High Pathology Avian Influenza

H5N1- clade 2.3.4.4b

Preparedness Planning

Shorebirds

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Acronyms	Full form
NT	Northern Territory
DLPE	Department of Lands, Planning and Environment
DAF	Department of Agriculture and Fisheries

Contents

Purpose and Audience

In the Northern Territory (NT), the Northern Territory Department of Agriculture and Fisheries (NT DAF) is the lead agency for biosecurity emergencies and leads all phases of emergency management for a H5 bird flu incursion in the NT. The aim in response to the H5 Bird flu will be to minimise impacts on NT wildlife populations, domestic animals, people and the environment. Eradication of H5 bird flu in wildlife is not considered feasible and will not be attempted. Management will eventually transition following H5 bird flu becoming endemic within wildlife populations.

Objectives for a response in wildlife will vary, but may include:

- Ensuring public safety and Work Health and Safety (WHS),
- Identifying the source, extent and spread of diseases,
- Minimising the conservation impact of disease where possible,
- Enhance the surveillance of wild bird populations to identify at risk populations and monitor impacts,
- Managing animal welfare,
- Enhancing biosecurity for captive wildlife.

Within this context, this document is designed to assist wildlife managers to:

- Enable early detection of H5 avian influenza and infection in other susceptible species at priority sites.
- Implement biosecurity measures to reduce the risk of H5 avian influenza establishment and spread.
- Minimise risks to human, animal, and environmental health posed by H5 avian influenza.
- Ensure land/wildlife managers and biosecurity representatives working within the site, or deployed during an incident, are prepared for outbreak response and recovery.
- Establish communication, surveillance, and reporting protocols consistent with relevant legislation, emergency management arrangements, animal welfare requirements, and workplace health and safety obligations.

This document identifies sites of significance, including areas where key species are likely found. Some sites relate to species-specific risks - for example, wetlands important for populations of magpie geese or major shorebird aggregation areas, while others are recognised as matters of national significance, such as islands. Collectively, this information outlines which actions are eligible or ineligible for cost-sharing and highlights any further work required to refine each action. This supports more targeted planning and helps clarify the appropriate cost-sharing arrangements.

Broadly, preparedness and response actions aim to:

- protect people by reducing contact with infected birds and contaminated environments,
- prevent virus spread, including via footwear, clothing, or equipment,
- minimise stress and build resilience in wildlife populations.

This document outlines actions to support conservation and management of a potential an H5 avian influenza outbreak in wildlife populations. It aligns with Commonwealth priorities and obligations and informs future management and investment decisions to mitigate impacts on wildlife.

Introduction

This is a Preparedness document for shorebirds and their associated habitats across the Northern Territory (NT), with a focus on landscape-scale planning in response to a potential incursion of High Pathogenicity Avian Influenza (HPAI) H5N1 clade 2.3.4.4b (hereafter referred to as HPAI). The assessment specifically considers site and landscape-scale factors influencing disease risk, with an emphasis on avian species utilising **Darwin Harbour and surrounding intertidal coastal environments** including:

- Anson and Fog Bay (West Coast)
- South Van Diemen Gulf (Central Coast)
- Boucaut, Castlereagh and Buckingham Bay (North Coast)
- Roper to Limmen Bight (East Coast)
- Limmen Bight River to McArthur River Estuary (The Connector)
- Port McArthur (South-East)

The locations identified, particularly Darwin Harbour, have been prioritised based on their significance and importance to avian populations considered vulnerable to HPAI. These areas consistently support large aggregations of migratory and resident shorebirds, waterbirds, and other taxa during critical life-history stages (Chatto, 2005b; Garnett, 2008; Garnett, 1987; Lilleyman et al., 2013). Threatened species are a particular priority, such as the Ruddy Turnstone (*Arenaria interpres*), Sharp-tailed Sandpiper (Calidris acuminata), Red Knot (*Calidris canutus*), Curlew Sandpiper (*Calidris ferruginea)*, Bar-tailed Godwit (*Limosa lapponica*), Black-tailed Godwit (*Limosa limosa*), and Far Eastern Curlew (*Numenius madagascariensis*), alongside EPBC Act listed species, colonial breeding seabirds, and other culturally significant species.

Darwin Harbour is selected as a target site for biosecurity preparedness due to the proximity of the site to urban, agricultural and industrial areas, which increases the potential for disease spillover and spread. Close contact among birds, along with indirect transmission pathways (e.g., via contaminated substrates or fomites that may further amplify risk.

Additional locations and species of concern for HPAI are addressed in complementary preparedness documents. Together these materials identify species and locations at greatest risk from HPAI introduction due to ecological sensitivity, proximity to vulnerable environments, or association with Matters of National Environmental Significance. Supporting documents, including the Wildlife Actions Register, the Wildlife Risk Assessment and the HPAI Preparedness Resource Document, inform response planning and operational decision-making.

An Emergency Response to the arrival of HPAI will be activated via the National Management Agreement (NMA) at the scale deemed appropriate by a potential outbreak. The agreement functions in parallel with the Emergency Animal Disease Response Agreement (EADRA), providing interoperability of governance and decision-making.

Vaccination or translocation are not currently considered to be viable options for management of wild bird populations in the NT. Instead, actions will focus on HPAI preparedness (e.g., surveillance and population monitoring, mitigating existing threats via feral animal and weed control), response

(e.g., carcass removal from some locations, management of public access to infected areas) and recovery (e.g., population monitoring).

Species at Risk

Avian fauna in the NT may play a dual role in HPAI epidemiology, functioning both as vectors that enable virus dispersal along dispersal/ migratory routes and as susceptible hosts that can experience substantial mortality. Several avian species associated with the shorebird target sites in the NT are therefore considered vulnerable to HPAI. For HPAI preparedness planning, vulnerable species were grouped into assemblages based on ecological characteristics and habitat use, these include:

- Islands - offshore islands and associated avian assemblages, including colonial breeding seabirds and shorebirds that regularly use islands for roosting (Ray Chatto surveys, 1990-2001).
- Shorebirds - species occurring along mainland beaches and coastal mudflats, estuaries, and wetlands, including EPBC-listed migratory and resident species (Garnett, 2008, 1987).
- Colonial Waterbirds - freshwater and estuarine colonial breeders in wetlands and rivers.
- Barkly Tablelands- inland, episodic wetland-dependent species (Jaensch, 2003).
- Magpie goose- a culturally and ecologically significant species that forms large aggregations in floodplain wetlands and is of particular relevance due to its abundance, mobility, and susceptibility to HPAI disease impacts (Clancy, 2020).

The current document includes species with documented, repeated use of selected sites, for feeding or roosting. Ecological traits that heighten HPAI vulnerability in shorebird species include:

- Colonial breeding and high contact rates and potential for rapid transmission.
- Use of habitats overlapping with other susceptible species.
- Documented susceptibility or exposure to clade 2.3.4.4 HPAI viruses (Wildlife Health Australia, 2024).
- Migratory species use site for roosting and feeding- many are key vectors of HPAI along the East Asian-Australasian Flyway.

Target Species

Background

The following detail may assist in the scenario of developing a NMA Response Plan. This includes a description and estimated number and species in Wildlife Risk Assessment Template. Additionally, the catchment profile information can help define the 'vicinity' as per the AUSVETPLAN Avian influenza response strategy template. The intention is to provide habitat information, as well as estimates, not precise numbers, of susceptible species in the vicinity. This information requires updating on a case-by-case basis.

The intertidal zone of Darwin Harbour supports a diverse assemblage of shorebirds and seabirds, making it a critical site for HPAI preparedness. Migratory shorebirds are frequently detected in these habitats during the non-breeding season, and many are key vectors of HPAI along the East Asian-Australasian Flyway. Target species are also consistently recorded in Darwin Harbour surveys (Chatto, 2005b, Lilleyman et al., 2013, 2018, 2024) including Red-necked Stint (*Calidris ruficollis*), Great Knot (*Calidris tenuirostris*), Whimbrel (*Numenius phaeopus*), Bar-tailed Godwit (*Limosa lapponica*), and Far Eastern Curlew (*Numenius madagascariensis*).

Other regularly occurring migratory species that rely on intertidal mudflats for foraging and adjacent roosts, forming dense aggregations at high tide include Pacific Golden Plover (*Pluvialis fulva*), Greater Sand Plover (*Charadrius leschenaultii*), Lesser Sand Plover (*Charadrius mongolus*), Terek Sandpiper (*Xenus cinereus*), Grey-tailed Tattler (*Tringa brevipes*), Common Greenshank (*Tringa nebularia*), and Ruddy Turnstone (*Arenaria interpres*).

Resident shorebirds may also play an important role in HPAI transmission cycles. Species such as Masked Lapwing (*Vanellus miles*), Red-capped Plover (*Charadrius ruficapillus*), Black-winged Stilt (*Himantopus himantopus*), and the Beach Stone-curlew (*Esacus magnirostris*) frequently use intertidal, supratidal, and adjacent wetland habitats and may act as bridge species between migratory birds and inland ecosystems.

Colonial breeding seabirds are also associated with the respective NT coastal sites, including various tern species, egrets, and ibis. These species often form dense breeding or roosting colonies. Target species include Silver Gull (*Chroicocephalus novaehollandiae*), Gull-billed Tern (*Gelochelidon nilotica*), Caspian Tern (*Hydroprogne caspia*), Greater Crested Tern (*Thalasseus bergii*), Little Tern (*Sternula albifrons*), and Black-naped Tern (*Sterna sumatrana*).

Additionally, coastal wading birds and raptors, such as Eastern Reef Egret (*Egretta sacra*), White-bellied Sea Eagle (*Haliaeetus leucogaster*), and Brahminy Kite (*Haliastur indus*), occupy habitats at the interface of marine and intertidal zones and may act as scavengers or secondary hosts, potentially spreading HPAI via carrion or predation.

Target and Associated Species Table

Table 1: Shorebird species of interested regarding HPAI preparedness and response on NT Islands (taxonomy and sequencing follow AviList (Rheindt et al., 2025)).

Scientific Name	Common Name	Order	Family Scientific Name	Risk Group/ Family Name	Risk sub-group	Estimated HPAI Susceptibility Index
Phaethon rubricauda	Red-tailed Tropicbird	Phaethontiformes	Phaethontidae	Tropicbirds	Seabird	0.53
Egretta sacra	Eastern Reef Egret	Pelecaniformes	Ardeidae	Herons, Egrets and Bitterns	Heron	0.56
Esacus magnirostris	Beach Stone-curlew	Charadriiformes	Burhinidae	Stone-curlews	Other bird	0.51
Himantopus leucocephalus	Pied Stilt	Charadriiformes	Recurvirostridae	Stilts and Avocets	Stilts and Avocets	0.14
Pluvialis squatarola	Grey Plover	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Pluvialis fulva	Pacific Golden Plover	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Anarhynchus ruficapillus	Red-capped Plover	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Anarhynchus mongolus	Lesser Sand Plover	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Anarhynchus leschenaultii	Greater Sand Plover	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Anarhynchus veredus	Oriental Plover	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Vanellus miles	Masked Lapwing	Charadriiformes	Charadriidae	Plovers, Dotterel and Lapwings	Plovers, Dotterel and Lapwings	0.04
Numenius phaeopus	Eurasian Whimbrel	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Numenius minutus	Little Curlew	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Numenius madagascariensis	Far Eastern Curlew	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Limosa lapponica	Bar-tailed Godwit	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21

Limosa limosa	Black-tailed Godwit	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Arenaria interpres	Ruddy Turnstone	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris tenuirostris	Great Knot	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris canutus	Red Knot	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris falcinellus	Broad-billed Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris acuminata	Sharp-tailed Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris ferruginea	Curlew Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris ruficollis	Red-necked Stint	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Calidris alba	Sanderling	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Limnodromus semipalmatus	Asian Dowitcher	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Xenus cinereus	Terek Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Actitis hypoleucos	Common Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Tringa brevipes	Grey-tailed Tattler	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Tringa nebularia	Common Greenshank	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Tringa glareola	Wood Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Tringa stagnatilis	Marsh Sandpiper	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Tringa guttifer	Nordmann's Greenshank	Charadriiformes	Scolopacidae	Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes	Waders, gulls	0.21
Anous stolidus	Brown Noddy	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Chroicocephalus novaehollandiae	Silver Gull	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88

Onychoprion anaethetus	Bridled Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Sternula albifrons	Little Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Gelochelidon nilotica	Australian Gull-billed Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Hydroprogne caspia	Caspian Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Chlidonias leucopterus	White-winged Black Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Sterna dougallii	Roseate Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Sterna sumatrana	Black-naped Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Thalasseus bengalensis	Lesser Crested Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Thalasseus bergii	Greater Crested Tern	Charadriiformes	Laridae	Gulls, Terns and Noddies	Waders, gulls	0.88
Pandion haliaetus	Osprey	Accipitriformes	Pandionidae	Osprey	Raptors	0.11
Haliaeetus leucogaster	White-bellied Sea-Eagle	Accipitriformes	Accipitridae	Eagles, Kites and Goshawks	Raptors	0.68
Haliastur indus	Brahminy Kite	Accipitriformes	Accipitridae	Eagles, Kites and Goshawks	Raptors	0.68

Distribution and Movement

NT Shorebird Assemblage

The NT has some of the largest areas of intertidal habitat in Australia (0.22 km² per km of mapped coastline) frequented by many shorebirds. Ray Chatto's foundational research identified Darwin Harbour and surrounding coastal sites as critical shorebird habitat within the Top End region (Chatto, 2005). Baseline aerial surveys in 1981 and 1984 identified the south-east Gulf of Carpentaria as the primary, high-density area for shorebirds in northeastern Australia, documenting over 130,000 birds. The research highlights that over 85% of waders concentrate on coastlines with mangrove fringes, particularly near river mouths (Garnett, 1987).

Beyond Darwin Harbour, other NT coastal areas supporting significant shorebird populations include the Daly River catchment, including the estuary and lower floodplain, satisfies waterbird criteria for Ramsar listing, supporting 14 significant waterbird sites (Rea, 2005). Surveys in a 2,500 km² area including the Daly, Finniss, Anson Bay and Reynolds Rivers recorded over 560,000 shorebirds, equating to 26.8% of the total counted in the Top End (Rea, 2005). Castlereagh Bay and other coastal sites in the NT also support significant numbers of migratory shorebirds (Wales, 2005).

Habitat Use

The habitat of the Darwin Harbour and intertidal zones can be described as dispersed foraging grounds across intertidal mudflats and concentrated high-tide roosting at limited natural and artificial sites, which results in predictable periods of high-density congregation (Lilleyman et al., 2018).

Shorebirds in the NT utilise both natural and artificial habitats. Natural habitats include intertidal mudflats, sandflats, mangrove-fringed shorelines, coastal saltmarshes, and rocky shores. Artificial habitats, such as constructed watering points, may further increase avian densities and aggregation (Lilleyman et al., 2024). The East Arm Wharf at Darwin Port, an artificially created habitat, provides valuable additional roosting habitat for migratory shorebirds (Lilleyman et al., 2024, Lilleyman, Rogers, et al., 2020, Lukasiewicz et al., 2016).

Research has shown that artificial sites can support increasing shorebird populations even as natural sites experience declines (Jackson et al., 2021, Lilleyman, Rogers, et al., 2020). Shorebirds move between intertidal habitats and inland wetlands, necessitating integrated HPAI surveillance of terrestrial and marine environments as well as artificial habitats.

Flyway Connectivity

NT coastal shorebirds are integral components of the East Asian-Australasian Flyway, which connects breeding grounds in the Arctic and East Asia with non-breeding sites across Australasia (Lilleyman, 2020, Piersma et al., 2016, Szabo et al., 2016). The flyway supports millions of migratory shorebirds, with the Yellow Sea region serving as the critical bottleneck where most species stage during migration (Piersma et al., 2016, Szabo et al., 2016). Rapid habitat loss in the Yellow Sea, particularly coastal wetland losses in China and the Korean Peninsula, is the primary driver of population declines for many species using NT coastal habitats (Piersma et al., 2016, Szabo et al., 2016).

The persistence of shorebirds at degraded staging sites in the Yellow Sea despite severe declines in food resources implies a lack of alternative stopover sites (Zhang et al., 2018). It also implies strong site fidelity, even to deteriorating habitats. Underscoring the vulnerability of flyway populations to habitat loss at any critical node in the network, including key sites in the NT, described in this document.

Seasonal Movement and Breeding Phenology

Seasonal Movement

The East Asian - Australasian Flyway (EAAF) connects NT intercoastal sites with breeding grounds in Siberia, Alaska, and East Asia (Figure 1). Migratory shorebirds arrive in the NT from their northern breeding grounds during the austral spring and summer (September to March), with peak numbers typically occurring between October and February. The phenology of southward migration in the East Asian-Australasian Flyway reveals size-dependent stopover strategies, with smaller species making more frequent stops and larger species capable of longer non-stop flights (Choi et al., 2016).

Aerial surveys in Darwin Harbour in January 2017 captured peak non-breeding season abundance, recording 24 shorebird species (Lilleyman et al., 2018). The timing of surveys is critical for accurate population assessment, as shorebird numbers fluctuate seasonally and with tidal cycles.

Northward migration typically begins in March and continues through May, with birds departing NT coastal sites to stage at critical stopover sites in the Yellow Sea before continuing to Arctic and East Asian breeding grounds. The timing of departure is influenced by body condition, weather patterns, and the need to arrive at breeding grounds in optimal condition for reproduction.

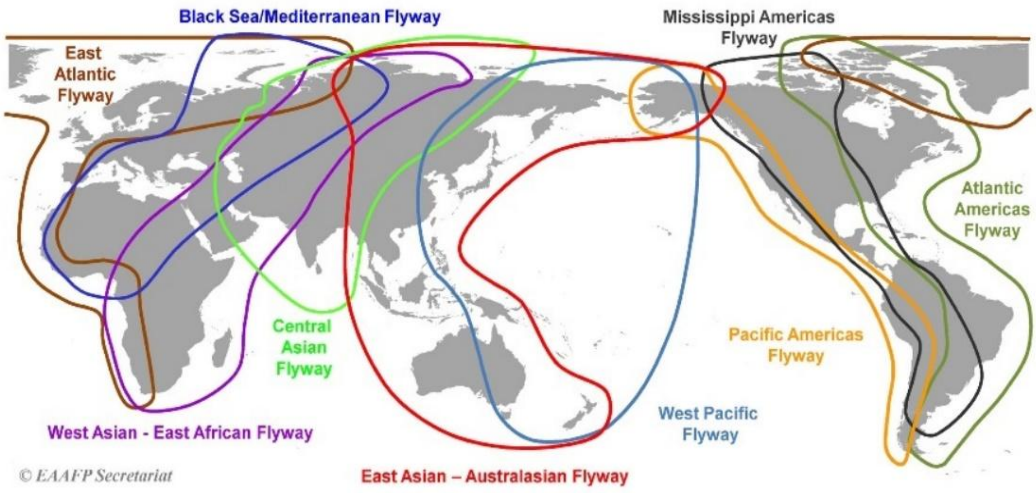


Figure 1: The major flyways around the world. The East Asian - Australasian Flyway (light blue line) extends from the Russian Far East and Alaska, southwards through East Asia and South-east Asia, to Australia and New Zealand encompassing ~22 countries.

Site Fidelity

Most shorebirds in Australia are long-distance migrants that breed in the northern hemisphere and spend the austral summer on Australian coasts in large aggregations. Their migration timing is shaped by the phenology of food resources, reproductive cycles, and survival requirements. Many

shorebirds exhibit strong site fidelity to specific non-breeding sites, returning to the same locations yearly (Minton, 2005). Banding and flagging studies in Darwin and other Australian sites have revealed individual birds returning to the same roost sites across multiple years (Minton, 2005; Lilleyman et al. 2024) This site fidelity has important implications for both conservation and HPAI disease transmission as repeated congregation facilitates may facilitate pathogen persistence.

Stopover duration at NT coastal sites varies by species and individual condition. Some species remain throughout the non-breeding season (September to March), at least when immature, while others may use NT sites as brief stopover locations during migration. The availability of high-quality foraging habitat and undisturbed roosting sites influences stopover duration and body condition gain.

Site Distribution

Shorebird distribution and behaviour in NT coastal areas are strongly influenced by tidal cycles. During low tide, birds disperse across extensive intertidal mudflats to forage. During high tide, birds concentrate at roosting sites, often in large mixed-species flocks (Lilleyman, 2020, Lukasiewicz et al., 2016)

The aerial surveys in Darwin Harbour conducted during both low tide (724 birds of 19 species) and high tide (789 birds of 13 species) demonstrate how tidal state influences species detectability and distribution (Lilleyman et al., 2018). High tide surveys are particularly effective for observing Far Eastern Curlews and other large species that concentrate at predictable roost sites.

Breeding Phenology

Some priority threatened shorebird species breed in diverse locations across the Northern Hemisphere, with breeding phenology varying by species and population. Birds must arrive at breeding grounds in good body condition to successfully reproduce, making the quality of non-breeding habitat and stopover sites along the migration route critical for breeding success.

Breeding success in the northern hemisphere is influenced by weather conditions, predation pressure, and food availability during the breeding season. Poor breeding years result in reduced juvenile recruitment to non-breeding populations in Australia, which can be detected through age-ratio monitoring at sites like Darwin Harbour.

The simultaneous declines in summer survival of Red Knot, Great Knot, and Bar-tailed Godwit signal a flyway at risk, with reduced summer survival likely linked to poor body condition upon arrival at breeding grounds due to inadequate refuelling at degraded Yellow Sea staging sites (Piersma et al., 2016).

Threats

Shorebirds and migratory waders are regarded as the primary vectors introducing avian influenza viruses into Australia (Wille et al., 2024). However, evaluating and predicting the risk of HPAI incursion is challenging. Long-term monitoring reveals significant population declines across multiple migratory shorebird species, with migrants disproportionately affected compared to resident species (Clemens *et al.*, 2016, Studds *et al.*, 2017). Continental-scale analyses demonstrate that many target species, including Great Knot and Far Eastern Curlew, have experienced severe population reductions linked to habitat loss at key staging sites along the flyway (Studds *et al.*, 2017, Koleček *et al.*, 2021).

The primary threat to migratory shorebird populations in the Darwin Harbor and the NT intercoastal zone is the loss of intertidal mudflats in crucial staging areas, which, elsewhere, has led to reduced survival for multiple species (Piersma et al., 2016, Szabo et al., 2016). The Yellow Sea region has until recently experienced rapid coastal development, with extensive land development converting intertidal habitats to industrial, urban, and agricultural uses (Szabo et al., 2016).

Despite the NT's relatively remote and intact coastal environments, compared to more developed regions of Australia, local threats to shorebirds are increasing and may be significant.

Coastal Development in Darwin Harbour and surrounding areas is a risk to the availability of critical shorebird habitat (Lilleyman et al., 2018, Lukasiewicz et al., 2016, Piersma et al., 2016). Disturbance from humans and their domestic pets such as dogs at roosting and feeding sites causes energy expenditure and displacement. Increased human disturbance around roosts, and recreational activities often interact and contribute to habitat degradation. High tide roosts are particularly vulnerable to disturbance, as birds have limited alternative sites during high tide periods (Kyne, 2010; Rogers, Battley, et al., 2006; Rogers, Piersma, et al., 2006)

Increased predation pressure from introduced predators or altered predator-prey dynamics due to habitat modification can impact shorebird populations. Hunting of migratory shorebirds occurs in some countries along the flyway and contributes further to population declines (Dhanjal-Adams, 2016) but is not a threat in Australia.

The congregation of large numbers of birds at limited roosting sites creates conditions conducive to disease transmission. Highly Pathogenic Avian Influenza (HPAI) represents an emerging threat of concern, particularly in the sites listed in this document.

Current Management Actions

BirdLife Australia's Migratory Shorebirds Program conducts regular monitoring at key NT sites, including Darwin Harbour. The monitoring provides data on population trends, species composition, and habitat use. The program relies on trained volunteers and professional staff to conduct standardised surveys (Hansen et al., 2018, Lilleyman et al., 2018, Lilleyman & O'brien, 2025).

Shorebird banding in Darwin, conducted in collaboration with the Australasian Wader Studies Group and Victorian Wader Study Group, provide data on individual birds through banding and flagging. Such programs enable tracking of individual movements, survival rates, and site fidelity across the flyway (Lilleyman *et al.*, 2020).

Area Management

Darwin Harbour Regional Plan of Management provides information regarding an integrated approach to sustainably managing the Region's resources. The plan covers Port Darwin, Shoal Bay and associated catchments. This area (referred to as the Darwin Harbour Region) covers 3,227km^2 and extends from Charles Point to Gunn Point including the estuarine areas and tributaries of Woods Inlet, West Arm, Middle Arm, East Arm, the Howard River and all of the land that drains into these waterways. Six local governments are contained within the Darwin Harbour region. These are the Darwin City Council, Palmerston City Council, Litchfield Shire Council, Cox Peninsula Community Government Council, Belyuen Community Government Council and the Coomalie Community Government Council.

Across the NT, key shorebird sites receive protection through various mechanisms. Shorebirds and migratory waders are protected under the EPBC Act and are directly linked to Australia's international migratory bird obligations, including the Convention on Migratory Species (CMS) and bilateral agreements with Japan, China and the Republic of Korea (JAMBA, CAMBA, ROKAMBA). These frameworks underpin flyway-scale conservation of migratory shorebirds and guide national actions to protect critical habitats used during migration.
Shorebird conservation in the NT operates within multiple policy frameworks:

1. EPBC Act
2. Territory Parks and Wildlife Conservation Act
3. International agreements: Including the Convention on Migratory Species and bilateral migratory bird agreements with Japan, China, and the Republic of Korea
4. Ramsar Convention
5. East Asian-Australasian Flyway Partnership.

Active management actions to maintain habitat quality and minimise disturbance may include:

- Disturbance management at high tide roosts and feeding areas,
- Access restrictions during critical periods,
- Signage and education to inform the public about shorebird conservation,
- Monitoring programs to track population trends and habitat condition,
- Threat mitigation, including predator control and vegetation management where appropriate.

Habitat Enhancement

The success of artificial sites like the East Arm Wharf in supporting increasing shorebird populations demonstrates the potential for habitat creation and enhancement. Well-designed artificial habitats may provide valuable supplementary roosting sites, particularly in areas where natural habitats are limited or degraded (Jackson et al., 2021, Lilleyman, Rogers, et al., 2020).

Public interest

The Northern Territory's coastal shorebird populations are of international conservation significance due to their role in the East Asian-Australasian Flyway. The flyway supports over 50 migratory waterbird species and connects 22 countries across the Asia-Pacific region (Szabo et al., 2016). Australia serves as the primary non-breeding destination for many flyway species.

The critically endangered status of Far Eastern Curlew, with approximately three-quarters of the global population wintering in Australia, elevates the international conservation significance of shorebird sites supporting this species (Lilleyman *et al.*, 2020). Similarly, the critically endangered Curlew Sandpiper and endangered Great Knot populations using the target sites underscore the global importance of these sites.

The harbour's proximity to Darwin city creates both conservation challenges (e.g. disturbance) and opportunities regarding the preparedness and potential response to a HPAI incursion.

Public awareness of shorebirds in the Northern Territory has grown through the efforts of BirdLife Australia, conservation organisations, and media coverage of declining species like the Far Eastern Curlew. Educational programs, including guided shorebird watching events, school programs, and interpretive signage at key sites, help build public understanding and support for shorebird conservation. The proximity of Darwin Harbour to Darwin city provides opportunities for urban residents to engage with conservation and potentially HPAI preparedness.

Susceptibility to HPAI

HPAI represents an emerging and potentially catastrophic threat to shorebird populations globally and in the NT. Since 2020, this HPAI strain has caused mass mortality events in wild bird populations across multiple continents, with particularly severe impacts on colonial seabirds and waterfowl (Couty et al., 2026).

The congregation of large numbers of shorebirds at limited high-quality sites in the NT, combined with the species' migratory connectivity to regions where HPAI is present, creates conditions conducive to disease introduction, transmission, and potentially devastating population impacts. The priority threatened species listed in this document are particularly vulnerable, as HPAI outbreaks could drive critically endangered species like Far Eastern Curlew and Curlew Sandpiper toward extinction.

The most likely pathway for HPAI introduction to NT shorebird populations is through infected migratory birds arriving from northern breeding grounds or stopover sites where HPAI is present. Shorebirds migrating along the East Asian-Australasian Flyway pass through or near regions in East Asia and Siberia where HPAI has been detected in wild bird populations. Infected birds that survive the migration could introduce the virus to Australian non-breeding sites.

Alternative introduction pathways may include:

- Spillover from domestic poultry: Introduction through contact with infected domestic birds, though less likely for shorebirds than for waterfowl.
- Fomite transmission: Introduction via contaminated equipment, vehicles, or materials.
- Other wild bird species: Introduction by non-shorebird species (e.g., raptors, gulls, terns) that then transmit to shorebirds.

Once introduced to a site like Darwin Harbour, HPAI transmission among shorebirds would be facilitated by:

- High-density roosting. With close contact at roosts facilitates respiratory and faecal-oral transmission.
- Shared foraging areas during low tide. Faecal contamination of foraging substrates may lead to environmental transmission.
- Limited roosting sites, forcing birds to concentrate at a small number of sites.

Transmission of HPAI among NT coastal sites could occur through:

- Local movements, shorebirds move among sites within the NT, with birds using Darwin Harbour also visiting other Top End coastal areas.
- Migratory movements, birds departing infected NT sites could carry HPAI to other Australian sites or back to northern breeding grounds.
- Scavenger and predator vectors, raptors, gulls, and other species that prey on or scavenge infected shorebirds could mechanically or biologically transmit the virus among sites.
- Darwin Harbour's proximity to Darwin city increases the risk of human-mediated introduction (e.g., through contaminated equipment or materials) and complicates biosecurity management. However, it also provides advantages for surveillance and rapid response.

Recommended Biosecurity Controls

Biosecurity preparedness for HPAI in the Darwin Harbor and Intercoastal locations should be designed to operate at a landscape scale that could remain adaptable to changing conditions, associated wildlife movements and a potential HPAI incursion.

NT HPAI Wildlife Actions Register

The Wildlife Actions Register accompanies this document and summarises the actions considered in HPAI preparedness planning for the NT. It outlines key management activities, their alignment with the National Management Agreement (NMA), cost-sharing eligibility, and the likely lead agency for implementation.

The register is a living document and will continue to be updated as Australia's HPAI situation evolves. It identifies which actions are eligible or ineligible for NMA cost sharing and notes any further work required to develop each activity.
Overall, these actions aim to:

- protect people by reducing contact with infected birds and contaminated environments
- prevent the virus spreading via footwear, clothing, or equipment
- minimise additional stress on wildlife populations

Activities that may be subject to restriction may include, but are not limited to:

- tourism
- access to public spaces e.g., beaches, lakes.
- bird banding
- population monitoring or management activities
- research and environmental studies (with or without interaction with wildlife)
- pest animal control activities
- wildlife translocations
- recreational hunting.

There may be regular activities undertaken at the site that are essential to the health and welfare of the wildlife population, such as monitoring or maintenance activities. Permits or restriction exemptions may be required for certain activities if deemed appropriate by government authorities.

All Activities

Table 2: Activities during all phases

#	Management Category	Management Activity	Relative Priority - e.g., high/medium/low	Expected conservation benefit (to support implementation in emergency settings)	Biodiversity Outcome if No Action is Taken	Biodiversity Outcome if Action is Implemented
1	Control measure	**Long-term Population Monitoring - Magpie goose**	High	Supports conservation management of an iconic species, informs sustainable cultural harvest, and provides baseline data for detecting HPAI-related population impacts.	Mass mortality events may remain undetected until severe population decline occurs, potentially leading to collapse of harvestable populations and loss of ecological function.	Early detection of population impacts enables targeted management interventions, adaptive harvest controls and maintenance of sustainable, resilient populations.
2	Control measure	**Long-term monitoring- Wildlife Populations**	Medium	Supports ecosystem health assessment, early detection of population declines, and evaluation of HPAI impacts and recovery outcomes.	Population declines and local extinctions may occur without detection	Early warning of disease impacts supports evidence-based recovery planning, prioritisation of interventions and improved conservation outcomes.

Preparedness Activities

Table 4: Preparedness - Including resilience building and management activities

#	Management Category	Management Activity	Relative Priority - e.g., high/medium/low	Expected conservation benefit (to support implementation in emergency settings)	Biodiversity Outcome if No Action is Taken	Biodiversity Outcome if Action is Implemented
3	Surveillance	**Risk-Based Wildlife Surveillance (early detection)**	High	Critical for early detection of HPAI incursions, enabling timely response activation, reduced disease spread, and coordinated community engagement in emergency procedures.	Delayed detection may allow uncontrolled spread of HPAI across wildlife populations and into poultry systems, increasing biodiversity loss and economic impacts.	Rapid detection supports early containment, targeted response measures and maintenance of market and tourism confidence through proof-of-freedom evidence.
4	Surveillance	**Develop culturally appropriate wildlife biosecurity protocols**	High	Strengthens culturally informed preparedness and response capacity, integrates traditional ecological knowledge, and supports effective collaborative management.	Reduced compliance, mistrust and delayed reporting in remote and culturally sensitive areas may hinder response effectiveness.	Strong community participation improves surveillance coverage, reporting rates, cultural legitimacy and on-ground biosecurity outcomes.

5	Control measure	**Develop Carcass Management / Disposal Guidelines**	High	May reduce environmental viral loading, minimises secondary transmission risk, and improves responder safety and operational consistency.	Infected carcasses may increase scavenger exposure, environmental contamination and ongoing viral persistence in wetlands and waterways.	Effective carcass management reduces environmental viral load, breaks transmission pathways and protects sensitive wetland ecosystems.
6	Risk Assessment	**Data, Mapping and Modelling**	Medium	Improves risk assessment, resource prioritisation, epidemiological modelling, and evidence-based decision-making during preparedness and response activities.	Responses may be poorly targeted, inefficient and unable to prioritise high-value biodiversity assets.	Data-driven decision-making enables precise targeting of surveillance and protection measures for threatened species and MNES sites.
7	Risk Assessment	**Identify HPAI activities relevant to Threatened Species/ MNES**	High	Supports protection of threatened species and MNES, reduces risk of local population decline or extirpation, and enables rapid implementation of targeted response measures.	Highly vulnerable species or genetically distinct populations may suffer irreversible decline or extinction before interventions are mobilised.	Early prioritisation enables rapid activation of targeted protections and improves survival prospects for vulnerable species
8	Risk Assessment	**Develop Integrated Wildlife Response Plan**	High	Improves preparedness, coordination and operational efficiency while reducing the likelihood of fragmented response actions and ineffective resource allocation.	Fragmented governance and unclear responsibilities may delay response actions and reduce effectiveness.	Coordinated multi-agency mobilisation enables rapid, consistent and effective wildlife response operations across jurisdictions.
9	Risk Assessment	**Establish Decision Triggers & Wildlife Biosecurity Controls**	High	Supports timely and evidence-based decision-making, reduces disease spread risk, and strengthens implementation of proportionate control measures.	Delayed or inconsistent decisions may increase transmission and ecological damage.	Objective and defensible trigger mechanisms support timely implementation of effective biosecurity and containment measures.
10	Communications	**Communications Strategy**	High	Reduces misinformation and public concern, improves stakeholder coordination, and supports effective implementation of response measures.	Public confusion, misinformation and poor compliance may increase wildlife disturbance, illegal access and disease spread.	Clear and coordinated communication improves public confidence, stakeholder cooperation and adherence to biosecurity measures.
11	Control measure	**Feral Pest Control/Culling - Pigs and Buffalo**	Medium	Improves habitat condition and native species resilience while reducing scavenger-mediated spread	Habitat degradation and scavenger-mediated spread may increase wildlife vulnerability to HPAI and reduce recovery capacity.	Improved habitat condition and reduced scavenger pressure strengthen ecosystem resilience and native species survival.
12	Control measure	**Weed Reduction Activities**	Low	Enhances habitat resilience and supports healthier wildlife populations	Habitat degradation may concentrate birds into small refugia, increasing transmission risk and ecological stress.	Improved habitat distribution supports dispersed populations, reducing disease transmission and enhancing resilience.

Response Activities

Table 5: HPAI Incident Response Activities. Where indicated activities may be eligible under NMA cost-sharing arrangements, noting approval is at the discretion of the National Management Group. Eligible costs are those that are above and beyond the resource costs of a party that exists for / or are required to carry out its Normal Biosecurity and normal conservation commitments. NMA- Schedule 3

#	Management Category	Management Activity	Relative Priority - e.g., high/medium/low	Expected conservation benefit (to support implementation in emergency settings)	Biodiversity Outcome if No Action is Taken	Biodiversity Outcome if Action is Implemented
13	Control measure	**Humane Euthanasia**	Medium	Primarily supports animal welfare outcomes while reducing unnecessary suffering and maintaining public confidence in response activities.	Infected wildlife may experience prolonged suffering and continue shedding virus into the environment.	Reduced animal suffering and lower viral shedding contribute to improved welfare and biosecurity outcomes.
14	Surveillance	**Establish Surveillance in Outbreak Areas**	High	Defines extent of infection, improves situational awareness, and reduces risk of undetected spread to wildlife, livestock and humans.	Disease spread beyond the initial outbreak zone may remain undetected, increasing risk to wildlife and poultry sectors.	Enhanced surveillance enables targeted containment and protection of uninfected populations and ecosystems.
15	Surveillance	**Establish Surveillance for Surrounding Outbreak Areas**	High	Improves early detection at surrounding high-risk sites and reduces broader ecological and agricultural impacts.	Secondary outbreaks in isolated or high-value ecological areas may remain undetected until severe impacts occur.	Early detection in surrounding areas supports rapid protective actions and reduces risk to sensitive ecosystems.
16	Control measure	**Strategic and Targeted Feral Animal Control (Buffalo/Pig)**	Medium	Reduces potential for scavenger-mediated disease spread and lowers risk of HPAI transmission into unaffected areas and spillover species.	Feral animals may amplify environmental contamination and contribute to ongoing disease spread.	Reduced scavenger activity lowers environmental viral loads and supports outbreak containment.
17	Control measure	**Consider immediate hunting suspension- Magpie Goose Harvesting**	High	Reduces human-mediated spread risk, limits disturbance to infected wildlife populations, and protects community and cultural values.	Human-assisted spread through contaminated equipment, vehicles and movement between sites may accelerate disease transmission.	Reduced movement-related transmission supports containment and enables earlier recovery of hunting activities.
18	Control measure	**Limit Non-essential Access**	High	Reduces disturbance-driven dispersal and minimises mechanical spread through fomites, vehicles and human movement.	Increased human disturbance may disperse infected birds and spread virus between colonies and wetlands.	Reduced disturbance and human-mediated spread help localise outbreaks and support wildlife recovery.

19	Environmental Management	**Implement Carcass Disposal**	High	Reduces environmental contamination and wildlife exposure risk while supporting effective outbreak containment.	Persistent carcasses may contaminate wetlands and maintain long-term environmental reservoirs of virus.	Removal and safe disposal reduce environmental contamination and improve conditions for ecosystem recovery.
20	Environmental Management	**Decontamination Procedures**	High	Maintains operational biosecurity and reduces risk of cross-site contamination and spillover transmission.	Personnel, vehicles and equipment may become vectors for disease spread between sites.	Strong biosecurity protocols maintain operational integrity and minimise human-assisted transmission.
21	Communications	**Distribute Communications Products**	High	Supports compliance with response measures, improves public understanding, and maintains stakeholder confidence.	Poor awareness and misunderstanding may result in non-compliance, unauthorised access and increased spread risk.	Consistent messaging improves compliance, supports containment measures and enhances public trust.

Post Incursion Activities

Table 6: Post-incursion activities to build population resilience and ensure population management is appropriate.

#	Management Category	Management Activity	Relative Priority - e.g., high/medium/low	Expected conservation benefit (to support implementation in emergency settings)	Biodiversity Outcome if No Action is Taken	Biodiversity Outcome if Action is Implemented
22	Environmental Management	**Weed Reduction/ Land Management**	Medium	Restores habitat quality, supports ecosystem resilience, and reduces conditions that may facilitate disease spread.	Degraded habitats may limit recovery of surviving populations and reduce long-term ecosystem resilience.	Restored habitats improve ecosystem functionality and support recolonisation and population recovery.
23	Environmental Management	**Feral Pig and Buffalo control**	High	Supports wildlife recovery, improves habitat resilience, and maximises post-outbreak survivor recruitment and population stability.	Feral pests may suppress recovery of vulnerable native species through predation, habitat destruction and disturbance.	Reduced pest pressure supports rapid recovery and stabilisation of native wildlife populations following HPAI impacts.

Disease Surveillance

Active Surveillance

- Targeted sampling: Regular collection of faecal samples or swabs from live-captured shorebirds at key sites.
- Environmental sampling: Collection of environmental samples (water, sediment, faeces) from roosting and foraging sites for viral detection.
- Sentinel species monitoring: Focused surveillance of species known to be highly susceptible to HPAI (e.g., waterfowl, gulls) that may serve as early indicators of virus presence.

Passive Surveillance

- Mortality monitoring: Systematic reporting and investigation of shorebird mortality events. Training of rangers, birdwatchers, and the public to recognise and report unusual mortality.
- Behavioural monitoring: Observation for signs of illness in shorebird populations, including lethargy, neurological signs, or unusual behaviour.
- Carcass collection and testing: Rapid collection and testing of dead birds found at shorebird sites. Establishment of protocols for safe carcass handling and transport.

Surveillance Priorities

- High-priority sites: Listed below- for instance, Darwin Harbour, Daly River breeding colonies, and other sites supporting large shorebird concentrations or threatened species.
- High-priority species: Far Eastern Curlew, Great Knot, and other critically endangered or highly susceptible species.
- High-risk periods: Peak migration periods (September-November, March-May) when birds are arriving from or departing to regions where HPAI may be present.
- Trigger events: Increased surveillance following HPAI detections in nearby regions or along the flyway.

Population Monitoring

Regionally, baseline data on shorebird distribution and abundance are informed by limited studies such as Chatto (2001, 2003)**,** which surveyed shorebirds along the NT coastline and offshore islands. The surveys provided essential information on species' habitat use and baseline population trends. More recent monitoring initiatives in areas such as Darwin Harbour have highlighted the importance of maintaining intertidal mudflats, mangroves, and roosting sites for avian MNES.

Standardised ground counts at high tide roosts provide detailed species composition and abundance data. These counts are conducted by trained observers, following protocols developed by the Australasian Wader Studies Group. Aerial surveys cover large areas efficiently and can access remote sites difficult to reach on the ground.

Shorebird catching expeditions in Darwin have marked numerous individuals, contributing to flyway-wide understanding of population dynamics. Resighting of marked birds by observers across the flyway provides data on migration routes, stopover site use, and survival rates.

BirdLife Australia's Birdata platform enables citizen scientists to contribute shorebird observations, expanding the spatial and temporal coverage of monitoring. While citizen science data require quality control, they provide valuable supplementary information to professional surveys.

BirdLife Australia runs the Australian Shorebird Monitoring Project, which aggregates survey data from across Australia - supporting counts at ~520 key shorebird sites. This monitoring supports long-term trend analyses, including national-scale population change assessments for many species.

The Australian National Directory of Important Migratory Shorebird Habitat (2025) was published, under which updated population estimates for the 37 migratory shorebird species recognised under national legislation have been highlighted. For many species, these new estimates form the basis for identifying key sites (wetlands, intertidal flats) for conservation and for fulfilling national/international obligations (e.g., under the Environment Protection and Biodiversity Conservation Act 1999 and agreements like the Ramsar Convention) and continue to be a focus for HPAI mitigation activities.

Seasonal aggregation periods correspond with predictable high-density use, which can inform timing of targeted surveillance and monitoring activities and aligning sampling with peaks in shorebird abundance.

Limitations in Population Monitoring

While many seabird colonies and shorebird/wader aggregations are well documented, species presence and abundance vary seasonally, and between sites. Much of the freely available, existing data are often aggregated so "*common in NT coastal environment*" does not imply species are common at every site. Remote and small sites may have limited survey data and thus absence of record doesn't always mean absence of birds, but potentially a lack of observation.

HPAI population monitoring and disease surveillance at key sites is critical as they represent high risk locations with migratory bird staging sites, colonial breeding sites and critical biodiversity refuges.

Restricted Access / Site Closure

In the event of HPAI detection on NT intercoastal areas, temporary access restrictions may be an appropriate measure to reduce indirect disease spread and minimise additional stress on affected birds. While rapid virus spread is likely via natural movements of highly mobile species such as shorebirds, limiting human access to key habitats can reduce the risk of human-mediated transmission through contaminated footwear, vessels, vehicles or equipment. Additionally, disturbance alters spatial use, increasing contact rates among birds, therefore reduced disturbance also lowers the likelihood of disease transmission risk.

Access restrictions would operate as a supporting risk-management measure rather than a standalone response. Consistent with AUSVETPLAN, restricted areas, enhanced surveillance and biosecurity measures are appropriate where HPAI poses a risk to wildlife, while avoiding ecologically damaging interventions such as culling.

In the NT costal context, temporary closures would support targeted surveillance and if necessary, carcass management or feral pest eradication, recognising that outbreak outcomes depend on integrated surveillance, biosecurity and adaptive management rather than access controls alone.

Feral Pest Species Culling

Under AUSVETPLAN, routine culling or population reduction of wild animals (including feral species) is not recommended as a primary HPAI emergency response measure to eradicate disease in wild birds, as there is little evidence it effectively reduces virus transmission and it may increase disease spread by causing animals to disperse, mix more widely, or experience stress. However, AUSVETPLAN does recommend targeted feral pest control as a supporting, risk-based action where there is a clear and defensible link to biosecurity or outbreak management objectives, rather than disease eradication in wild birds. For example, controlling feral scavengers may be considered where they are spreading contaminated material (e.g., moving carcasses between sites), interfering with surveillance or carcass management, or increasing the risk of transmission to domestic species such as poultry, or sensitive wildlife areas.

Any such action must be considered site-specific, proportionate, coordinated with surveillance and access restrictions, and designed to minimise disturbance to infected or susceptible bird populations. In practice, AUSVETPLAN places much greater emphasis on restricted access, biosecurity, surveillance, and carcass management, with feral animal control used only where it clearly supports those measures and does not exacerbate disease spread or ecological harm.

Carcass Management

Due to the remote and vast landscape in the NT, in most situations, it is considered appropriate to leave wild bird carcases in situ, carcass removal may be justified in some situations e.g., public places, in close proximity to poultry operations and densely populated public spaces to reduce potential disease transmission and improve social amenity. Carcass management will typically be carried out by specially trained personnel, however, a public guidance document is available via the DADLPE website, should this be necessary. The use of appropriate PPE is essential to ensure carcasses are removed safely.

Key Sites/ Locations at Risk

The Northern Territory coastline extends over 10,000 km (129-138° E, 11-16.5° S), encompassing the Timor Sea, Arafura Sea, and Gulf of Carpentaria. It is characterised by mangrove-fringed intertidal mudflats, estuaries, and seasonally inundated floodplains, where wet-dry cycles concentrate large assemblages of waterbirds and shorebirds (Chatto, 2005, East, Hamilton and Garner, 2008). The northern beaches of Darwin (e.g., Sandy Creek and Lee Point-Buffalo Creek) meet criteria for *nationally and internationally important migratory shorebird habitat* under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

In Darwin Harbour, the intertidal zone is the primary habitat for migratory shorebirds during the non-breeding season. Birds forage across extensive mudflats at low tide and roost in adjacent mangrove, saltmarsh, and supratidal habitats at high tide. These dynamics have direct implications for HPAI, and intertidal habitats therefore represent potential interfaces for viral introduction, particularly during the austral summer when migratory birds aggregate at high densities. Cyclical patterns of dispersal (at low tide) and aggregation (at high tide) may further influence transmission, with feeding areas facilitating environmental exposure and roost sites increasing contact rates.

The following sites represent important interfaces for species requiring integrated surveillance and population monitoring of biodiversity, movement, and mitigation of disease risk. Some of the sites are highly remote, whilst some are in closer proximity to urban and peri-urban areas and are delineated by natural boundaries. The locations are figure 2:

- Darwin Harbor
- Inter-tidal Regions:
    - Anson and Fog Bay (West Coast)
    - South Van Diemen Gulf (Central Coast)
    - Boucaut, Castlereagh, & Buckingham Bay (North Coast)
    - Roper to Limmen Bight (East Coast)
    - Limmen Bight River to McArthur River Estuary (South-East Coast)
    - Port McArthur (South-East Coast).

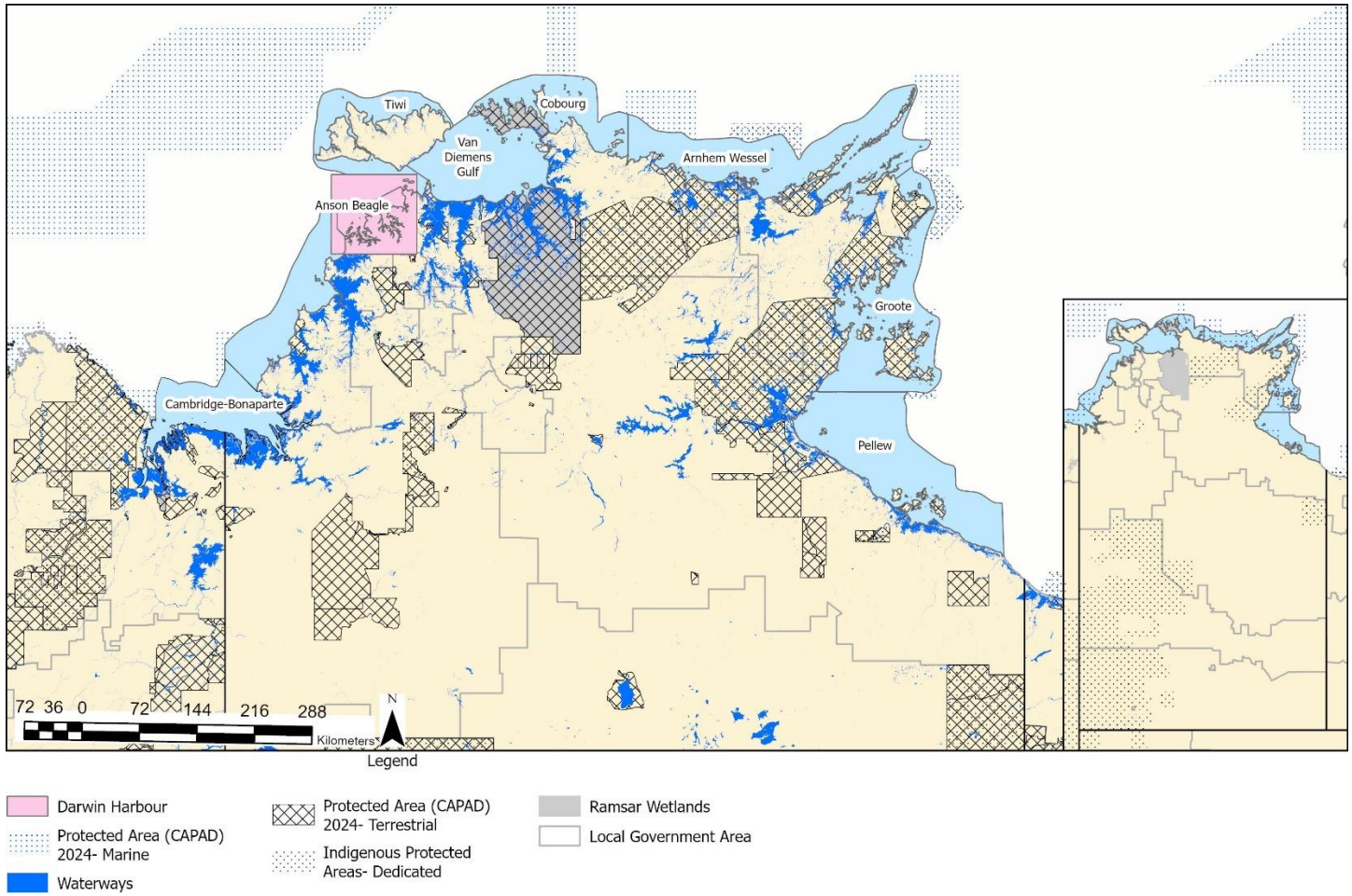


Figure 1: Key sites/ geographic locations in the NT relevant to this report is Darwin Harbor (shaded pink), the remaining blue areas remain important for shorebirds- represented by Integrated Marine and Coastal Regionalisation of Australia (IMCRA) Bioregions. CAPAD, Indigenous Protected Areas, Hatched areas constitute separate management areas/ units and are not considered in this report.

Shorebirds Profile

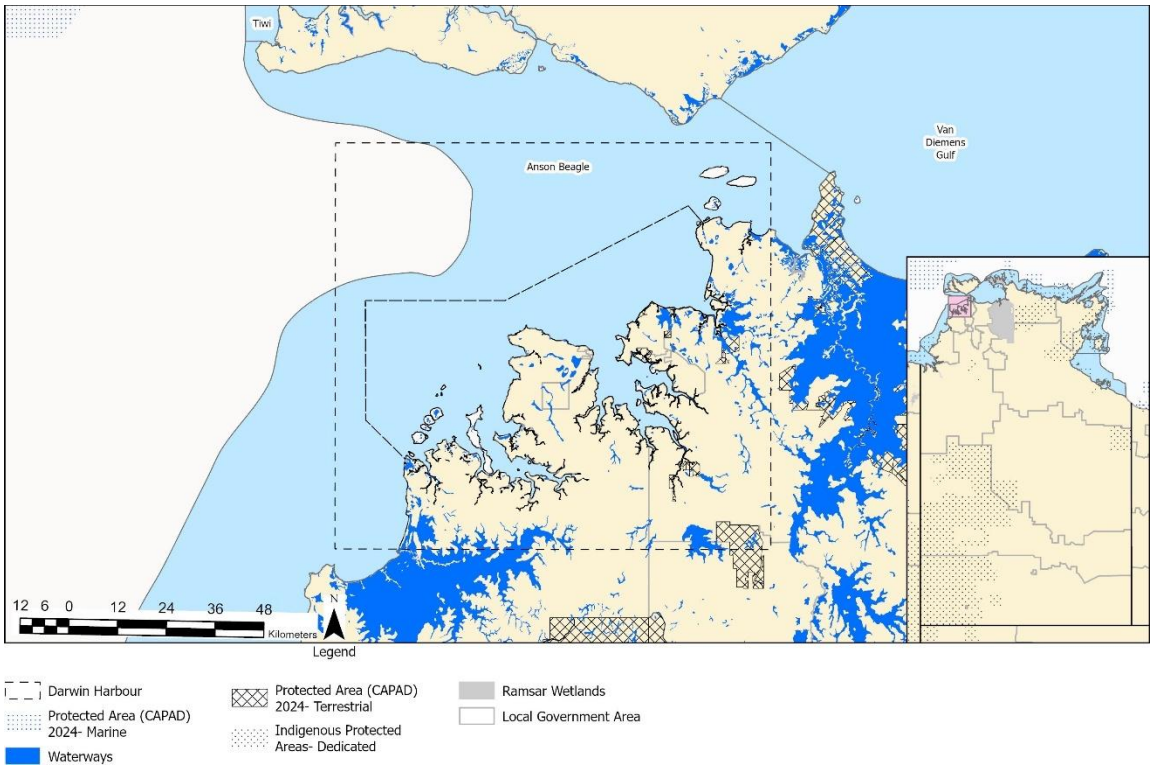
The following detail can assist in forming the information required in the scenario of a potential NMA Response Plan. Additionally, the catchment profile information can help define the 'vicinity' as per the AUSVETPLAN Avian influenza Response strategy template.

This information requires updating on a case-by-case basis. There is significant variation in the distribution, density, and habitats of wildlife between and within island of the Northern Territory, which may change by season and scale.

Limited access to the Top End - especially during the wet season- restricts data detail. As such, the information provides regional context rather than precise site-level estimates.

Darwin Harbour

Map



Location	Darwin Harbour
Site Overview	
Coordinates (approx.):	~12°20′ to 12°35′ S, 130°45′ to 131°00′ E
Catchment Area	~3,200 km² (Darwin Harbour catchment including the Elizabeth, Blackmore, and Howard River systems)
Proximity to urban areas	Adjacent to the city of Darwin, includes urban, industrial, port, and peri-urban environments with direct road access and marine infrastructure
Ecological and Land Context	
Tenure and Access Description	Mixed tenure including Northern Territory Government land, Commonwealth land, Aboriginal land trusts, conservation reserves, and freehold/leasehold land. Key areas include Darwin Harbour, Charles Darwin National Park, and adjacent

	coastal reserves. The harbour supports major infrastructure including the Port of Darwin, marinas, boat ramps, industrial facilities, and urban developments.
Ecosystem Description	Darwin Harbour is a large, shallow, macro-tidal tropical estuary characterised by: • Extensive intertidal mudflats (~38 km² exposed at low tide) • Mangrove forests (one of the largest contiguous mangrove systems in northern Australia) • Tidal creeks, estuarine channels, and saltmarshes • Seagrass beds and nearshore marine habitats The system is strongly influenced by monsoonal rainfall and large tidal ranges (>6-8 m), resulting in dynamic wet-dry season hydrology.
Fauna and Ecological Significance	Darwin Harbour is recognised as a site of national and international importance for migratory shorebirds, supporting species listed under international agreements (e.g., JAMBA, CAMBA, ROKAMBA) and the EPBC Act (DCCEEW). Regularly supports >20 migratory shorebird species during the non-breeding season. Key habitat for species such as red-necked stint, great knot, bar-tailed godwit, and far eastern curlew. Provides critical foraging habitat (intertidal mudflats) and roosting habitat (supratidal areas, mangroves, saltmarsh) The harbour also supports seabird breeding and roosting colonies, marine fauna including dugongs, dolphins, and marine turtles, estuarine species including fish, crustaceans, and estuarine crocodiles. The ecological function is driven by strong connectivity between intertidal, estuarine, and terrestrial systems
Wildlife Density & Diversity	High - particularly during the austral summer when migratory shorebirds aggregate at high densities in intertidal and roosting habitats
Existing Ecological Threats	• Coastal and urban development • Port and industrial activities • Habitat modification and disturbance • Invasive species (e.g., weeds, feral animals in catchment areas) • Water quality impacts from catchment runoff.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Presence of urban environments, poultry (domestic/backyard), and interface between wild birds and human-modified landscapes.
Cultural and Social Context	
Cultural and Social features	Darwin Harbour lies within the traditional lands of the Larrakia people, who maintain cultural connections to sea country, coastal resources, and cultural sites. The harbour is a focal point for urban population (~150,000 in Darwin region), supporting recreation, fishing, tourism, and cultural activities.
Key Stakeholders	• Larrakia Traditional Owners • Larrakia Rangers (Sea Country Rangers program) • Northern Territory Government agencies • Australian Government (DCCEEW, biosecurity agencies) • Port of Darwin and industry stakeholders • Research institutions (e.g., Charles Darwin University) • Environmental NGOs (e.g., BirdLife Australia) • Local Government Authority
Local Government Authority	City of Darwin, Litchfield Council (catchment areas)
Conservation Management organisations	Northern Territory Government, Australian Government (DCCEEW), Parks and Wildlife Commission of the NT and Larrakia Rangers.
Land Use and Human Activity	
Key Land Use Types	Urban, industrial (port), conservation, recreation, fisheries

Human Use and Activity frequency	Includes shipping, fishing, recreation, tourism, research, and urban activities, continuous access via road and marine infrastructure
Risk and Management	
Site biosecurity implications	High potential interface between migratory birds and human activity Key entry point for marine and biological vectors. Potential measures include: • Surveillance of migratory shorebirds • Monitoring mortality events • Hygiene protocols for vessels and equipment • Public awareness and reporting systems • Coordination with national HPAI response frameworks
Management Implications	Existing frameworks (e.g., Darwin Harbour Strategy, NT Government management plans) provide a basis for integrating disease surveillance with environmental management. Balancing development pressures with conservation and biosecurity is critical.
Surveillance and Monitoring	Current and recommended activities include: • Long-term shorebird monitoring • Water quality and ecosystem health monitoring • Surveillance for avian influenza and other diseases in wild birds • Monitoring of key habitats • Collaboration between government agencies, researchers, and local stakeholders

Inter-tidal Regions

West Coast- Anson and Fog Bay

Location	Anson and Fog Bays
Site Overview	
Coordinates (approx.):	13.35° S, 130.25° E
Catchment Area	~53,000 km^2 (Daly River Catchment).
Proximity to urban areas	~100km Southwest of Darwin. Closest service centre is Dundee Beach.
Ecological and Land Context	
Tenure and Access Description	Mix of Crown Land, Pastoral Lease, and Aboriginal Freehold. Limited to boat/4WD access. Seasonal restrictions during the wet season.
Ecosystem Description	Dynamic coastal system influenced by the massive sediment discharge of the Daly and Finniss Rivers. Habitat includes mangrove forests, chenier plains, intertidal mudflats, active river mouths, coastal beach ridges, and the Peron Islands.
Fauna and Ecological Significance	Internationally significant shorebird habitat, including aggregation point for Great Knots. Supports migratory shorebirds, estuarine fauna, and coastal wetland biodiversity.
Wildlife Density & Diversity	High biodiversity and seasonal abundance of migratory shorebirds and marine fauna. Functions as an important arrival and feeding site for migratory species along the East Asian- Australasian Flyway.
Existing Ecological Threats	Coastal erosion, rapid shoreline change, storm surge impacts, riverine flooding, sea-level rise, feral animals, and disturbance to beaches.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Low domestic animal density. Some risk associated with coastal settlements, recreational camping and feral pigs.
Cultural and Social Context	
Cultural and Social features	Significant for Rak Pekli and Malak Malak peoples. Region has strong cultural values, customary use, and high recreational fishing importance.
Key Stakeholders	NT Government, Daly River Management Advisory Committee, Traditional Owners and ranger groups.
Local Government Authority	Victoria Daly Regional Council.
Conservation Management organisations	Thamarrurr Rangers, Northern Territory Parks and Wildlife.
Land Use and Human Activity	
Key Land Use Types	Conservation management, recreational fishing, tourism, camping, pastoralism and Indigenous land management.
Human Use and Activity frequency	Seasonal, with peak visitation during the dry season for fishing, camping, and boating activities
Risk and Management	
Site biosecurity implications	Biosecurity risk associated with feral species movement through the Daly River system and vessel-based introduction pathways.
Management Implications	Focus surveillance on nesting beaches and mitigating disturbance and feral species to safeguard migratory shorebird habitat.
Surveillance and Monitoring	Periodic aerial shorebird counts: focus on turtle nesting monitoring and Ranger based patrols.

Central Coast- South Van Diemen Gulf

Location	Southern Shore of Van Diemen Gulf (East of Darwin)
Site Overview	
Coordinates (approx.):	12.25° S, 131.75° E
Catchment Area	~22,000 km^{2,} incorporating Adelaide and Mary River catchments.
Proximity to urban areas	Approx. 60-80km East of Darwin metropolitan area, with primary access via the Arnhem Highway
Ecological and Land Context	
Tenure and Access Description	Mixed tenure including national parks, pastoral leases, and Aboriginal land. Access is generally good via sealed and unsealed roads connected to the Arnhem Highway corridor.
Ecosystem Description	Tropical coastal floodplain and estuarine system influenced by the Adelaide and Mary Rivers. The habitat includes tidal saltpans, black-soil freshwater floodplains, paperbark wetlands, intertidal mudflats, and dense mangrove forests.
Fauna and Ecological Significance	Internationally important habitat for migratory shorebirds, particularly large aggregations of Little Curlew and Black-tailed Godwit. Supports diverse wetland fauna including waterbirds, estuarine crocodiles, and fish species associated with tropical floodplains.
Wildlife Density & Diversity	Extremely high seasonal abundance and diversity. Bird populations shift between inland freshwater floodplains and coastal mudflats in response to seasonal inundation patterns.
Existing Ecological Threats	Spread of the invasive weed *Mimosa pigra*, feral buffalo and pigs, altered hydrology, and climate-driven sea-level rise.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Risk associated with nearby cattle stations, feral pig populations, and waterbird congregation areas.
Cultural and Social Context	
Cultural and Social features	Traditional lands of the Limilngan-Wulna and Kungarakan peoples. Region has strong cultural significance and is internationally recognised for recreational barramundi fishing and wetland tourism.
Key Stakeholders	Northern Territory Parks and Wildlife, Mary River Catchment Advisory Committee, Pastoralists.
Local Government Authority	Litchfield Council and West Arnhem Regional Council.
Conservation Management organisations	BirdLife Australia, Lower Mary River Landcare, Northern Territory Parks and Wildlife.
Land Use and Human Activity	
Key Land Use Types	Conservation management, cattle grazing, recreational fishing, ecotourism, birdwatching, and Indigenous land management activities.
Human Use and Activity frequency	Seasonal visitation, especially during the dry season when fishing, boating, wildlife tourism, and birdwatching activity peaks.
Risk and Management	
Site biosecurity implications	Biosecurity risk due to strong connectivity with Darwin, regular visitor movement, extensive wetland habitat connectivity, and feral animal dispersal pathways
Management Implications	Management of invasive weeds and feral animals, protection of freshwater wetland integrity, monitoring saltwater intrusion, and maintaining habitat for migratory shorebirds.
Surveillance and Monitoring	Ideal location for monitoring/ surveillance programs supported by relatively easy access from Darwin.

North Coast- Boucaut, Castlereagh, & Buckingham Bays

Location	Costal Corridor extending from Boucaut Bay to Buckingham Bay
Site Overview	
Coordinates (approx.):	12.10° S, 135.50° E
Catchment Area	~12,000 km^2 incorporating the catchments of the Goyder River, Blyth River, and Buckingham River systems
Proximity to urban areas	150km+ from Nhulunbuy. The coastline remains largely undisturbed and forms part of a wetland system of international importance along the East Asian-Australasian Flyway (EAAF).
Ecological and Land Context	
Tenure and Access Description	Aboriginal Freehold Land (Arnhem Land Trust). Permit-only access through Traditional Owner governance arrangements.
Ecosystem Description	Vast tropical coastal wetland system characterised by extensive intertidal mudflats, saline wetlands, tidal creeks, and dense mangrove forests. The region contains some of the most intact coastal shorebird habitat in northern Australia.
Fauna and Ecological Significance	Internationally significant shorebird habitat supporting aggregations exceeding 30,000 waterbirds during peak migration periods. Critical habitat for Far Eastern Curlew and Great Knot, along with numerous migratory wader species protected under international agreements.
Wildlife Density & Diversity	Among the highest recorded shorebird densities globally, with exceptional seasonal concentrations of migratory waders, estuarine fauna, and coastal wetland biodiversity.
Existing Ecological Threats	Feral buffalo and pigs causing wetland disturbance, climate change impacts including sea-level rise and habitat inundation, and potential long-term changes to coastal sediment dynamics.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Some domestic animal presence, generally confined to remote homelands and outstations. Minimal agricultural influence
Cultural and Social Context	
Cultural and Social features	Sea Country for Yolngu people. Traditional ecological knowledge plays a central role in land and sea management.
Key Stakeholders	Northern Land Council (NLC), Traditional Owners and Marthakal Rangers.
Local Government Authority	East Arnhem Regional Council.
Conservation Management organisations	Gumurr Marthakal Rangers, BirdLife Australia, Arnhem Land Aboriginal Land Trust.
Land Use and Human Activity	
Key Land Use Types	Traditional land and sea management, customary harvesting, biodiversity conservation, cultural activities, and research access.
Human Use and Activity frequency	Human presence is primarily associated with Traditional Owners, ranger programs, and approved research operations.
Risk and Management	
Site biosecurity implications	Primary biosecurity pathway is migratory bird movement through the East Asian–Australasian Flyway.
Management Implications	Indigenous-led management; feral animal exclusion from sensitive mudflats.
Surveillance and Monitoring	Remote sensing and ranger-led activities.

East Coast- Roper to Limmen Bight

Location	Roper River to Limmen Bight
Site Overview	
Coordinates (approx.):	14.75° S, 135.40° E
Catchment Area	~81,000 km^2 , dominated by the Roper River Catchment system
Proximity to urban areas	360km East of Katherine.
Ecological and Land Context	
Tenure and Access Description	National Park (Limmen), Marine Park, and Aboriginal Freehold. Key protected areas include Limmen National Park and adjoining coastal marine environments.
Ecosystem Description	Diverse tropical coastal landscape comprising extensive tidal wetlands, saline floodplains, estuaries, mudflats, mangrove forests, and offshore seagrass meadows. Seasonal wetlands dry rapidly during the dry season, creating dynamic habitat conditions.
Fauna and Ecological Significance	High productivity driven by river outflow. Internationally significant for Godwits and Knots. Corridor for birds moving between the Gulf of Carpentaria and the northern coast. It is vital for Bar-tailed Godwits and Great Knots. Coastal ecosystem driven by nutrient-rich river outflows from the Roper catchment. Internationally significant habitat for migratory shorebirds including Bar-tailed Godwit and Great Knot. Functions as an important movement corridor between the Gulf of Carpentaria and northern Australian coastlines.
Wildlife Density & Diversity	High seasonal abundance and diversity, including large mixed-species breeding and feeding aggregations. Waterbird concentrations exceeding 10,000 individuals have been recorded near the Roper River mouth.
Existing Ecological Threats	Overgrazing and wetland degradation caused by feral livestock, altered hydrological regimes, marine debris accumulation, invasive weeds, and climate-related coastal change.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Interaction between wildlife and cattle or feral livestock in riparian and floodplain environments associated with river systems.
Cultural and Social Context	
Cultural and Social features	Marra and Yanyuwa Country; iconic "lost city" rock formations nearby.
Key Stakeholders	Northern Territory Parks and Wildlife, Mabunji Aboriginal Resource Association, Li-Anthawirriyarra Rangers.
Local Government Authority	Roper Gulf Regional Council.
Conservation Management organisations	Limmen Bight Marine Park authorities, Northern Land Council.
Land Use and Human Activity	
Key Land Use Types	National Park management, biodiversity conservation, Indigenous land and sea management, offshore commercial fishing, tourism, and limited pastoral activity.
Human Use and Activity frequency	Seasonal activity associated with tourism, recreational fishing, park visitation, ranger operations, and offshore fisheries during the dry season.
Risk and Management	
Site biosecurity implications	Risk associated with river catchment connectivity, focus on preventing the spread of weeds and feral animals via river catchments.
Management Implications	Integration of existing protocols
Surveillance and Monitoring	Marine-park monitoring, Ranger land management programs.

Limmen Bight River to Macarthur River Estuary

Location	Central Limmen Bight Coastline (Limmen River to McArthur River)- Bing Bong and Rosie River Corridor.
Site Overview	
Coordinates (approx.):	15.35° S, 136.15° E
Catchment Area	~15,000 km^2, dominated by the Rosie River and coastal creek systems.
Proximity to urban areas	Remote and sparsely populated coastal region associated with the Bing Bong export facility and the community of Borroloola, located approximately 60 km inland.
Ecological and Land Context	
Tenure and Access Description	Aboriginal Freehold Land and Pastoral Lease (Lorella Springs/McArthur River Station). Access is highly restricted outside established station tracks and industrial corridors.
Ecosystem Description	Low-relief tropical coastline characterised by extensive tidal flats, shallow subtidal shelves, estuarine wetlands, and highly productive seagrass meadows. The Rosie River estuary and surrounding coastal habitats support interconnected marine and shorebird ecosystems.
Fauna and Ecological Significance	Important migratory shorebird corridor linking coastal habitats across the Gulf of Carpentaria. Extensive seagrass habitats support marine fauna, while mudflats and estuarine wetlands provide habitat for species such as Great Knot and migratory sandpipers.
Wildlife Density & Diversity	Extreme density of marine megafauna; moderate but consistent shorebird presence (Great Knots, Sandpipers).
Existing Ecological Threats	Feral pigs causing predation on nests and wetland disturbance, potential vessel strike risks associated with industrial shipping, marine pollution, sediment disturbance, and risks associated with heavy metal transport from mining operations.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Interaction between wildlife, feral pigs, feral cattle, and waterbirds within river deltas and coastal wetland systems.
Cultural and Social Context	
Cultural and Social features	Part of the Yanyuwa "Sea Country" and Marra cultural landscapes. Coastal and marine resources remain significant for customary harvesting, cultural practice, and Indigenous stewardship.
Key Stakeholders	Li-Anthawirriyarra Sea Rangers, Marra Traditional Owners and Glencore/ McArthur River Mining (Bing Bong Port).
Local Government Authority	Roper Gulf Regional Council.
Conservation Management organisations	Limmen Bight Marine Park authorities and Indigenous Ranger groups.
Land Use and Human Activity	
Key Land Use Types	Mining logistics (mineral transport), Traditional harvesting and Conservation.
Human Use and Activity frequency	Human activity is concentrated around industrial shipping infrastructure and traditional subsistence fishing practices, with otherwise low population density across the coastline.
Risk and Management	
Site biosecurity implications	The Bing Bong export facility represents a significant potential pathway for ship-borne invasive marine species, pathogens, and marine pest introduction into sensitive coastal ecosystems.
Management Implications	Strong integration between industrial port management, marine biosecurity, Indigenous-led conservation, and protection of seagrass and shorebird habitat from shipping and feral animal impacts.
Surveillance and Monitoring	Specialised aerial fauna surveys, marine habitat monitoring, ranger-led coastal patrols, port-based environmental compliance programs, and monitoring of shipping-related environmental risks.

Location	Port McArthur (McArthur River Estuary & Sir Edward Pellew Group)
Site Overview	
Coordinates (approx.):	15.75° S, 136.85° E
Catchment Area	~20,000 km^2 – associated with the McArthur River Catchment.
Proximity to urban areas	Highly isolated coastal region located approximately 100 km from Borroloola, the nearest regional service centre. Access is influenced by industrial operations associated with Port McArthur.
Ecological and Land Context	
Tenure and Access Description	Mixed tenure including Aboriginal Freehold land, pastoral leasehold areas, and commercially managed port infrastructure. Access to some areas is controlled through industrial port operations and Traditional Owner permissions.
Ecosystem Description	Large estuarine delta system protected by the Sir Edward Pellew island chain. Habitats include mangrove-lined tidal channels, extensive intertidal mudflats, offshore sandbars, seagrass meadows, and sandy cay systems supporting coastal and marine biodiversity.
Fauna and Ecological Significance	Internationally important habitat for migratory shorebirds and seabirds. Globally significant nesting habitat for Little Tern and critical staging habitat for Great Knot along the East Asian-Australasian Flyway. The Sir Edward Pellew islands provide essential resting and feeding habitat for migratory waders crossing the Gulf of Carpentaria.
Wildlife Density & Diversity	High concentrations of migratory shorebirds, marine fauna, turtles, dugongs, and estuarine species. The island and sand cay systems create a ecological bottleneck where migratory birds congregate prior to long-distance flights across the Gulf.
Existing Ecological Threats	Risks associated with mining export operations (including lead and zinc loading), marine debris, vessel disturbance, feral pigs on islands, contamination risks to marine food webs, and island biosecurity threats from invasive species introduction.
Reservoir Hosts (e.g., Nearby Domestic Bird Presence)	Interaction between wildlife, feral cattle, feral pigs, and domestic bird populations associated with nearby settlements and pastoral areas around Borroloola.
Cultural and Social Context	
Cultural and Social features	Traditional Country of the Yanyuwa, Garrwa, and Gurdanji peoples. The region has strong cultural and spiritual significance connected to Sea Country, customary harvesting, and intergenerational stewardship of marine resources.
Key Stakeholders	McArthur River Mine, Northern Land Council, Traditional Owners, Port Authorities.
Local Government Authority	Roper Gulf Regional Council.
Conservation Management organisations	Li-Anthawirriyarra Sea Rangers.
Land Use and Human Activity	
Key Land Use Types	Mining logistics/shipping, Traditional harvesting, Commercial/Recreational fishing.
Human Use and Activity frequency	Commercial shipping traffic, seasonal recreational fishing.
Risk and Management	
Site biosecurity implications	High biosecurity risk associated with industrial shipping pathways, ballast water transfer, mechanical transport of invasive species, and potential contamination events affecting highly sensitive coastal ecosystems.
Management Implications	Integration of industrial environmental management with Indigenous-led conservation, strengthened marine biosecurity protocols, island pest exclusion, monitoring of contaminant pathways, and protection of migratory shorebird habitat.
Surveillance and Monitoring	Ranger-led coastal and island monitoring, industrial environmental compliance programs, marine biosecurity surveillance, shorebird surveys, and long-term ecological monitoring associated with port and mining operations.

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