in the staging areas to allow the birds to refuel (TSSC 2016b).

Threats: The greatest threat facing Bar-tailed Godwits is habitat loss and degradation at key staging areas in the Yellow Sea (see **Section 3.5.2** for more details), where about 80% of the East Asian-Australasian Flyway population stage on the northward migration. Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves (TSSC 2016b).

Population trend: The estimated EAAF population size of Bar-tailed Godwit (western Alaskan) within the 20-year period 1986-2006 was estimated at 155,000 birds, of which approximately 61,000 spend the non-breeding season in Australia with the remaining 94,000 in New Zealand (Bamford et al. 2008, TSSC 2016b). However, the flyway population has experienced a substantial decline since this estimate. The maximum and average recorded abundance of Bar-tailed Godwit within Moreton Bay over the 28-year period 1978-2006 was reported as 13,233 and 6,018 birds respectively (Clemens et al. 2008). An analysis over the 15 year period 1992-2008 found a significant decline in abundance in Moreton Bay estimated at 6.4% per year (Wilson et al. 2011), and total numbers using Moreton Bay are estimated to have declined by 68% between 1993 and 2008 (TSSC 2016b). Over the 19 years 1996-2014, the rate of decline has been greater in northern Australia than in southern Australia, with an overall rate of decline of 3.2% nationally (Clemens et al. 2016). The most recent analysis suggests Bar-tailed Godwit (western Alaskan) has experienced a substantial national population decline of 32.4% over 29 years (1.4% per year) (TSSC 2016b).

Occurrence in the Toondah Harbour PDA: During the summer months October 2014 to March 2015, an average of 24.8 and maximum of 36 Bar-tailed Godwits were recorded feeding on intertidal mudflats within the Toondah Harbour PDA (see **Section 3.5.4** for more details). The feeding density recorded within the study area (average 0.62 birds/ha, maximum 0.9 birds/ha within the approximately 40 ha of mudflats in the study area) is substantially less that the densities of 3 to 8 birds/ha recorded in the highest quality feeding habitats on the eastern side of Moreton Bay (Zharikov and Skilleter 2003). Bar-tailed Godwits were recorded roosting at the Nandeebie Claypan roost site on 56% of 114 surveys between late September and March over the period

1995 to 2015, with an average of 609 and maximum of 2,300 birds recorded on surveys when the species was present, reducing to an average and maximum of 556 and 1,400 birds respectively over the past ten years since 2007 (see **Section 3.5.4** for more details). These data confirm that Nandeebie Claypan is an important roost site for Bar-tailed Godwits that feed in southern Moreton Bay, particularly on spring high tides. The nearby Oyster Point roost site is similarly important; Bar-tailed Godwits typically roost initially at Oyster Point on the rising tide, moving to Nandeebie Claypan (or other alternative roost sites further north, such as the Geoff Skinner Reserve in Wellington Point or Manly Harbour) when the rising spring tides or human disturbance displace the birds from Oyster Point.

*3.4.5 Red Knot (*Calidris canutus*)*

Status: EPBC Act: Endangered; NC Act: Special Least Concern.

Distribution: The Red Knot is a migratory shorebird that has a global distribution and an extremely large range. Two subspecies of Red Knot utilise the East Asian-Australasian Flyway: *C. c. piersmai* breeds in the New Siberian Islands and tends to overwinter almost exclusively in north-western Australia; and *C. c. rogersi* breeds in Chukotka, in far-eastern Siberia and tends to overwinter in eastern Australia and New Zealand (Rogers et al. 2010, TSSC 2013c).

Habitat and ecology: In Australia, Red Knots feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats with relatively soft sediments, often feeding in flocks in shallow water at the mudflat/sandflat edge. Red Knots feed on worms, bivalves, gastropods, crustaceans and echinoderms (TSSC 2016c). During the high tide phase of the tidal cycle, Red Knots roost in often large flocks on sandy spits, sandbars, shallow lagoons, saltmarshes and claypans, preferring open areas far away from potential cover for predators, but close to feeding grounds, and often where the substrate is damp (Rogers et al. 2006). Red Knots leave Tasmania from February–May and leave south-east mainland Australia from late February or late March to early April. Returning birds arrive in northern Australia from late August and arrive in south-west Australia from September (TSSC 2016c). During migration, the Yellow Sea is extremely important as stopover habitat for Red Knot, with over 45% of the EAAF population using a single site at Bohai Bay, China during their migration (Rogers et al. 2010).

Threats: The greatest threat facing Red Knots is habitat loss and degradation at key staging areas in the Yellow Sea (see **Section 3.5.2** for more details). Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves (TSSC 2016c).

Population trend: The population of Red Knot using the EAAF was previously estimated to be around 220,000 birds (Bamford et al. 2008), but a revised estimate for the flyway is 112,000 individuals, of which 68,000 occur in Australia (Rogers et al. 2010, Garnett et al. 2011). The population of Red Knot is Australia is estimated to have experienced a severe population decline of 62.0% over 23 years (4.4% per year), and numbers of Red Knots using Moreton Bay have declined by 75% between 1993 and 2008 (TSSC 2016c). The primary cause of this decline is attributed to ongoing loss of intertidal mudflat habitat at key migration staging sites in the Yellow Sea (Murray et al. 2014, TSSC 2016c).

Occurrence in the Toondah Harbour PDA: Surveys have not detected Red Knots feeding in the PDA, and there are no historical records of Red Knot roosting in the vicinity of the PDA. However, the species has been recorded within a 1 km radius of the PDA. Red Knots have potential to feed on mudflats adjacent to the study area, particularly extensive mudflat areas to the south of the PDA. The species has potential to occasionally visit mudflats within the PDA; however, the lack of survey records suggests mudflat habitat within the PDA is of marginal value to Red Knots.

*3.4.6 Lesser Sand Plover (*Charadrius mongolus*)*

Status: EPBC Act: Endangered; NC Act: Special Least Concern.

Distribution: The Lesser Sand Plover is a migratory shorebird that has a global distribution and an extremely large range. Four of the five subspecies occur in the EAAF, and two of these, *C. m. mongolus* and *C. m. stegmanni*, occur in Australia during the non-breeding season; *C. m. mongolus* breeds in inland eastern Siberia whereas *C. m. stegmanni* breeds mostly in Kamchatka, on the northern Kuril and Commander Islands and on the Chukotka Peninsula in Russia (TSSC 2016d).

Habitat and ecology: In Australia, Lesser Sand Plovers feed during the low tide phase of the tide cycle on open intertidal mudflats or sandflats in estuaries or beaches, or in shallow ponds in saltworks. They feed on insects, crustaceans (especially crabs and amphipods), molluscs (especially bivalves) and polycheate worms (TSSC 2016d). During the high tide phase of the tidal cycle, Lesser Sand Plovers roost in often large flocks on beaches or in estuarine lagoons close to feeding grounds. During migration, Lesser Sand Plovers arrive in northern and eastern Australia during August-October, and leave again during March-April. The Yellow Sea is a very important staging area for this species as it supports about 50% of the EAAF population during northern migration, and Lesser Sand Plovers are also common in the Yellow Sea during southern migration (TSSC 2016d).

Threats: The greatest threat to Lesser Sand Plover is indirect and direct habitat loss, particularly at critical migration staging areas through eastern Asia. In Australia, threats include habitat loss, habitat degradation and human disturbance (TSSC 2016d).

Population trend: The population of Lesser Sand Plovers visiting Australia is estimated to be approximately 25,360 birds (Clemens et al. 2016). A recent analysis suggests that the Lesser Sand Plovers over-wintering in Australia have experienced a severe population decline of 74.8% over 24 years (6% per year), in large part due to ongoing loss of intertidal mudflat habitat at key migration staging sites in the Yellow Sea (TSSC 2016d). The estimated rate of decline in Australia is 7.2% per year over the period 1973 to 2014 and 13.4% per year over the period 1996 to 2014 (Clemens et al. 2016).

Occurrence in the Toondah Harbour PDA: Surveys have not detected Lesser Sand Plovers feeding in the PDA, and there are no historical records of Lesser Sand Plovers roosting in the vicinity of the PDA. However, the species was observed foraging on the more extensive mudflat areas adjacent to the PDA to the south (east of Oyster Point). The species has potential to occasionally visit mudflats within the PDA; however, the lack of survey records suggests mudflat habitat within the PDA is of marginal value to Lesser Sand Plovers.

*3.4.7 Greater Sand Plover (*Charadrius leschenaultii*)*

Status: EPBC Act: Vulnerable; NC Act: Special Least Concern.

Distribution: The Greater Sand Plover is a migratory shorebird that has a global distribution and an extremely large range. The subspecies C*. l. leschenaultii* occurs in the EAAF, breeding in Mongolia, north-western China and southern Siberia during the northern hemisphere summer and migrating along the EAAF to spend the non-breeding period in Australia (75% of the EAAF population) or south-east Asia (Bamford et al. 2008).

Habitat and ecology: In Australia, Greater Sand Plovers feed during the low tide phase of the tide cycle from the surface of wet sand or mud on open intertidal mudflats or sandflats in estuaries,

lagoons or beaches; they are more often associated with firm sandy flats than soft muddy ones. They feed mostly on molluscs, worms, crustaceans (especially small crabs and sometimes shrimps) and insects (TSSC 2016e). During the high tide phase of the tidal cycle, Greater Sand Plovers roost in often large flocks on beaches, estuarine lagoons, adjacent areas of saltmarsh and occasionally on rocky points, usually close to their feeding grounds. During migration, Greater Sand Plovers arrive in northern Australia from late July, and leave again between late February and April (TSSC 2016e).

Threats: The greatest threat to Greater Sand Plover habitat loss and degradation, particularly at critical migration staging areas through eastern Asia. In Australia, threats include habitat loss, habitat degradation and human disturbance (TSSC 2016d).

Population trend: The population of Greater Sand Plover visiting Australia is estimated to be approximately 75,000 birds, representing 75% of the population using the EAAF (Bamford et al. 2008). The annual rate of decline of the Greater Sand Plover population using Moreton Bay over the 15 year period 1992-2008 was estimated at 6.0% per year (Wilson et al. 2011). Overall, the evidence suggests there has been a population decline of 30-49% over 17 years across the EAAF (Garnett et al. 2011).

Occurrence in the Toondah Harbour PDA: Surveys have not detected Greater Sand Plovers feeding in the PDA, and there are no historical records of Greater Sand Plovers roosting in the vicinity of the PDA. However, the species was observed foraging on the more extensive mudflat areas adjacent to the PDA to the south (east of Oyster Point). The species has potential to occasionally visit mudflats within the PDA; however, the lack of survey records suggests mudflat habitat within the PDA is of marginal value to Greater Sand Plovers.

3.4.8 Koala (Phascolarctos cinereus)

Status: EPBC Act: Vulnerable; NC Act: Vulnerable.

Distribution: Koalas are widely distributed throughout north-east, central and south-east Queensland, extending south through New South Wales and Victoria into South Australia and Kangaroo Island. In Brisbane, they are renowned throughout the well forested outer suburbs, particularly to the south-east (Low 1995).

Habitat and ecology: Koalas have a distinct association with eucalypt woodland and forest habitat types containing suitable food trees (Hume and Esson 1993; Moore and Foley 2000; Martin et al. 2008), particularly those growing on alluvial or other fertile soils (Moore et al. 2004, Crowther et al. 2009). They are not necessarily restricted to bushland or remnant areas and are known to exist and breed within farmland and the urban environment (Dique et al. 2004). Similarly, movement is not confined to vegetated corridors, as they also move across cleared rural land and through suburbs (Martin et al. 2008).

They use a variety of trees, including many non-eucalypts, for feeding and resting (Dique et al. 2004; Martin et al. 2008). They do, however, have distinct, localised feeding preferences throughout their range, selecting some species in preference to others (Pahl and Hume 1990). Tree species preferences vary around Queensland; in the Redlands of south-east Queensland, the dominant diet species are *Eucalyptus* tereticornis (Hasegawa 1995) and *E. microcorys* (Tun 1993), whereas on North Stradbroke Island, Koalas prefer *E. robusta* (55% of diet), *E. pilularis* (13%), *E. tereticornis* (10%) and *Lophostemon confertus* (8%) (Woodward et al. 2008). Koala preference for certain species and individual trees appears to be based on: high leaf moisture content, high leaf nitrogen content (which is often related to low fibre content making leaves more palatable) and low

amounts of chemical compounds produced by eucalypts to resist herbivory (Pahl and Hume 1990; Hume and Esson 1993; Moore and Foley 2000).

Individual animals, although solitary, coexist within overlapping home ranges, which contain sufficient feed trees that are visited repeatedly and often shared with other individuals (Martin et al. 2008). Home range sizes vary their distribution, but the average home range size is 34 ha and 15 ha for males and females respectively in south-east Queensland (White 1999). Koala densities reported in south-eastern Queensland include density estimates of 0-0.76 koalas/ha (mean 0.16 koalas/ha) in high koala density bushland sites in the former Pine Rivers Shire (Dique et al. 2003a), 0.75 koalas/ha at Burbank in the Koala Coast (Dique et al. 2003a) and 0.02-1.26 koalas/ha on the Koala Coast (Dique et al. 2004).

Breeding occurs in spring/summer when males become territorial, attacking and fighting rivals, and using loud bellows to advertise their presence (Martin et al.2008). Young permanently leave the females pouch after seven months, but continue to ride on the mothers back until 12 months and the beginning of a new breeding season. After this time adolescent females may remain in the natal habitat, but males generally disperse to new territories between 1-3 years of age (Dique et al. 2003b; Martin et al. 2008).

Threats: Current threats to Koalas include habitat destruction and fragmentation, bushfire and disease (Maxwell et al. 1996). Populations around urban areas are also at increased risk of mortality due to dog attack and vehicle strike (Preece 2007, DERM 2009; Rhodes et al. 2011). To maintain and conserve a landscape that contains a sufficient amount of habitat to sustain a viable koala population, at least 40- 50% of the landscape should comprise primary and secondary koala habitat across landscape extents of 1 km radius around where koalas occur (McAlpine et al. 2007). Furthermore, to maintain and restore koala habitat patches (or clusters of highly connected patches) that are large enough to sustain viable koala populations, primary and secondary koala habitat patches should be larger than 50-100 ha in size, unless they are part of a cluster of highly connected patches (i.e., patches separated by less than 100-200 m), in which case highly connected patches should be larger than 100 ha in total area (McAlpine et al. 2007).

Population trend: There has been a rapid decline in Koala population densities in the 'Koala Coast' region (the mainland portion of Redland City, the eastern portion of Logan City and the south-eastern portion of Brisbane City) and the Pine Rivers region; between 1996 and 2014 there has been an 80% decline in Koala Coast populations and an estimated 54% decline in Pine Rivers populations, with the rate of decline increasing in recent years (Rhodes et al. 2015). In light of this pattern and rate of decline, Rhodes et al. (2015) concluded that the loss of Koalas from many sites in the Koala Coast is imminent due to the extent of urban development. The remaining Koala populations in southeast Queensland are inferred to have declined from an estimated 15,000 animals in 1995; while the extent of the decline has not yet been quantified, the populations face similar threats but at lower intensity (TSSC 2011).

Occurrence in the Toondah Harbour PDA: The initial field survey identified a total of 286 habitat trees important for Koala are scattered across the western portion of the PDA as a component of the urban environment (**Figure 3.1**). Koala scats were observed under 33 of these trees, confirming recent Koala use of trees in the PDA, but no Koalas were observed. On later occasions, up to two Koalas were observed in habitat trees within the PDA, and up to three Koalas were observed in trees at Nandeebie Park immediately south of the PDA. These observations of Koala in the trees within the PDA, together with the high frequency of Koala scats observed under suitable food trees across the PDA during the field survey, indicates these trees support at least several individuals of the local urban Koala population whose home ranges incorporate portions of the PDA. These Koalas are known to move regularly through the western portion of the PDA, visiting favoured food trees. Other important food trees these Koalas will be visiting include larger patches of suitable habitat along the foreshore immediately south of the PDA boundary, and

scattered food trees in the urban footprint to the west of the PDA. There is a very limited occurrence of Koala food trees north of the PDA.

The results of the habitat assessment performed in accordance with the EPBC Act referral guidelines for Koala habitat assessment tool (Commonwealth of Australia 2014) are summarised in **Table 3.3**. The total habitat score from this assessment was 3; as this total score is less than 5, Koala habitat within the study area is not recognised as 'habitat critical to the survival of Koala' under the EPBC Act referral guidelines, largely because the study area occurs within an urban matrix that has poor habitat connectivity (key existing threats to Koala).

3.4.9 Grey-headed Flying-fox (Pteropus poliocephalus)

Status: EPBC Act: Vulnerable; NC Act: Least Concern.

Distribution: Grey-headed Flying-fox occurs throughout coastal south-eastern Australia, from Mackay in Queensland south to Melbourne in Victoria. Its range extends inland to the western slopes of the Great Dividing Range (Roberts *et al.* 2008; Curtis *et al.* 2012).

Habitat and ecology: Two habitat characteristics are important for Grey-headed Flying-foxes: foraging resources and roosting sites. As a canopy-feeding frugivore and nectarivore, Grey-headed Flying-foxes utilise rainforests, open eucalypt forests, woodlands, melaleuca swamps and banksia woodlands. Roosts are commonly within dense vegetation close to water, primarily rainforest patches, stands of melaleuca, mangroves or riparian vegetation (Nelson 1965), but colonies may use exotic vegetation in urban areas (Birt *et al.* 1998). The species congregates in large camps of up to 200,000 individuals from early until late summer, with the number of bats within a camp being influenced by the availability of blossom in the surrounding area. Adults normally disperse during the winter and can migrate up to 750 km as individuals or small groups (Eby 1991, Churchill 2008).

Threats: Grey-headed Flying-foxes are subject to several threatening processes, the most severe being loss of habitat. Habitat loss is thought to have resulted in a 50% decline in the population by the 1930s (Duncan *et al.* 1999). The loss of habitat, particularly reliable winter feeding resources along the east coast, has continued to lead to population decline. The species will also forage within commercial fruit farms, sometimes significantly reducing their yield. This has resulted in direct culling or the destruction of camps by harassment. Other threatening processes include accumulation of lethal levels of lead in urban areas (Hariono *et al.* 1993), and electrocution on overhead powerlines, which disproportionately kills lactating females (Duncan *et al.* 1999).

Occurrence in the Toondah Harbour PDA: While there are no historical records of Grey-headed Flying-fox from within the PDA, the species is known to roost seasonally at a flying-fox camp in the Black Swamp wetlands, located 2 km west of the PDA. Given the close proximity of the PDA to a known roosting camp, Grey-headed Flying-foxes may visit occasionally to feed on seasonally flowering trees in the PDA. However, the relatively few trees in the PDA will not support a regionally significant proportion of the population of this species.

Table 3.3. Koala habitat assessment tool results summary.

Attribute	Score	Coastal area criteria	Score	Assessment details
Koala occurrence	+2 (high)	Evidence of one or more Koalas within the last 2 years	**2**	**Desktop:** The EPBC Act Protected Matters Search Tool report identified the Koala as 'known to occur' in the study area. The Wildlife online point buffer search identified 420 Koala records since 1980 within a 1 km radius of the study area. **On-ground:** During a one day survey, the majority of the study area was traversed on foot searching for Koala resting in trees and for scats at the base of food trees. No Koala was directly observed on this survey, but scats consistent with Koala were found at multiple locations across the study area. Up to two Koalas were observed in habitat trees within the PDA study area subsequently.
	+1 (medium)	Evidence of one or more Koalas within 2 km of the edge of the impact area within the last 5 years		
	0 (low)	None of the above		
Vegetation Composition*	+2 (high)	Has forest or woodland with 2 or more known koala food tree species, OR 1 food tree species that alone accounts for >50% of the vegetation in the relevant strata.	**0**	**Desktop:** The Queensland RE mapping identifies that terrestrial vegetation within the study area is all non-remnant. The SPRP Map of Assessable Development Area Koala Habitat Values maps portions of the study area as Medium Value Rehabilitation. **On-ground:** A total of 286 non-juvenile habitat trees for Koala are scattered across the western portion of the PDA as a component of the urban environment, including the known important Koala food tree species *Eucalyptus tereticornis* and *E. robusta*. While many trees are mature trees, the majority appear to have been planted. No terrestrial forest or woodland occurs within the study area.
	+1 (medium)	Has forest or woodland with only 1 species of known koala food tree present.		
	0 (low)	None of the above		
Habitat connectivity	+2 (high)	Area is part of a contiguous landscape ≥ 500 ha.	**0**	The study area is located in an extensive urban environment on the coast and is not part of a contiguous landscape; therefore, there is very poor habitat connectivity.
	+1 (medium)	Area is part of a contiguous landscape < 500 ha but ≥300 ha.		
	0 (low)	None of the above		
Key existing threats	+2 (high)	Little or no evidence of Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence. Areas which score 0 for koala occurrence and have no dog or vehicle threat present.	**0**	**Desktop:** The Queensland Government database on Koala mortalities records numerous Koala mortalities from vehicle strike and dog attack in the local area. **On-ground:** The study area is located within an urban matrix that includes residential areas with high-volume-traffic roads, with the ocean on the eastern boundary. Therefore, the study area is surrounded by key existing threats to Koala, including high risk of vehicle strike and dog attack that can be expected to result in a relatively high frequency of Koala mortality relative to the population density of Koala in the area.
	+1 (medium)	Evidence of infrequent or irregular Koala mortality from vehicle strike or dog attack at present in areas that score 1 or 2 for Koala occurrence, or areas which score 0 for koala occurrence and are likely to have some degree dog or vehicle threat present.		

Attribute	Score	Coastal area criteria	Score	Assessment details
	0 (low)	Evidence of frequent or regular Koala mortality from vehicle strike or dog attack in the study area at present, or areas with score 0 for Koala occurrence and have a significant dog or vehicle threat present.		
Recovery value **	+2 (high)	Habitat is likely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1 of the referral guidelines (Commonwealth of Australia 2014).	**1**	Habitat in the study area comprises mostly planted trees in an urban matrix with key existing threats to Koala, particularly from vehicle strike and dog attack. While these trees support several Koalas in an urban context, the study area is not part of a large, connected area of forest or woodland habitat. Furthermore, the local population has a high incidence of disease, but does breed successfully. However, the Koala population of the Koala Coast, which includes Redland City, is regarded as a significant Koala population because of its relatively large population density and size (despite a large proportion of the population occurring in an urban environment) and the genetic distinctiveness of Koalas in this population compared with other Koalas in South East Queensland (Lee *et al*. 2010, DERM 2012). There is therefore uncertainty as to whether the habitat is important for achieving the interim recovery objectives, based on uncertainty in how successfully koalas in an urban context can be managed to ensure the long-term persistence of the population.
	+1 (medium)	Uncertainty exists as to whether the habitat is important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1 of the referral guidelines (Commonwealth of Australia 2014).		
	0 (low)	Habitat is unlikely to be important for achieving the interim recovery objectives for the relevant context, as outlined in Table 1 of the referral guidelines (Commonwealth of Australia 2014).		
Total Score			**3**	As the total score is less than 5, Koala habitat within the study area is not recognised as 'habitat critical to the survival of Koala' under the draft EPBC Act referral guidelines.

* Koala food tree species are based on published, location-specific food tree preferences in Redland City (Hasegawa 1995, Tun 1993, Woodward et al. 2008).
** Interim recovery objective in coastal areas is to protect and conserve large, connected areas of Koala habitat, particularly large, connected areas that support Koalas that are: genetically diverse/distinct; or free of disease or have a very low incidence of disease; or breeding (i.e. presence of back young or juveniles).

3.5 MIGRATORY SHOREBIRD SPECIES

In this section, background information on migratory shorebird ecology, population trends and threats is provided whereafter detailed information on migratory shorebird use of the study area from the surveys is provided.

3.5.1 Migratory shorebird ecology

A shorebird is a bird species in the order Charadriiformes (Colwell 2010). Most shorebirds live on or near the coast, on beaches, reefs and tidal mudflats, though some also frequent, or are largely confined to, freshwater habitats (Colwell 2010). Most coastal species feed on flat, tidal shores with extensive muddy or sandy intertidal areas. Most species are gregarious, wary and fly strongly and swiftly (Geering *et al*. 2007, Colwell 2010).

A large proportion of Australia's shorebird species are migratory, spending their non-breeding season (the Austral summer) in Australia and migrating up to 13,000 km north along the East Asian–Australasian Flyway to breeding grounds in eastern Siberia and western Alaska (most species, Bamford *et al*. 2008) or south to New Zealand (Double-banded Plover (*Charadrius bicinctus*), Pierce 1999). They are highly dependent on a relatively small number of key feeding grounds at stop-over sites on their migration routes and on their non-breeding grounds in order to replenish their fat reserves for migration. If their feeding rates are reduced and they do not manage to lay down sufficient reserves of fat, their subsequent survival on migration is severely compromised (Baker *et al*. 2004).

On their over-wintering grounds in Australia, coastal migratory shorebirds have a daily activity pattern driven largely by the tidal cycle, roosting in flocks at sites above the high water mark at high tide and moving to intertidal sandflat and mudflat feeding areas as the tide recedes (Colwell 2010). They are capable of feeding during both the day and night. Shorebirds feed on a wide variety of benthic invertebrates, including crustaceans, molluscs and polychaete worms that are taken either on the surface of intertidal areas or extracted from soft muddy or sandy sediments by probing with their often elongated bills. Different shorebird species specialise on different prey, prey sizes and feeding styles depending on their evolved bill morphology and body size (Lifjeld 1984; Baker 1989; Barbosa and Moreno1999; Durell 2000). Species with long, slender bills that depend on deep probing of sediments for locating prey tend to prefer feeding in softer sediments with less resistance to bill probing (Finn *et al*. 2008).

Migratory shorebirds also depend on roosting areas near their feeding areas that allow them to rest (during times when their feeding habitat is inundated at high tide) without losing too much energy to disturbance (Colwell 2010). Migratory shorebirds select roost sites on the basis of: distance from feeding areas (preferring sites close to feeding areas); distance from tall cover (preferring sites with little cover to ensure a clear view of approaching predators); climate (preferring sites at the water's edge to stay cool); height of the tide (whether the site will be inundated); and background colour of the roost site (providing camouflage against predators) (Rogers *et al*. 2006a). There is also some evidence that feeding site selection is influenced by distance from available roost sites (Rogers *et al*. 2006a), since energy expended flying between feeding and roosting sites reduces the birds' ability to store fat for migration (Rogers 2003). As a result of these requirements, both feeding and roosting habitats are essential to migratory shorebirds.

3.5.2 Threats to migratory shorebirds and population trends

Many of these key feeding and roosting sites for migratory shorebirds are coastal wetlands that are increasingly threatened by development for aquaculture, industry and housing (Wetlands International 2006; Yang *et al*. 2011; MacKinnon *et al*. 2012; Murray *et al.* 2014), particularly at key stop-over sites on their migration routes through east Asia. This makes migratory shorebirds particularly susceptible to habitat loss, disturbance and environmental change (Gill *et al*. 2001; Piersma and Baker 2000; Baker *et al*. 2004; Wilson *et al*. 2011; Melville *et al.* 2016; Moores *et al*. 2016; Piersma *et al*. 2016). Consequently, migratory shorebirds are in decline around the world (Donaldson *et al*. 2000; Baker *et al*. 2004; Wetlands International 2006), including in Australia (Close & Newman 1982; Nebel *et al*. 2008; Wilson *et al*. 2011; Clemens *et al*. 2016).

An analysis of shorebird population trends in Moreton Bay over 15 years (1992-2008) found that the abundances of at least seven migratory shorebird species declined significantly by between 43% and 79% over this period, whereas the abundances of resident shorebird species showed no significant trends. The primary cause of the population declines of migratory shorebirds in Moreton Bay was attributed to habitat loss at key migration stopover sites in the Yellow Sea region (Wilson et al. 2011). Similarly, a more recent analysis revealed significant Australia-wide decreases in abundance in 12 of 19 migratory shorebird species, with estimated annual rates of decline of between 1.98% and 9.53% (Clemens et al. 2016).

The Yellow Sea supports the most important stop-over feeding habitats for migratory shorebirds on the East Asian-Australasian Flyway. In the 1950's, tidal flats occupied 1.12 million ha in the Yellow Sea in the mid-1950's, but this had reduced to 545,000 ha by the 1980's and 389,000 ha by the 2000's, representing a loss of up to 65% over 50 years (Murray et al. 2014). This loss of tidal feeding habitat has largely resulted from extensive land reclamation for agriculture, aquaculture, urban and industrial development, and is ongoing (Murray et al. 2014, Moores et al. 2016). The largest single reclamation project has been at Saemangeum, South Korea, where approximately 29,000 ha of tidal flats were impounded behind a 33-km long sea-wall in 2006. These Saemangeum tidal flats supported at least 330,000 migratory shorebirds prior to the reclamation, including 30% of the world population of Great Knot. Following the completion of the impoundment, an estimated 130,000 migratory shorebirds disappeared from the flyway population within the first two years and 300,000 had disappeared by 2013 including an estimated 104,000 Great Knots; these missing birds are presumed to have died following the loss of habitat (Moores et al. 2016). These studies highlight why past and ongoing feeding habitat loss at key staging sites in the Yellow Sea is the single biggest threat to migratory shorebirds on the East-Australasian Flyway. Other threats, including in Australia, include human disturbance at feeding and roosting sites, habitat loss and degradation from pollution, changes to the water regime and invasion of mudflats and coastal saltmarshes from the spread of mangroves.

3.5.3 Migratory shorebird species in the Toondah Harbour PDA

The database searches (**Appendices 1** and **2**) identified a total of 33 terrestrial fauna species or sub-species listed as migratory shorebird species under the EPBC Act that may occur within the study area or environs. Eleven of these species (including three critically endangered and one vulnerable species) were recorded within or immediately adjacent to the study area during field surveys, and a further eight species (including two endangered and one vulnerable species) were assessed as likely to occur based on database records for the local area and presence of suitable habitat (**Table 3.4**). The remaining 14 species or sub-species were assessed as unlikely to occur (see **Appendix 3** for details).

Table 3.4. Terrestrial fauna species listed as migratory shorebird species under the EPBC Act that are known or likely to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
Numenius madagascariensis	Eastern Curlew	CE, M	V	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan)	V, M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris tenuirostris	Great Knot	CE, M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Calidris ferruginea	Curlew Sandpiper	CE, M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) and adjacent to the study area.
Numenius phaeopus	Whimbrel	M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Xenus cinereus	Terek Sandpiper	M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Tringa brevipes	Grey-tailed Tattler	M	S	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Arenaria interpres	Ruddy Turnstone	M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at mangrove and shoreline roost sites within and adjacent to the study area.
Calidris ruficollis	Red-necked Stint	M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) or adjacent to the study area.
Limosa limosa	Black-tailed Godwit	M	S	**Known**. Recorded rarely at roost sites within and adjacent to the study area.
Pluvialis fulva	Pacific Golden Plover	M	S	**Known**. Feeds on intertidal mudflats within (rarely) or adjacent to the study area and roosts at shoreline roost sites within (rarely) and adjacent to the study area.
Calidris canutus	Red Knot	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to occur within 1 km of the study area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius mongolus	Lesser Sand Plover	E, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius leschenaultii	Greater Sand Plover	V, M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Calidris acuminata	Sharp-tailed Sandpiper	M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
				mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Tringa nebularia	Common Greenshank	M	S	**Potential**. While it has not been recorded within the study area, the species is known to feed on intertidal mudflats south of the study area, it has potential to feed on intertidal mudflats within the study area (rarely) and it has potential to roost at shoreline roost sites within (rarely) or adjacent to the study area.
Tringa stagnatilis	Marsh Sandpiper	M	S	**Potential**. While it has not been recorded within the study area, the species is known from the local area and it has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Actitis hypoleucos	Common Sandpiper	M	S	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.
Charadrius bicincutus	Double-banded Plover	M	S	**Potential**. While it has not been recorded within the study area, the species is known from the local area and has potential to feed on intertidal mudflats within (rarely) or adjacent to the study area and roost at shoreline roost sites within (rarely) or adjacent to the study area.

[1] Status under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): CE = critically endangered; E = endangered; M = migratory; V = vulnerable.
[2] Status under the *Nature Conservation Act 1992* (NC Act): S = special least concern (migratory), V = vulnerable.

Migratory shorebirds utilise two different types of habitat within or adjacent to the Toondah Harbour PDA, namely intertidal mudflats that provide feeding habitat when exposed during low tide, and stands of mangrove trees, offshore sandbars and shoreline saltmarsh and claypan areas that provide high tide roost sites. Shorebird use of these two habitat types is discussed in more detail below.

3.5.4 Migratory shorebird use of intertidal mudflats for feeding during low tide

Intertidal mudflats within the study area extend from the shoreline in the west of the PDA to the astronomical low tide level in the east, including areas both to the north and south of the dredged ferry channel (see **Figure 3.1, Photo 1**). Areas of high, moderate and low value for feeding are mapped based on a rapid assessment of the relative density of benthic invertebrates (BAAM and frc environmental 2014).

The results of six summer surveys and one winter survey conducted from October 2014 to June 2015 within the Toondah Harbour PDA are summarized in **Table 3.5** below. Migratory shorebirds were observed foraging throughout the mapped distribution of intertidal foraging habitat within the PDA, but foraging birds were more concentrated in, and spent more time within the mapped areas of high and moderate habitat value (see **Figure 3.1**). Data from the QWSG, which conducted a total of 17 low tide surveys within the PDA over the months June to October 2014, are summarized in **Table 3.6** below. These surveys recorded the same five species of migratory shorebird as the BAAM surveys. During the winter months, only Grey-tailed Tattler was present, but the number and abundance of migratory shorebird species increased from September as migratory shorebirds migrated into the area for the austral summer. During the summer months October to March, the number of migratory shorebirds recorded feeding within the PDA averaged 101 with a maximum of

158, representing 0.33% and 0.53% respectively of the estimated total of 30,000 migratory shorebirds that use Moreton Bay. The respective numbers for the critically endangered Eastern Curlew were an average of 4.5 and maximum of 7 and for the vulnerable Bar-tailed Godwit were an average of 24.8 and maximum of 36 birds. A single individual of the critically endangered Great Knot was observed on a single survey.

Table 3.5. Summary of migratory shorebirds foraging within and immediately adjoining the Toondah Harbour PDA area during the low tide surveys from October 2014 to June 2015 (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	31/10/2014	06/11/2014	26/12/2014	09/01/2015	24/02/2015	19/03/2015	18/06/2015
Low tide height (m)				0.6	0.4	0.4	0.5	0.6	0.3	0.4
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	32	6	33	27	9	30	
Numenius phaeopus	Whimbrel	M	S	6	13	15	19	12	16	
Numenius madagascariensis	Eastern Curlew	CE,M	V	4	2	7	4	4	1	
Tringa brevipes	Grey-tailed Tattler	M	S	88		60	41	55	91	
Calidris tenuirostris	Great Knot	CE,M	S			1				
Calidris ruficollis	Red-necked Stint	M	S					1		
Xenus cinereus	Terek Sandpiper	M	S	7		42		26		
Total migratory shorebirds				**137**	**21**	**158**	**91**	**107**	**138**	**0**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: V = vulnerable; S = special least concern (migratory).

Table 3.6. Average (and maximum) numbers of migratory shorebird species foraging within Toondah Harbour PDA each month during QWSG low tide surveys in 2014.

	Month in 2014			Jun	Jul	Aug	Sep	Oct
	Number of surveys			3	4	2	3	5
Species	**Common name**	**EPBC[1]**	**NCA[2]**					
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	0	0	0	0	27.6 (36)
Numenius phaeopus	Whimbrel	M	S	0	0	0	9.0 (17)	12.0 (18)
Numenius madagascariensis	Eastern Curlew	CE,M	V	0	0	2.0 (3)	4.0 (5)	5.4 (6)
Tringa brevipes	Grey-tailed Tattler	M	S	9.0 (27)	20.0 (52)	14.0 (20)	26.7 (43)	52.8 (92)
Xenus cinereus	Terek Sandpiper	M	S	0	0	0	0	4.0 (11)
Total				**9.0 (27)**	**20.0 (52)**	**16.0 (23)**	**39.7 (53)**	**101.8 (144)**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: V = vulnerable; S = special least concern (migratory).

3.5.5 Migratory shorebird use of roost sites during high tide

There are no migratory shorebird roost sites within the boundaries of the Toondah Harbour PDA; however, there are two high tide roost sites located immediately adjacent to the PDA (see **Figure 3.1**):

- Most mangrove trees in the cluster of mangroves around Cassim Island near the eastern boundary of the PDA and north of the harbor entrance channel (**Photo 2**) are used daily as a high tide roost by several migratory shorebird species that can roost in mangrove trees, namely Whimbrel (**Photo 3**), Grey-tailed Tattler, Terek Sandpiper and Ruddy Turnstone; and
- An area of saltmarsh and claypan known as the Nandeebie Claypan (**Photo 4**) to the south of the PDA is used infrequently by a variety of migratory shorebirds, particularly on spring high tides.

Photo 1. Intertidal mudflat in the Toondah Harbour PDA exposed at low tide (looking from the mainland towards the mangroves of Cassim Island), foraging habitat for migratory shorebirds.

Photo 2. Offshore mangroves of Cassim Island (on the eastern boundary of Toondah Harbour PDA) at high tide, an important roost site for migratory shorebirds.

Photo 3. Whimbrel roosting in mangrove tree at Cassim Island.

Photo 4. Proximity of a public walkway (foreground) to the Nandeebie Claypan migratory shorebird roost site (background, inundated by a spring high tide).

A further high tide roost site that is used regularly by migratory shorebirds is located further to the south at Oyster Point (see **Figure 3.2**).

The high tide survey results of roosting migratory shorebirds are summarised in **Tables 3.7** and **3.8** for Cassim Island and the Nandeebie Claypan, respectively. An average of 699 and maximum of 920 migratory shorebirds of four species were recorded roosting at Cassim Island during four summer high-tide surveys (**Table 3.6**). Most of the roosting shorebirds were concentrated in the western and south-western portions of the mangroves of the Cassim Island roost (i.e. closest to the PDA boundary), with smaller numbers occasionally using the outer trees along the north-western edge. The birds may select these areas for protection from the prevailing south-easterly

winds. The smaller shorebirds (Grey-tailed Tattler, Terek Sandpiper, Ruddy Turnstone) preferred to roost in the trees close to the waterside edge, whereas Whimbrels were more dispersed over a greater area of mangroves.

Up to 1,060 migratory shorebirds were recorded roosting at the Nandeebie claypan at high tide, but numbers were highly variable, with greater numbers tending to be recorded on spring high tides. Furthermore, migratory shorebirds were observed moving between the Nandeebie Claypan and the nearby Oyster Point roost site depending on the tide height (moving from Oyster Point to Nandeebie on the rising tide and vice versa as the tide receded) and extent of disturbance at Oyster Point.

Table 3.7. Summary of migratory shorebirds roosting in the mangroves of Cassim Island during four summer and one winter survey over the period November 2014 to June 2015 (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	06/11/2014	09/1/2015	16/2/2015	19/3/2015	18/6/2015
Numenius phaeopus	Whimbrel	M	S	184	270	160	140	0
Tringa brevipes	Grey-tailed Tattler	M	S	215	600	570	460	0
Arenaria interpres	Ruddy Turnstone	M	S	10	20	50	26	0
Xenus cinereus	Terek Sandpiper	M	S	8	30	30	22	0
Total				**417**	**920**	**810**	**648**	**0**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: M = migratory.
[2] Status under the Queensland *Nature Conservation Act 1992*: S = special least concern (migratory).

Table 3.8. Summary of migratory shorebirds roosting on the Nandeebie Claypan during 15 summer and one winter survey over the period November 2014 to June 2015 (BAAM 2014, 2015).

Species	Common name	EPBC[1]	NCA[2]	30/10/2014	31/10/2014	05/11/2014	06/11/2014	21/11/2014	25/11/2014	26/11/2014	27/11/2014	08/12/2014	09/12/2014	06/01/2015	08/01/2015	16/02/2015	03/03/2015	20/03/2015	18/06/2015
High tide height (m)				2.2	2.2	2.3	2.4	2.3	2.5	2.4	2.3	2.5	2.4	2.5	2.4	2.4	2.3	1.6	1.9
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S					43							1026	730	841		
Numenius phaeopus	Whimbrel	M	S	5			1			103	2	23				124			
Numenius madagascariensis	Eastern Curlew	CE,M	V	14	6		1	6	1	2	2	2	1	1	34	45	36		
Calidris tenuirostris	Great Knot	CE,M	S													1	5		
Total migratory shorebirds				**19**	**6**	**0**	**2**	**49**	**1**	**105**	**4**	**25**	**1**	**1**	**1060**	**900**	**882**	**0**	**0**

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: S = special least concern (migratory); V = vulnerable.

A relatively large number of Bar-tailed Godwits utilising the Nandeebie Claypan roost were observed with engraved leg flags (see **Appendix 4** for combinations) that are used to monitor the

movements of individually identifiable birds both within Moreton Bay and the East Australasian flyway more broadly.

The QWSG conducted a total of 148 high tide surveys (98 of these surveys in the summer months late September to March) of the Nandeebie Claypan roost site between March 1995 and May 2014, with a gap in surveys in the summers of 2004/5 to 2006/7. Combining these surveys with the BAAM (2014, 2015) surveys, the maximum roost counts each summer are shown in **Figure 3.2** and the average roost count each year for surveys in the months of October to March inclusive are shown in **Figure 3.3**. The maximum roost count each year has typically ranged between 500 and 1,500 migratory shorebirds, with a maximum count of 2,562 migratory shorebirds in February 1996. During the summer months late September to March over the period 1995 to 2015, an average of 474 and maximum of 2,560 migratory shorebirds were recorded on the 83% of surveys when migratory shorebirds were present; however over the past ten years (since 2007) the average and maximum numbers were 397 and 1,406 respectively, reflecting the decline in migratory shorebirds within Moreton Bay more generally. Species specific data are summarised in **Table 3.9**.

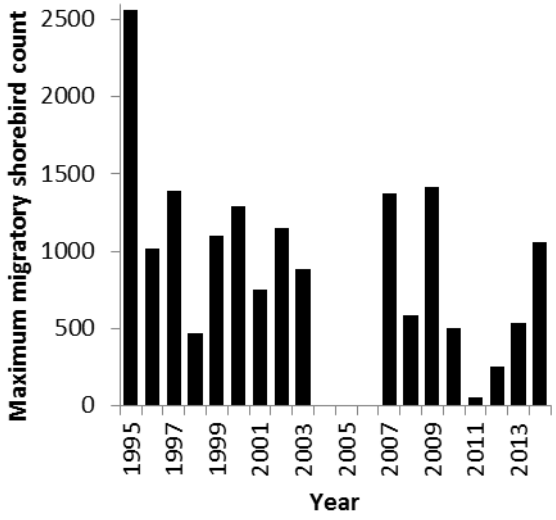


Figure 3.2. Maximum count of migratory shorebirds roosting at Nandeebie claypan each season of 1995/6 to 2003/4 and 2007/8 to 2014/15.

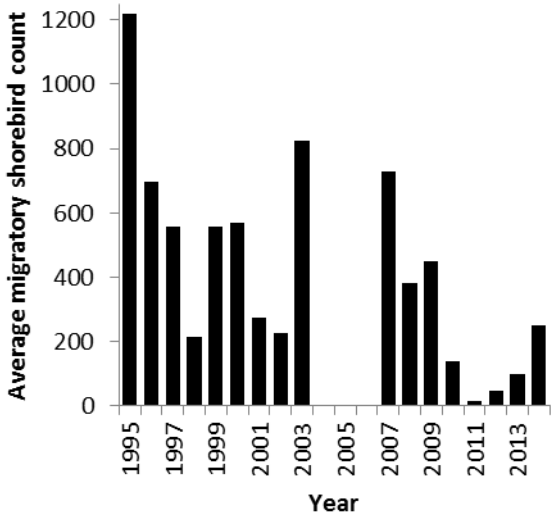


Figure 3.3. Average count of migratory shorebirds roosting at Nandeebie claypan over the months October to March each season of 1995/6 to 2003/4 and 2007/8 to 2014/15.

Table 3.9. Migratory shorebird species recorded roosting at the Nandeebie claypan during 114 surveys over summer months (late September to March) over the period 1995 to 2015, the number (N) and percentage (%) of summer surveys in which the species was recorded, the average count of the species when present, and the maximum count over all surveys (summarising data from QWSG, BAAM 2014, 2015).

Species	Common name	EPBC	NCA	N	% of surveys	Average count	Maximum count
Calidris ferruginea	Curlew Sandpiper	CE,M	S	2	1.8	1.5	2
Calidris tenuirostris	Great Knot	CE,M	S	17	14.9	27.2	90
Limosa lapponica baueri	Bar-tailed Godwit	V,M	S	64	56.1	608.8	2,300
Limosa limosa	Black-tailed Godwit	M	S	1	0.9	2.0	2
Numenius madagascariensis	Eastern Curlew	CE,M	V	76	66.7	24.7	180
Numenius phaeopus	Whimbrel	M	S	56	49.1	64.5	508

Species	Common name	EPBC	NCA	N	% of surveys	Average count	Maximum count
Pluvialis fulva	Pacific Golden Plover	M	S	1	0.9	1.0	1
Tringa brevipes	Grey-tailed Tattler	M	S	2	1.8	29.5	56

[1] Status under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: CE = critically endangered; M = migratory; V = vulnerable.
[2] Status under the Queensland *Nature Conservation Act 1992*: S = special least concern (migratory); V = vulnerable.

There appears to have been a reduction in migratory shorebird use of the Nandeebie claypan for roosting since 2009, and the reasons for this may be threefold. First, it may reflect the ongoing decline in the populations of many migratory shorebird species. Second, there has been a gradual encroachment of mangroves colonising what was originally a larger and more open claypan, reducing the suitability of the site for migratory shorebirds, which prefer roost sites less enclosed by taller vegetation, as more open sites provide less cover for approaching predators (Rogers 2003; Rogers *et al*. 2006a). Third, a concrete walkway/cycleway was constructed along the shoreline in 2004. This walkway is not screened from the roost site (see **Photo 4**) and facilitates the movement of walkers, cyclists, dogs etc. to within 30-50 m of the edge of the area occupied by roosting birds. The construction of the walkway and the increasing population of Cleveland has likely increased disturbance to roosting shorebirds at this site over time.

3.5.6 Importance of the Toondah Harbour PDA for migratory shorebirds

EPBC Act Policy Statement 3.21 provides definitive guidelines for assessing the significance of sites for migratory shorebirds. Under these guidelines, if a shorebird area has already been identified as internationally important for shorebirds, then shorebird habitat within that shorebird area is recognised as important habitat under the EPBC Act. The guidelines define a shorebird area as:

"*Following Clemens et al. (2010) a shorebird area is defined as: the geographic area that had been used by the same group of shorebirds over the main non-breeding period. This is effectively the home range of the local population when present. Shorebird areas may include multiple roosting and feeding habitats. While most migratory shorebird areas will represent contiguous habitat, non-contiguous habitats may be included as part of* the *same area where there is evidence of regular bird movement between them. Migratory shorebird areas may therefore extend beyond the boundaries of a property or project area, and may also extend beyond Ramsar boundaries for internationally important areas*".

As outlined under **Section 3.1.1** earlier, the Moreton Bay shorebird area is recognised as an internationally important wetland under the Ramsar Convention, particularly for migratory shorebirds. Since the shorebird feeding and roosting habitats within the Toondah Harbour PDA are encompassed within the Moreton Bay Ramsar wetlands, these habitats are defined as important habitat for migratory shorebirds under the EPBC Act. The relative importance of the shorebird habitats within the Toondah Harbour PDA can be described as a function of the total numbers of migratory shorebirds they regularly support in relation to the Moreton Bay shorebird area as a whole. The approximately 40 ha of intertidal mudflat/sandflat habitat at low tide within the PDA constitutes 0.17% of the 23,000 ha of intertidal flats within Moreton Bay (Blackman and Craven 1999 cited in Finn et al. 2001). The average of 101 and maximum of 158 birds that feed on the intertidal flats within the PDA in summer represent approximately 0.33% and 0.53% respectively of the estimated total of 30,000 migratory shorebirds that use Moreton Bay.

3.6 OTHER MIGRATORY SPECIES

The desktop assessment identified 18 species (excluding migratory shorebird species that are dealt with under the previous section) listed as migratory species under the EPBC Act as having

potential to occur in the Toondah Harbour PDA study (**Appendices 1** and **2**). Four of these species were recorded within or immediately adjacent to the study area during field surveys, and a further six species were assessed as having potential to occur (as regular or rare seasonal visitors) based on database records for the local area and presence of suitable habitat (**Table 3.10**). The remaining eight species were assessed as unlikely to occur (see **Appendix 3** for details).

Table 3.10. Terrestrial fauna species listed as migratory species (excluding migratory shorebirds) under the EPBC Act that are known or likely to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Likelihood of occurrence details
Pandion cristatus	Eastern Osprey	M	S	**Known**. Single birds were seen flying over the study area on two of the low-tide surveys. Forages for fish over open waters. No nest site occurs in the study area, but the species nests on a number of shipping lane buoys between Toondah Harbour and North Stradbroke Island, and elsewhere close to the coast of Moreton Bay.
Gelochelidon nilotica	Gull-billed Tern	M	S	**Known**. Feeds over open waters and intertidal mudflats (maximum 7 birds recorded); rarely roosts at Nandeebie Claypan (maximum 32 roosting birds).
Hydroprogne caspia	Caspian Tern	M	S	**Known**. Feeds over open waters and intertidal mudflats (maximum 2 birds); rarely roosts at Nandeebie Claypan (maximum 14 roosting birds).
Sternula albifrons	Little Tern	M	S	**Known**. Feeds over open waters (maximum 1 bird recorded); while it is known to roost at Oyster Point, it was not recorded roosting at Nandeebie Claypan.
Chlidonias leucopterus	White-winged Black Tern	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Thallaseus bergii	Crested Tern	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a regular visitor, feeding on fish over open waters, the study area is not important habitat for this species.
Sterna hirundo	Common Tern	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Hirundapus caudacutus	White-throated Needletail	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a regular seasonal visitor feeding on insects in the air, the study area is not important habitat for this species.
Cuculus optatus	Oriental Cuckoo	M	S	**Potential**. The species was not recorded during any of the surveys, but it has been recorded within 1 km of the study area in the past. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.
Rhipidura rufifrons	Rufous Fantail	M	S	**Potential**. The species has not been recorded within 1 km of the study area, but suitable mangrove forest habitat occurs in the southern portion of the PDA. While it may occur as a rare seasonal visitor, the study area is not important habitat for this species.

[1] Status under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act): M = migratory.
[2] Status under the *Nature Conservation Act 1992* (NC Act): S = special least concern (migratory).

The four migratory bird species known to occur in the study area are all marine species that hunt for fish over open waters in sheltered coastal bays or near-shore seas. Of these species, only Eastern Osprey is known to nest in the vicinity of Toondah Harbour PDA, but not within the PDA.

3.6.1 Importance of the Toondah Harbour PDA for other migratory birds

The referral guideline for 14 birds listed as migratory species under the EPBC Act (Commonwealth of Australia 2015b) provides guidelines for assessing the importance of habitat for migratory species that are not migratory shorebird species. The referral guideline specifies that an action is likely to have a significant impact on a migratory species if there is a real chance or possibility that it will seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an 'ecologically significant proportion of the population' of a migratory species. An ecologically significant proportion of the population is defined at a national level as 0.1% of the estimated national population of the species, and at an international level as 1% of the population of the species. The relevant population size and habitat area thresholds for the migratory species known or likely to occur in the Toondah Harbour PDA are summarised in **Table 3.11** below.

Table 3.11. Summary of threshold criteria for the assessment of habitat importance and impact significance for migratory species (excluding migratory shorebirds).

		Population size threshold[1]		Habitat area threshold[2]	
Species	**Common name**	**1%**	**0.1%**	**1%**	**0.1%**
Pandion cristatus	Eastern Osprey	240	24	840 km coastline	84 km coastline
Gelochelidon nilotica	Gull-billed Tern	1,000	100	None specified	None specified
Hydroprogne caspia	Caspian Tern	1000	100	None specified	None specified
Sternula albifrons	Little Tern	1150	115	None specified	None specified
Chlidonias leucopterus	White-winged Black Tern	250-10,000	25-1,000	None specified	None specified
Thallaseus bergii	Crested Tern	No data*	No data*	None specified	None specified
Sterna hirundo	Common Tern	No data*	No data*	None specified	None specified
Hirundapus caudacutus	White-throated Needletail	100	10	None specified	None specified
Cuculus optatus	Oriental Cuckoo	10,000	1,000	250,000 ha	25,000 ha
Rhipidura rufifrons	Rufous Fantail	11,000	1,100	2,600 ha	260 ha

[1] Sources: Wetlands International (2006) and Commonwealth of Australia 2015b).
[2] Areas of important habitat for each species likely to result in a significant impact if affected, as specified in referral guideline (Commonwealth of Australia 2015b).
* While there are no population size data available, these are common, widely distributed species with very large global populations.

Habitat within the Toondah Harbour PDA that is used by migratory species (excluding migratory shorebirds) does not meet the population or habitat area thresholds for recognition as important habitat for any migratory species. Therefore, the Project is unlikely to have a significant impact on any migratory species (excluding migratory shorebirds).

4.0 MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

This section outlines matters of state environmental significance (MSES) with relevance to terrestrial ecology.

4.1 REGULATED VEGETATION

4.1.1 Regional Ecosystems

The Toondah Harbour PDA contains patches of vegetation currently mapped by the Queensland Government as remnant vegetation of the following two regional ecosystems (REs), both of which have a 'least concern' status under the VM Act:

- RE 12.1.2 (Saltpan vegetation including grassland, herbland and sedgeland on marine clay plains); and
- RE 12.1.3 (Mangrove shrubland to low closed forest on marine clay plains and estuaries).

The Queensland Government map of regulated vegetation in the study area is provided in **Appendix 2** and the ground-truthed map of remnant regional ecosystems within the boundaries of the PDA is shown in **Figure 4.1**.

4.1.2 Essential Habitat

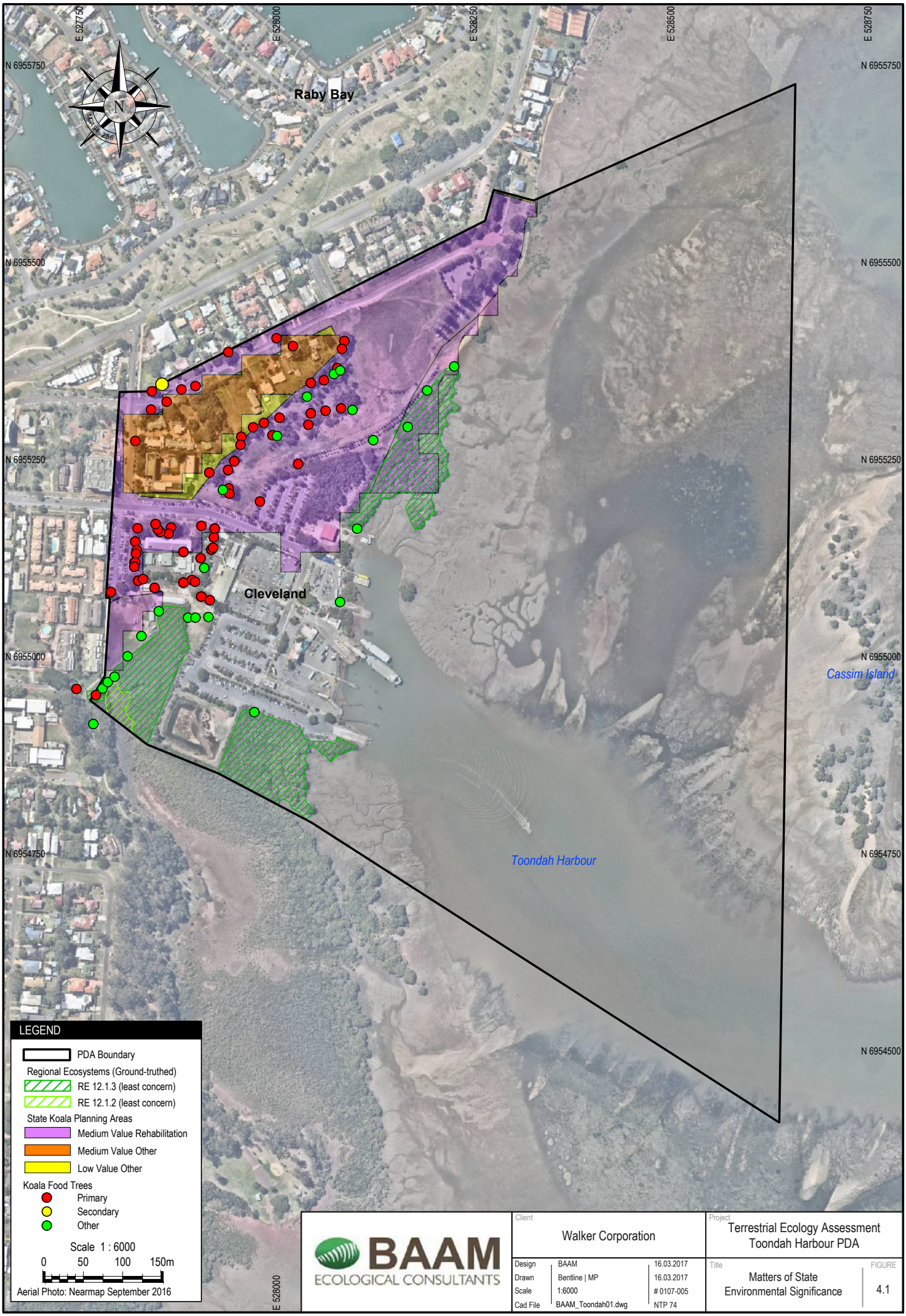
The Queensland Government mapping of regulated vegetation does not identify any essential habitat regulated under the VM Act as occurring within the boundaries of the PDA (see **Appendix 2**).

4.2 THREATENED AND NEAR THREATENED SPECIES

The database searches (**Appendices 1** and **2**) identified a total of 22 terrestrial fauna species and five terrestrial flora species listed as threatened species under the NC Act that may occur within the study area or environs. Two threatened fauna species (both listed vulnerable) were recorded within or immediately adjacent to the study area during field surveys (**Table 4.1**). These two species are dealt with under **Section 3.4** as they are also listed as threatened species under the EPBC Act; however, additional information relevant to Koala is presented in **Section 4.3** below. The remaining 20 fauna species and all five flora species were assessed as unlikely to occur (see **Appendix 3** for details). The study area does not fall within a 'high risk' area of the Queensland Government protected plants flora survey trigger map (see **Appendix 2**); therefore a protected flora survey is not required.

Table 4.1. Terrestrial fauna species listed as threatened species under the NC Act that are known or likely to occur in the study area.

Species	Common name	EPBC[1]	NCA[2]	Occurrence details
Numenius madagascariensis	Eastern Curlew	CE, M	V	**Known**. Feeds on intertidal mudflats within and adjacent to the study area and roosts at shoreline roost sites within and adjacent to the study area.
Phascolarctos cinereus (SEQ Bioregion)	Koala (SEQ Bioregion)	V	V	**Known**. Feeds on food trees (*species of Eucalyptus, Corymbia, Lophostemon* and *Melaleuca*) growing in the urban environment within and adjacent to the study area.



BAAM ECOLOGICAL CONSULTANTS

Client	Walker Corporation	
Design	BAAM	16.03.2017
Drawn	Bentline | MP	16.03.2017
Scale	1:6000	# 0107-005
Cad File	BAAM_Toondah01.dwg	NTP 74

Project: Terrestrial Ecology Assessment Toondah Harbour PDA

Title: Matters of State Environmental Significance

FIGURE: 4.1

4.3 SOUTH EAST QUEENSLAND KOALA CONSERVATION STATE PLANNING REGULATORY PROVISIONS

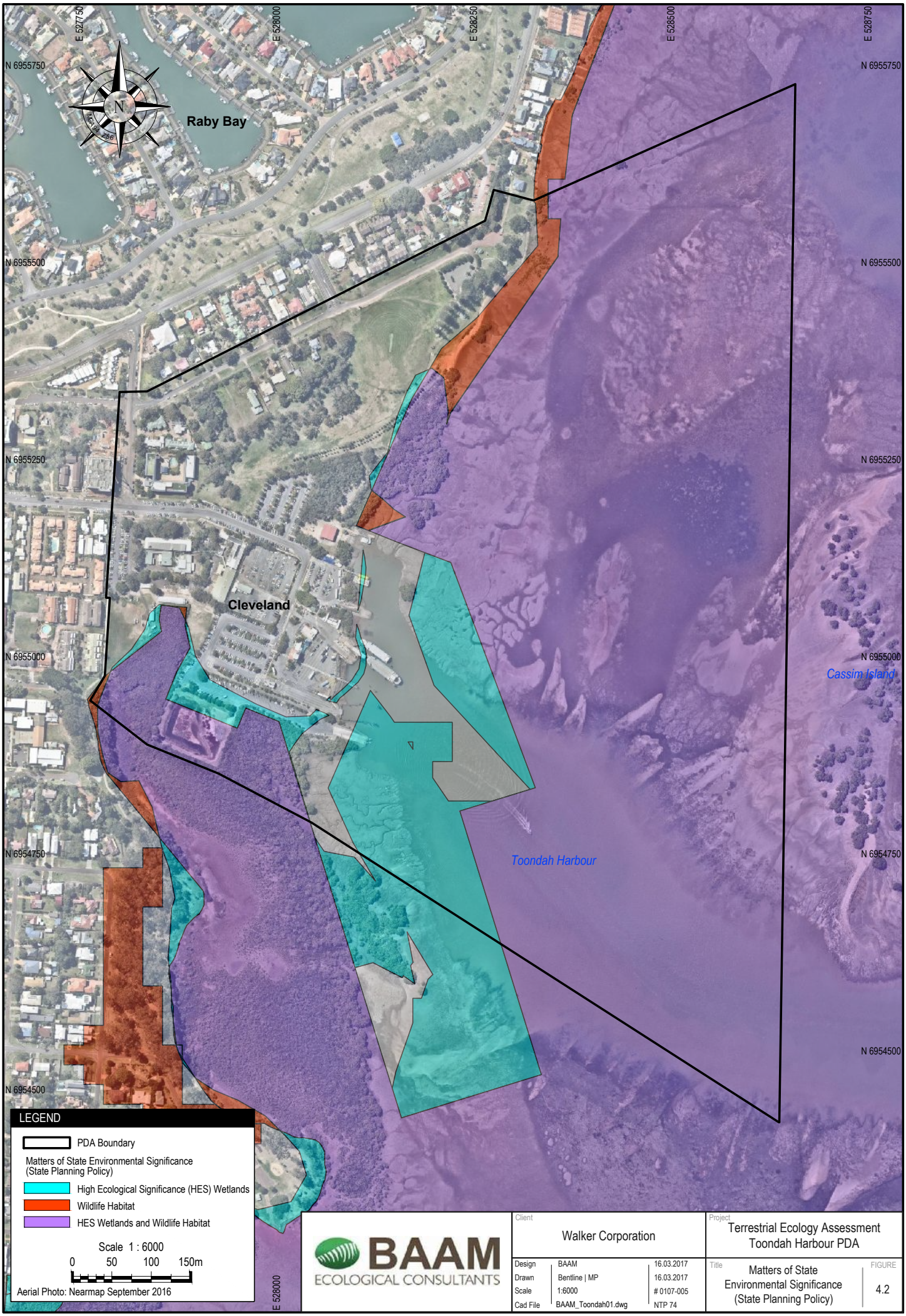
The Toondah Harbour PDA is located within a priority koala assessable development area under the South East Queensland Koala Conservation State Planning Regulatory Provisions (SPRP). For developments subject to particular schedules of the SPRP, clearing of non-juvenile Koala habitat trees within areas mapped 'bushland', 'high value rehabilitation' and 'medium value rehabilitation' requires offsetting in accordance with the Queensland *Environmental Offsets Act 2014* and Queensland Environmental Offsets Policy unless the Project is exempt from the SPRP. A total of 286 non-juvenile Koala habitat trees were recorded within the PDA boundary (**Figure 4.1**); 58 of these trees occur within areas mapped as 'medium value rehabilitation' under the SPRP.

4.4 STATE PLANNING POLICY

Queensland's State Planning Policy (SPP) includes a biodiversity State interest that states: *'The sustainable, long-term conservation of biodiversity is supported. Significant impacts on matters of national or state environmental significance are avoided, or where this cannot be reasonably achieved; impacts are minimised and residual impacts offset*'. The Queensland Government maps matters of state environmental significance (MSES) of relevance to the SPP to support the implementation of SPP biodiversity policy. The following two MSES are mapped within the Toondah Harbour PDA (see **Figure 4.2**):

- High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- Wildlife habitat for threatened wildlife and special least concern animals under the NC Act.

The Queensland Government MSES report for the study area is included in **Appendix 2**.



BAAM ECOLOGICAL CONSULTANTS

Client	Walker Corporation	
Project	Terrestrial Ecology Assessment Toondah Harbour PDA	
Design	BAAM	16.03.2017
Drawn	Bentline | MP	16.03.2017
Scale	1:6000	# 0107-005
Cad File	BAAM_Toondah01.dwg	NTP 74
Title	Matters of State Environmental Significance (State Planning Policy)	FIGURE 4.2

5.0 POTENTIAL IMPACTS OF THE PROJECT

This section identifies the potential impacts of the Project on matters of national and state environmental significance relevant to terrestrial ecology based on the Project description. As the Project is still at the planning stage of development, potential impacts are identified in general terms. It is understood that the information on potential impacts will be used to inform the ongoing design of the Project, including layout and construction and operational management.

5.1 PROJECT DESCRIPTION

The Walker Group's proposal for the development of the Toondah Harbour PDA includes residential, retail, marina, hotel, port facilities and tourism infrastructure to be developed within the PDA. As a portion of the development is proposed to occur on intertidal lands within the PDA, dredging and land reclamation will be required over intertidal lands.

5.2 POTENTIAL IMPACTS ON MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE

The potential impacts of the Project on matters of national environmental significance include the following:

- Direct and indirect impacts on a small portion of the Moreton Bay Ramsar wetlands;
- Direct impact on an area of intertidal mudflats and sandflats that is recognised as important feeding habitat for migratory shorebirds, including known feeding habitat for two critically endangered and one vulnerable species;
- Indirect impacts on mudflats and sandflats adjacent to the PDA that are recognised as important feeding habitat for migratory shorebirds, including known and likely feeding habitat for three critically endangered, two endangered and one vulnerable species; indirect impacts relate to reduced food availability for migratory shorebirds in intertidal mudflats and sandflats adjacent to the PDA in the event that altered water quality or hydrodynamics affects benthic invertebrate abundance in intertidal mudflats and sandflats adjacent to the PDA;
- Increased disturbance to migratory shorebirds roosting at three important roost sites for migratory shorebirds located close to the Project, including roosts known to be used by three critically endangered and one vulnerable species (see further detail below); increased disturbance has potential to lead to a substantial reduction in the use of the roost sites by migratory shorebirds;
- Increased disturbance to migratory shorebirds feeding on intertidal mudflats and sandflats adjacent to the PDA in the event that the Project facilitates greater pedestrian access to these areas at low tide, particularly the areas to the east of the Cassim Island mangroves that might be attractive to recreational walkers with dogs;
- Loss of food trees used by several individuals of the vulnerable Koala in an urban area that is not recognised as 'habitat critical to the survival of Koala';
- Mortality of Koalas during clearing of Koala habitat trees prior to construction;
- Increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation; and
- Direct or indirect impacts on a small area of the vulnerable Temperate Coastal Saltmarsh threatened ecological community.

Potential direct impacts relate to the clearing of habitat or vegetation for infrastructure, the marina basin or reclamation. The loss of feeding important intertidal feeding habitat for migratory shorebirds, including for threatened species, may lead to a corresponding decrease in the number

of migratory shorebirds using the Moreton Bay wetlands proportional to the loss of habitat if migratory shorebird populations in Moreton Bay were currently subject to density-dependent population regulation. However, since migratory shorebird populations using Moreton Bay have undergone substantial declines due to factors outside of Moreton Bay (discussed in detail in **Section 3.5**), the carrying capacity of the Moreton Bay wetlands for supporting migratory shorebirds is likely to be underutilised i.e. migratory shorebirds may not be currently subject to density-dependent population regulation due to the substantial loss of birds from the system. In this case, the loss of a relatively small area of intertidal feeding habitat (approximately 0.17% of the 23,000 ha of intertidal mudflat/sandflat in Moreton Bay) may not lead to a corresponding reduction in the number of migratory shorebirds using Moreton Bay.

Increased disturbance to migratory shorebirds roosting in the mangroves of the Cassim Island roost site may result from:

- presence of built infrastructure and human activities closer to the roost site than at present;
- increased noise, particularly during Project construction and pile driving;
- increased lighting of the roost site at night from Project lighting;
- general Project construction activities;
- increased use of the waters within and adjacent to the roost by kayakers at high tide in the event that the Project provides launching points for kayakers; and
- increased use of the waters within and adjacent to the roost by small recreational boats at high tide resulting from increased recreational boat traffic at Toondah Harbour.

Increased disturbance to migratory shorebirds roosting at the Nandeebie Claypan and Oyster Point roost sites may result from:

- increased pedestrian and cyclist traffic along the public walkway adjacent to the Nandeebie Claypan that increases the risk of people and dogs leaving the walkway to enter the roost site;
- increased recreational use of Oyster Point, where recreational activities already cause substantial disturbance to roosting shorebirds.

5.3 REVIEW OF DISTURBANCE IMPACTS ON SHOREBIRDS

This section reviews published knowledge of disturbance impacts on feeding and roosting shorebirds to inform mitigation and management measures.

5.3.1 Disturbance from recreational activities

During the approach of a disturbance agent, foraging and roosting shorebirds reduce their foraging or resting activity to become more vigilant and will typically begin to walk away from the approach. If the approach continues, the birds will eventually take flight to a new location. Disturbance causes birds to spend energy flying away and to lose feeding time while relocating to different feeding areas, where the increased bird densities may intensify competition from interference and, if of sufficient duration, from prey depletion (Goss-Custard et al. 2006). There is little published information on critical thresholds of disturbance. In France, modelling shows that foraging oystercatcher *Haematopus ostralegus* experience reduced survival and breeding success if they are put to flight more than 1.0-1.5 times per hour in winters with good feeding conditions, or more than 0.2-0.5 times per hour when feeding conditions are poor (Goss-Custard et al. 2006). At Roebuck Bay in Western Australia, Great Knot spent an average of 30 minutes per high tide in alarm flights from disturbance by raptors and humans at the most disturbed roost site, yet still preferred to use this site than an alternative site 25 km away (Rogers et al. 2006c). At the most

disturbed roost site in Moreton Bay, Brisbane, up to 400 shorebirds continued to use the roost during spring high tides despite a median number of flights per hour of 0.7, with a total time in flight of less than 5 min (Milton et al. 2011).

Birds taking flight are the most obvious result of disturbance, and different shorebird species have different sensitivities, taking flight at different distances from disturbance agents. Flight initiation distances in response to a variety of disturbance agents are summarised in **Table 5.1**.

Table 5.1 Average flight initiation distance (FID) (and minimum-maximum range) of a variety of migratory shorebird species in response to various disturbance agents, summarised from studies in Australia and elsewhere in the world.

Species	Agent	Bird activity	FID avg (m)	FID range (m)	Ref.*
Australian studies					
Eastern Curlew *Numenius madagascariensis*	Walker	Mixed	126	81-196	1
Whimbrel *N. phaeopus*	Walker	Mixed	90		1
Pacific Golden Plover *Pluvialis dominica*	Walker	Mixed	49	40-60	1
Grey Plover *P. squatarola*	Walker	Mixed	44		1
Latham's Snipe *Gallinago harwickii*	Walker	Mixed	19	9-45	1
Black-tailed Godwit *Limosa limosa*	Walker	Mixed	31	27-35	1
Bar-tailed Godwit *L. lapponica*	Walker Walker	Mixed Foraging	60	45-69 18-38	1 2
Common Sandpiper *Tringa hypoleucos*	Walker	Mixed	43		1
Grey-tailed Tattler *T. brevipes*	Walker	Mixed	23		1
Common Greenshank *T. nebularia*	Walker	Mixed	55	25-145	1
Marsh Sandpiper *T. stagnatilis*	Walker	Mixed	44	20-99	1
Ruddy Turnstone *Arenaria interpres*	Walker	Mixed	30	17-54	1
Sanderling *Caldris alba*	Walker	Mixed	32	22-39	1
Red-necked Stint *C. ruficollis*	Walker	Mixed	19	9-41	1
Pectoral Sandpiper *C. melanotos*	Walker	Mixed	23	16-30	1
Sharp-tailed Sandpiper *C. acuminata*	Walker	Mixed	20	4-44	1
Curlew Sandpiper *C. ferruginea*	Walker	Mixed	25	14-35	1
Shorebirds and terns	Plane Boat Walker Dog	Roosting Roosting Roosting Roosting	170 75 25 30		8 8 8 8
Studies elsewhere					
Eurasian Curlew *N. arquata*	Walker Walker Walker Walker Walker Walker Helicopter Car Kayak Wind-surfer	Foraging Foraging Foraging Foraging Foraging Roosting Roosting Roosting Roosting Roosting	 211 339 102-196 88 213 200 188 230 400	102-196 124-299 225-550 33-186	3 4 5 3 9 6 6 6 7 7
Bar-tailed Godwit *L. lapponica*	Walker Walker Walker Walker Kayak Wind-surfer	Foraging Foraging Foraging Foraging Roosting Roosting	107 219 101-138 45 210 240	88-127 150-225 25-83	4 5 3 9 7 7
Grey Plover *P. squatarola*	Walker Walker	Foraging Foraging	124 64	106-142 31-85	4 9
Ruddy Turnstone *Arenaria interpres*	Walker	Foraging	47	31-53	4

Species	Agent	Bird activity	FID avg (m)	FID range (m)	Ref.*
	Walker	Foraging	25	3-87	9

* References: (1) Glover *et al*. 2011; (2) Blumstein *et al*. 2003; (3) Glimmerveen and Went 1984 in Smit and Visser 1993; (4) van der Meer in Smit and Visser 1993; (5) Wolff *et al*. 1982 in Smit and Visser 1993; (6) Blankestijn *et al*. 1986 in Smit and Visser 1993; (7) Koepff and Dietrich 1986 in Smit and Visser 1993; (8) Milton *et al*. 2011; (9) Collop *et al*. 2016.
[1] No significant difference in FID between species.

Larger species such as Eastern Curlew and Whimbrel tend to be more 'flighty', meaning they are more sensitive to disturbance and tend to take flight at greater distances from disturbance agents than most other shorebirds (Smit and Visser 1993, Glover et al. 2011). Joggers and walkers with a leashed dog are more disturbing than a walker alone (Lafferty 2001, Glover et al. 2011), and unleashed dogs are substantially more disturbing (Pfister and Harrington 1992, Kyne 2010, Stigner et al. 2016).

Other more disturbing sources of disturbance are watercraft, particularly jet-skis (Smit and Visser 1993, Collins et al. 2000, Rodgers and Schwikert 2003). Jet-skis are more disturbing that most other watercraft because of their generally faster travelling speeds and sharp turning abilities. At an important shorebird stopover and winter refuge in the southern United States, Red Knots avoided roosts that had high average recreational boat activity within 1,000 m and dowitchers, *Limnodromus griseus* and *L. scolopaceus*, avoided prospective roosts when boat activity within 100 m was high, but disturbance did not appear to be a factor in roost site selection for other species (Peters and Otis 2006).

Shorebird responses to disturbance often depend on the context in which the disturbance takes place. Individuals in larger flocks tend to be more sensitive to disturbance, particularly when they are in large, mixed species flocks, such as occurs at shorebird roosting sites (Rogers *et al*. 2006b, Glover *et al*. 2011). The relationship between flock size and disturbance does not appear to be linear; rather, disturbance levels climbed abruptly if bird numbers exceeded 50-100 (Rogers *et al*. 2006b). Therefore, flight initiation distances for individual species may be larger than those reported in **Table 5.1** when these species are roosting in large, mixed-species flocks.

Shorebirds living in environments that are heavily used by humans and exposed to repetitive, non-lethal disturbance stimuli experience energetic costs associated with their responses to disturbance (West *et al*. 2002, Goss-Custard *et al*. 2006). To reduce these costs, shorebirds are expected to habituate to repetitive stimuli that do not present a direct mortality risk (Deniz *et al*. 2003). Many studies have demonstrated the ability of many shorebird species to habituate to many forms of repetitive disturbance (Smit and Visser 1993, West *et al*. 2002, Baudains and Lloyd 2007), although the process of habituation may require lengthy exposure to repetitive disturbance stimuli (Komenda-Zehnder *et al*. 2003).

5.3.2 Disturbance from noise

Seabirds exhibit alert behaviours to most levels of noise exposure, but begin to take flight in response to noise exposure levels greater than 85 dBA (Brown 1990), consistent with observations that sound levels of 43-87 dBA have limited effects on foraging shorebirds, but sound levels of 84-100 dBA cause most shorebirds in an habituated population to leave the area of disturbance (Smit and Visser 1993). Disturbance reactions are generally stronger when disturbing sounds are combined with visual disturbance (Smit and Visser 1993). Also, intermittent bursts of noise are generally more disturbing than continuous noise; birds are expected to habituate more readily to the latter (Smit and Visser 1993).

5.3.3 Disturbance from lighting

At Roebuck Bay in Western Australia, shorebirds avoid roosting at sites where they are exposed to artificial lighting such as streetlights or traffic; possibly such lighting makes roosting shorebirds too easily detected by predators (Rogers *et al*. 2006c).

5.4 POTENTIAL IMPACTS ON MATTERS OF STATE ENVIRONMENTAL SIGNIFICANCE

The potential impacts of the Project on matters of state environmental significance include the following:

- direct impact on small areas of remnant regional ecosystems listed as having least concern status under the VM Act;
- loss of food trees used by several individuals of the vulnerable Koala in an urban area, including non-juvenile Koala habitat trees within areas mapped as medium value rehabilitation under the SPRP;
- mortality of Koalas during clearing of Koala habitat trees prior to construction;
- increased risk of mortality to the vulnerable Koala due to increased vehicle traffic and dog ownership resulting from increased urbanisation;
- direct and indirect impacts on High ecological significance (HES) wetlands on the Map of Referable Wetlands; and
- direct and indirect impacts on wildlife habitat for threatened and special least concern fauna species.

6.0 POTENTIAL IMPACT MITIGATION AND MANAGEMENT MEASURES

This section outlines a variety of measures that could be implemented to mitigate and manage the potential impacts of the Project on terrestrial ecology matters.

6.1 MEASURES TO MITIGATE POTENTIAL IMPACTS ON MIGRATORY SHOREBIRDS

The direct impact of the Project on loss of feeding habitat for migratory shorebirds can be mitigated by minimising the area of intertidal feeding habitat in the development footprint of the Project design.

Potential impacts of disturbance on migratory shorebirds can be mitigated through the implementation of the following measures recommended by the referral guidelines (Commonwealth of Australia 2015a):

- buffer zones around important areas for migratory shorebirds, particularly important roost sites; ideally there should be no Project activities or public access within the buffer zones;
- construction of appropriate barriers, such as fences around important habitat to restrict access; ideally, there should be no public access (by humans and/or domestic animals) to areas identified as important to migratory shorebirds;
- landscape and urban design to include sympathetic lighting strategies, vegetation screening and sound attenuation; and
- increased community education through mechanisms such as interpretive signs at access points to shorebird habitats.

6.1.1 Potential impact mitigation for the Cassim Island shorebird roost site

The implementation of a buffer zone around the Cassim Island shorebird roost site will likely be critical to mitigating potential impacts on this important roost site. Based on the information presented in **Section 5.3**, a minimum buffer of approximately 100 m from the outer edge of the roost site boundary would likely be necessary to keep disturbance to roosting Whimbrel to a minimum. Should the outer boundary of the Project footprint extent to the eastern boundary of the PDA, which approaches to within 30 m of the western boundary of the roost site, it is likely that most species would cease roosting along the western edge of the mangroves where most roosting birds were concentrated during the surveys. The displaced birds may then move to other areas of the roost site, including areas more distant from the PDA boundary that they were recorded using during the surveys; these alternative roosting areas would be effectively screened from the Project infrastructure by the western band of mangrove trees. Landscape and urban design along the eastern boundary of the Project opposite the mangroves of the roost site should include sympathetic lighting strategies (to reduce light spill to mangroves and intertidal mudflats), vegetation screening (to minimise visual disturbance) and sound attenuation.

In the event that the Project provides launch points for kayakers, implementation of a buffer exclusion zone, with no public access within 100 m of any of the mangroves of the roost site, would be critical for mitigating disturbance to roosting shorebirds. Effective implementation of such a buffer exclusion zone would require interpretative signage specific to the Cassim Island roost site to be placed at shoreline entry points as well as sufficient resources to regularly enforce the exclusion zone over the long term.

The impact of disturbance from general Project construction activities, particularly activities such as dredging and pile driving, can be mitigated by timing these activities to occur over the winter months May to August when most migratory shorebirds are absent from Moreton Bay.

6.1.2 Potential impact mitigation for the Nandeebie Claypan roost site

The maintenance of tall mangrove vegetation between the north-western edge of the roost site and the Project footprint would assist with screening the roost site from Project infrastructure and construction and operational activities. Construction of a relatively low barrier fence and vegetation screening along the boundary of the public walkway adjoining the Nandeebie Claypan roost site, together with site-specific information signs erected along the barrier fence would help minimise the risk of public and dog access to the Nandeebie Claypan roost site. The suitability of the Nandeebie Claypan roost site for migratory shorebirds could be enhanced though control of mangroves that are slowly encroaching on the roost site, particularly along the eastern boundary of the roost site.

6.1.3 Potential impact mitigation for intertidal mudflat feeding habitats

Public use of the intertidal mudflats within and adjacent to the Toondah Harbour PDA area is currently inhibited by the soft, muddy substrates and loose surface coral rubble that makes walking through these areas unpleasant. This may change in the event that the Project creates sandy beaches on the shoreline perimeter of the Project footprint or permits easier public access to portions of sandflat with a more open, sandy substrate in the vicinity of Cassim Island. This potential impact can be mitigated by adopting a landscape design that minimises the accessibility to the public of areas of sandflat adjacent to the Project.

6.2 MEASURES TO MITIGATE POTENTIAL IMPACTS ON KOALAS

The potential impacts of the Project on Koalas that currently utilise feed trees within the PDA can be mitigated by:

- adopting a landscape and urban design that retains as many of the primary food trees as possible;
- adopting a landscape and urban design that includes a linear strip of public open space to serve as a corridor connecting retained Koala food trees with bushland habitat in Nandeebie Park to the south of the PDA;
- planting additional primary Koala food trees both within the PDA and surrounding areas where possible, to mitigate the likely loss of some Koala food trees within the PDA, noting that it will take years for the plantings to reach a size that they begin to provide food for Koalas;
- including traffic calming designs for roads crossing the open space corridor, and implementing a maximum speed limit of 40 km/hr;
- ensuring that the clearing of any trees during Project construction is performed under the guidance of a licenced fauna spotter; and
- using Koala exclusion fencing to fence off areas that may pose a risk of injury to Koala during construction e.g. deep pits that Koala may fall into.

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