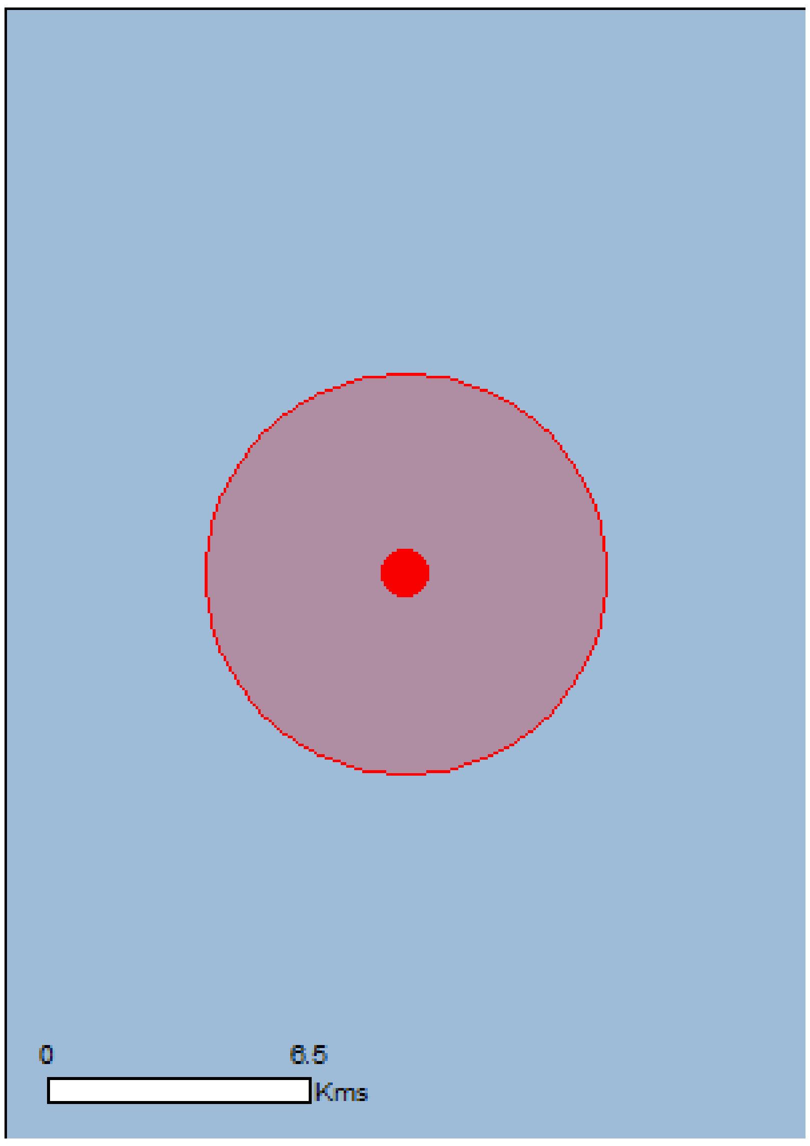
EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

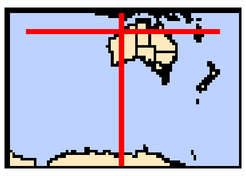
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 06/06/19 13:24:47



Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	29
Listed Migratory Species:	65

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	104
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	1
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The West Kimberley	WA	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Roebuck bay	Within 10km of Ramsar

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
Rostratula australis		
Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Tyto novaehollandiae kimberli		
Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Macrotis lagotis		
Greater Bilby [282]	Vulnerable	Species or species habitat likely to occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Saccolaimus saccolaimus nudicluniatus		
Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Keraudrenia exastia		
Fringed Keraudrenia [66301]	Critically Endangered	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis		
Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus angusticeps		
Northwestern Coastal Ctenotus, Airlie Island Ctenotus [25937]	Vulnerable	Species or species habitat likely to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata		
Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area

Name	Status	Type of Presence
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Sternula albifrons Little Tern [82849]		Foraging, feeding or related behaviour known to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area

Name	Threatened	Type of Presence
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area

Name	Threatened	Type of Presence
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Defence - BROOME TRAINING DEPOT

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area

Name	Threatened	Type of Presence
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area

Name	Threatened	Type of Presence
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna albifrons Little Tern [813]		Foraging, feeding or related behaviour known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area

Name	Threatened	Type of Presence
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within

Name	Threatened	Type of Presence
		area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Foraging, feeding or related behaviour known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence

Name	Status	Type of Presence
Mammals		
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		

Name	Status	Type of Presence
Rhinella marina Cane Toad [83218]		Species or species habitat may occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Dolichandra unguis-cati Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Jatropha gossypifolia Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Nationally Important Wetlands

[Resource Information]

Name	State
Roebuck Bay	WA

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-18.00598 122.21031

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix A Likelihood of Occurrence Assessment

An assessment was undertaken of the likelihood of occurrence for key ecological species identified through desktop review. Desktop assessments were undertaken using the Species Profile and Threats Database (SPRAT) – Department of the Environment and Energy, and NatureMap Search from the Department of Biodiversity, Conservation and Attractions, along with additional scientific literature. These searches were specific to within 5 km from the identified project site. The below criteria were applied to determine the likelihood of occurrence for threatened species:

Low potential to occur – the species has not been recorded in the region (no records from desktop searches) and/or current known distribution does not encompass project area and/or suitable habitat is generally lacking from the project area.

Moderate potential to occur – the species has been recorded in the region (desktop searches) however suitable habitat is generally lacking from the project area or species has not been recorded in the region (no records from desktop searches) however potentially suitable habitat occurs at the project area.

High potential to occur – the species has been recorded in the region (desktop searches) and suitable habitat is present at the project area.

Known to occur – the species has been recorded on-site in the recent past (i.e. last 5-10 years) and the site provides suitable habitat for it.

Codes used in the following likelihood of occurrence tables:

EPBC Act (species listed under the Commonwealth *Environment Protection and Biodiversity* Conservation Act 1999): Ex = Extinct, CE = Critically Endangered, E = Endangered, V = Vulnerable, M = Migratory, MM = Migratory Marine, MT = Migratory Terrestrial, MW = Migratory Wetlands, Ma = Listed Marine

WC Act (species listed under the Western Australian Wildlife Conservation Act 1950):

- Threatened Species: EX = Presumed Extinct, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, IA = Migratory birds protected under an International Agreement, CD = Conservation Dependent, OS = Other Specially Protected
- Priority Species: P1 = Priority 1, P2 = Priority 2, P3 = Priority 3, P4 = Priority 4

IUCN (species listed under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species): EX = Extinct, EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern.

Marine Mammals

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Balaenoptera musculus Blue Whale	E, C	EN	EN	Blue whales have a cosmopolitan distribution found in all oceans except the Arctic, but absent from some regional seas such as the Mediterranean, Okhotsk and Bering seas. Blue whales feed almost exclusively on krill, with a variety of species being taken by different blue whale populations. They feed both at the surface and also at depth, following the diurnal vertical migrations of their prey to at least 100 m. The migration patterns of blue whales are not well understood, but appear to be highly diverse. (Reilly *et al.*, 2008)	**High likelihood to occur** Species or species habitat may occur within area. The Blue Whale is known to through the region during their annual migration, north from April-August for calving in tropical waters and south from August- October for feeding and are generally found in deeper waters offshore from the BBF area around July-September (IFWA 2011).
Balaenoptera edeni Bryde's Whale	M, C			The species appears to be limited to the 200m depth contour, moving along the coast in response to the availability of suitable prey, while the offshore form is found in deeper waters (500 to 1,000m) (Best 1977).	**Moderate likelihood to occur** Species or species habitat may occur within area (GHD 2017). Because of its small population, lack of sightings and preference for deeper water, it is unlikely to be encountered in the BBF area (GHD 2017).
Dugong dugon Dugong	MM	OS	VU	In Australia, dugongs occur in the shallow coastal waters of northern Australia from the Queensland/New South Wales border in the east to Shark Bay on the Western Australian coast, often largely sighted feeding in wide seagrass beds but	**High likelihood to occur** Species or species habitat likely to occur within area (GHD 2017) and studies by Bennelongia *et al*

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				also in estuarine streams. North-West Australia is thought to have one of the largest populations of Dugongs in the world (DSEWPaC, 2012b). They are also found in other parts of the Indian and Pacific Oceans in warm shallow seas in areas where seagrass is found. Regional sightings pooled from 1996 to 2008 show some sighting around Cockatoo and Irvine Islands but notably less than around the Dampier Peninsula, Derby and around Walcott Inlet (Holley and Prince, 2011). Aerial surveys completed by RPS further sighted Dugong populations in the Roebuck Bay area (2009; as cited in Mckenzie *et al.* 2017).	(2009) & Brown *et al* (2014) have recorded their presence in Roebuck Bay in particular feeding on seagrass beds in the northern areas of Roebuck Bay. However, they are a highly mobile species moving in and out of the bay dependant on resource availability (DPaW 2016).
Megaptera novaeangliae Humpback Whale	V, M	CD	LC	Humpback Whales occur throughout Australian waters with their distribution influenced by their migratory pathways and aggregation areas for resting, breeding and calving. The migratory habitat for the humpback whale around mainland Australia is primarily coastal waters less than 200 m in depth and generally within 20 km of the coast. Humpbacks arrive in the coastal waters of the Kimberley after summer from June to August to breed and calve before returning to the Southern Ocean feeding areas to the Antarctic during September to November after the winter season has passed (GHD 2017).	**High likelihood to occur** The species or species habitat are known to occur within the area, however they typically occur offshore (>35km) particularly on the northern migration, although some whales often with calves can stay close to shore in water depth <10m during southern migration (i.e. September).
Orcaella heinsohni Irrawaddy Dolphin/ Australian Snubfin	C, MM,	P4	VU, NT	This dolphin is primarily found in nearshore habitats but has been recorded up to 23km offshore. Stranding and museum specimen records indicate that Australian Snubfin Dolphins occur only in waters off the northern half of Australia, from	High likelihood to occur Species or species habitat may occur within area (GHD 2017). Beagle Bay and Pender Bay which are north of the BBF area are

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				approximately Broome (17° 57´ S) on the west coast to the Brisbane River (27° 32´ S) on the east coast (Parra *et al.* 2002). Aerial and boat-based surveys indicate that Australian Snubfin Dolphins occur mostly in protected shallow waters close to the coast, and close to river and creek mouths (Parra *et al.* 2002).	considered important areas for the Australian Snubfin Dolphin (Department of the Environment and Energy, 2016; RPS 2012). Due to shallow water preferences, the Irrawaddy/Snubfin is likely to be present all year round in the BBF area.
Orcinus orca Killer whale, Orca	C, M		DD	In Australia killer whales are recorded from all states. The Killer whale prefer oceanic, pelagic and neritic regions in both warm and cold waters and are predominately seen along the continental slope (DoEE 2019c).	**Low likelihood to occur**
Sousa chinensis Indo-Pacific Humpback dolphin	C, MM	P4	NT	The Indo-Pacific Humpback Dolphin is primarily found in nearshore habitats, such as those associated with the Buccaneer Archipelago (DoEE 2016; Brown, A.M *et al* 2016). Indo-Pacific Humpback dolphins typically occur in open waters around coasts and islands, generally less than 20m water depth (Parra *et al.,* 2002). In Australia, Indo-Pacific Humpback Dolphins are known to occur along the northern coastline, extending to Exmouth Gulf on the west coast (25° S), and the Queensland/NSW border region on the east coast (34° S) (Corkeron *et al.* 1997). There are few records between the Gulf of Carpentaria in the north and Exmouth Gulf in the west, this is probably due to a lack of research effort and the remoteness of the area (Bannister *et al.* 1996; Parra *et al.* 2002).	**High likelihood to occur** Breeding known to occur within area (GHD 2017). Due to shallow water preferences, the Indo-Pacific Humpback is likely to be present all year round in the BBF area as they are common in estuaries and embayment's in the region including Roe-buck Bay (RPS 2012).
Tursiops aduncus Indo-Pacific/Spotted Bottlenose Dolphin	MM, C	MM		The Bottlenose Dolphin is a cosmopolitan species in all Australian waters in coastal, estuarine and pelagic settings. The Bottlenose Dolphin is widely distributed in tropical and sub-tropical coastal and	**High likelihood to occur** Species or species habitat likely to occur within area (GHD 2017). Bottlenose Dolphins have been

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				shallow offshore Indo-Pacific waters and the western Pacific Ocean, however there is limited information on the distribution and population of the Arafura/Timor sea population (Möller & Beheregaray 2001).	observed during surveys by Jenner and Jenner (2009) between Cape Leveque (north of Broome) and Scott Reef in June, July, October and November 2008). Other studies by RPS (2012) observed bottlenose dolphins in the nearshore zone and likely to be present throughout the year.

Marine Reptiles

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Aipysurus apraefrontalis Short-nosed Seasnake	CE, Ma	CR	CR	The Short-nosed Seasnake is endemic to Western Australia, and has been recorded from Exmouth Gulf, Western Australia to the reefs of the Sahul Shelf, in the eastern Indian Ocean. The species prefers the reef flats or shallow waters along the outer reef edge in water depths to 10 m (McCosker 1975).	**Moderate likelihood to occur** Species or species habitat likely to occur within area.
Caretta caretta loggerhead turtle	E, MM, Ma	EN	VU	In Australia, Loggerhead Turtles nest on open, sandy beaches concentrated in southern Queensland and from Shark Bay to the North West Cape in Western Australia. They live at or near the surface of the ocean and move with the ocean currents, choosing a wide variety of tidal and sub-tidal habitat as feeding areas and showing fidelity to both their foraging and breeding areas. (Department of Environment and Heritage 2005). The Loggerhead Turtle occurs in the waters of coral and rocky reefs, seagrass beds and muddy bays throughout eastern, northern and western Australia (Limpus 1995).	**High likelihood to occur** The species has been recorded in the region (desktop searches) and Foraging, feeding or related behaviour known to occur within area (Bennelogia *et al.* 2009)

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Chelonia mydas Green turtle	V, MM, Ma	VU	EN	Green Turtles nest, forage and migrate across tropical northern Australia. They usually occur between the 20°C isotherms, although individuals can stray into temperate waters (Cogger 2014). In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore Islands off the Pilbara region (DEH 2005).	**High likelihood to occur** The species has been recorded in the region (desktop searches) and breeding is known to occur within area.
Crocodylus porosus Salt-water Crocodile	M, Ma	OS	LC	Found in Australian coastal waters, estuaries and lakes, inland swamps and marshes. It has been found at King Sound (near Broome) (DoEE 2019d).	**Moderate likelihood to occur** Species or species habitat likely to occur within area
Dermochelys coriacea leatherback turtle	E, MM, Ma	VU	VU	The Leatherback Turtle is a pelagic feeder, found in tropical, subtropical and temperate waters throughout the world. Large body size, high metabolism, a thick adipose tissue layer and regulation of blood flow them to utilise cold water foraging areas unlike other sea turtle species. For this reason, this species is regularly found in the high latitudes of all oceans including the South Pacific Ocean in the waters offshore from NSW, Victoria, Tasmania and Western Australia (Benson *et al.* 2011).	**Moderate likelihood to occur** the species has not been recorded in the region (no records from desktop searches). Breeding is likely to occur within area.
Eretmochelys imbricata Hawksbill turtle	V, MM, Ma	VU	CR	Hawksbill Turtles are found in tropical, subtropical and temperate waters in all the oceans of the world. In Australia, the key nesting and inter-nesting areas (where females live between laying successive clutches in the same season) occur on offshore Islands off Onslow (Pendoley 2005).	**Moderate likelihood to occur** Breeding likely to occur within area.
Natator depressus Flatback turtle	V, MM, Ma	VU	DD	The Flatback Turtle is found only in the tropical waters of northern Australia, Papua New Guinea and Irian Jaya, and is one of only two species of sea turtle without a global distribution. On the North-West Shelf, the major rookeries are on the mid-eastern coast of	**High likelihood to Occur** The species has been recorded in the region (desktop searches) and

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				Barrow Island and at Mundabullangana Station near Cape Thouin on the mainland (Prince 1994).	breeding is known to occur within area.

Sharks and Rays

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Anoxypristis cuspidata Narrow sawfish, Knife tooth sawfish	M		E	This sawfish inhabits fresh and brackish waters in betho-pelagic depths and offshore waters to at least 40m. The species commonly occurs in the Indo-Pacific region (D'Anastasi et al 2019).	**Moderate likelihood to occur**
Carcharodon carcharias Great White Shark	V, MM	VU	VU	In Australia, Great White Sharks have been recorded from central Queensland around the south coast to north-west Western Australia but may occur further north on both coasts (Bonfil *et al.* 2005). They inhabit inshore waters around rocky reefs, surf beaches and shallow coastal bays; waters on the outer continental shelf and slope; and the open ocean. These sharks most commonly live in depths above 100 m (Pogonoski *et al.*, 2002).	**Moderate likelihood to occur** The species has not been recorded in the region (no records from desktop searches). Species may occur within area, but it is unlikely.
Manta alfredi Reef Manta	M			This species occurs in tropical and subtropical waters and widespread in the Indian ocean. They often reside in nearshore waters with high productivity, around rocky reefs and seamounts. Inshore coastal waters are often preferred habitat for cleaning and feeding (Marshall et al 2018).	**Moderate likelihood to occur** Species or species habitat may occur in the area.
Manta alfredi Reef Manta	M			Occurs in tropical and temperate waters, occupying a widespread distribution. It is a seasonal visitor to coastal and offshore sites. Commonly sighted along productive coastlines associated with upwellings, oceanic island groups and offshore pinnacles and seamounts (Marshall et al 2018).	**Moderate likelihood to occur** Species or species habitat may occur in the area.

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Pristis clavata Dwarf Sawfish	V, MM	P1	EN	The species' Australian distribution has previously been considered to extend north from Cairns around the Cape York Peninsula in Queensland, across northern Australian waters to the Pilbara coast in Western Australia (Last & Stevens 1994). The Dwarf Sawfish usually inhabits shallow (2–3 m) coastal waters and estuarine habitats, which are utilized as nurseries for juveniles. Surveys have found most captures are of Dwarf Sawfish occur over soft sediment environments (Department of the Environment, 2015).	**High likelihood to occur** The species has been recorded in the region (records from desktop searches). The western extent of this species range has not been fully resolved, however species or species habitat known to occur within area (Morgan *et al* 2010).
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish	V, M			The Freshwater Sawfish may potentially occur in all large rivers of northern Australia from the Fitzroy River, Western Australia, to the western side of Cape York Peninsula, Queensland (Allen 2000 pers. Comm.). It is a marine/estuarine species and the period it spends in either marine or estuarine waters is largely related to its life cycle as well as different the time of the day. The preferred habitat of this species is mud bottoms of river embayment's and estuaries, but they are also found well upstream (Allen 1997).	**High likelihood to occur** Species or species habitat known to occur within area therefore given this species known distribution, it is possible that they can occur in the BBF area.
Pristis zijsron Green Sawfish	V, MM	VU	CR	The green sawfish inhabit shallow coastal marine and estuarine waters of northern Australia, from about Eighty Mile Beach, Western Australia, to the Cairns region, Queensland. It has occasionally been caught as far south as Sydney. Green sawfish are known to be pupped near the Ashburton River mouth and utilise the estuary and nearby mangrove creeks, before moving offshore to mature at a length of about 3 m (Allen *et al.* 2015).	**High likelihood to occur** The species is known to occur within area for breeding purposes. Individuals have been recorded from inshore coastal environments and estuaries to offshore deep waters (Morgan *et al* 2010).
Rhincodon typus Whale Shark	V, MM	OS	EN	Found worldwide in tropical and subtropical oceans. In Australia, the Whale Shark is known from NSW,	**Low likelihood to occur**

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				Queensland, Northern Territory, Western Australia and occasionally Victoria and South Australia, but it is most commonly seen in waters off northern Western Australia, Northern Territory and Queensland (Compagno and Last 1999). Whale Sharks are known to inhabit both deep and shallow coastal waters and the lagoons or coral islets and reefs. A study by Wilson *et al* (2006) found Whale Sharks spend at least 40% of their time in the upper 15 m of the water column and at least 50% of their time at depths equal to or less than 30 m.	The species has not been recorded in the region (no records from desktop searches) and are generally found in waters deeper than present at the BBF area. Species or species habitat may occur within the BBF area but unlikely due to the preference for deeper waters.

Plants

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Acacia monticola		P3		Identified by NatureMap database search	**Low likelihood to occur**
Corymbia paractica		P1		Identified by DBCA database search	**High likelihood to occur**
Goodenia byrnesii		P1		Identified by Coffey (2013 & 2016) and Woodman (2008)	**High likelihood to occur** Species or species habitat known to occur within area
Glycine Pindanica		P3		Identified by DBCA and NatureMap database search	**Low likelihood to occur**
Gomphrena Pusilla		P2		Identified by DBCA and NatureMap database search	**Low likelihood to occur**
Keraudrenia exastia Fringed Keraudrenia	CE	CR		The Fringed Keraudrenia is endemic to Western Australia and is known from seven subpopulations within the Port of Broome, in Broome, Western Australia (WA DEC 2006). The Fringed Keraudrenia is considered to have a very restricted geographic distribution.	**High likelihood to occur** Species or species habitat known to occur within area.

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				The Fringed Keraudrenia grows in Pindan (red soil) heathland (Western Australian Herbarium 2006). Apart from one subpopulation which occupies a north-facing dune slope, the remaining six subpopulations occur on almost flat land and associated vegetation includes Feathertop Spinifex (*Triodia schinzii*) and scattered trees, under 7 m in height, of Soap Wattle (*Acacia colei*), Bloodwood (*Eucalyptus dampieri*) and several other common species with a variety of intermediate sized shrubs (Broome Botanical Society 1995).	
Monsoon Vine Thicket (PEC 67)		P1		Identified by Woodman (2008), DBCA database search	**High likelihood to occur**
Sersalisia sericea Mangarr (Minyjuru)		P1		Identified by Coffey (2013) and DBCA database search	**High likelihood to occur**
Seringia exastia Fringed Fire-bush	CE	CR		Identified by Coffey (2013 and 2016), Woodman (2008), DBCA and NatureMap database search	**High likelihood to occur**
Seringia katatong		P3		Identified by DBCA database search	**Low likelihood to occur**
Polymeria sp. Broome		P3		Identified by NatureMap database search	**Low likelihood to occur**
Tephrosia andrewii		P3		Identified by DBCA database search	**Low likelihood to occur**

Birds

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Calidris canutus Red Knot, Knot	E, M, Ma	VU	NT	The Red knot is common in all main suitable habitats around the coast of Australia (Barrett *et al* 2003; Minton, C.D.T. 2006, pers. Comm.; Watkins 1993). Very large numbers are regularly recorded in	**High likelihood of occurrence** Species or species habitat known to occur within area. The Red Knot prefers to inhabit the intertidal

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				the north-west Australia, with 80-mile beach and Roebuck Bay near Broome being particular strongholds. The Red Knot mainly inhabits mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools exposed wave-cut rock platforms or coral reefs (Higgins & Davies 1996).	mudflats of the Eighty Mile Beach in Western Australia (Johnstone 2017).
Calidris ferruginea Curlew Sandpiper	CE, M, Ma	VU	NT	In Australia, Curlew Sandpipers occur around the coasts and are also quite widespread inland, though in smaller numbers. Records occur in all states during the non-breeding period, and also during the breeding season when many non-breeding one-year old birds remain in Australia rather than migrating north. In Western Australia they are widespread around coastal and subcoastal plains. They mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast.	**High likelihood of occurrence** Species or species habitat known to occur within area. They occur in large numbers, in thousands to tens of thousands in Roebuck Bay. In Roebuck Bay, they are also said to feed on part of the mudflats that have been exposed for a longer period, foraging in small groups (Tulp & de Goeij 1994)
Calidris tenuirostris Great Knot	CE, M, Ma	VU	EN	The Great knot has been recorded around the entirety of the Australian coast, with a few scattered records inland. The greatest numbers are found in Northern Australia; where the species is common on the coasts of the Pilbara and Kimberley. In Australasia, the species typically prefers sheltered coastal habitats, with large intertidal mudflats or sandflats. This includes inlets, bays, harbours, estuaries and lagoons (Higgins & Davies 1996).	**High likelihood of occurrence** Roosting is known to occur within area. The highest recorded numbers of birds are within Eighty Mile Beach and Roebuck Bay which is near the BBF area.
Charadrius leschenaultia Greater Sand Plover, Large Sand Plover	V, M, Ma	VU	LC	In Australia, the Greater Sand Plover occurs in coastal areas in all states, thought the greatest numbers occur in northern Australia, especially the north-west (Marchant & Higgins 1993; Minton *et al.*	**High likelihood of occurrence** Roosting is known to occur within area. Two Internationally important sites in Australia south of the BBF

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				2006). The species is widespread between North West Cape and Roebuck Bay (Barrett *et al.* 2003; Blakers *et al.* 1984; Lane 1987; Storr 1980, 1987). The species is almost entirely coastal, inhabiting littoral and estuarine habitats. They mainly occur on sheltered sandy, shelly or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons (Bamford 1988; Blakers *et al.* 1984; Lane 1987; Sibson 1948; Stewart *et al.* 2007), and inshore reefs, rock platforms, small rocky islands or sand cays on coral reefs (Abbott 1982; Morris 1989; Sedgwick 1978).	area include Eighty Mile Beach and Roebuck Bay.
Charadrius mongolus Lesser Sand Plover, Mongolian Plover	E, M, Ma	EN	LC	Within Australia, the Lesser Sand Plover is widespread in coastal regions, and has been recorded in all states. Internationally important sites in Australia near the BBF area include Eighty Mile Beach, Roebuck Bay and Broome. In non-breeding grounds in Australia, this species usually occurs in coastal littoral and estuarine environments. It inhabits large intertidal sandflats or mudflats in sheltered bays, harbours and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops (Marchant & Higgins 1993).	**High likelihood of occurrence** Roosting known to occur within area.
Elanus scriptus Letter Winged Kite		P4	NT	Is an endemic species found in the arid regions of western Australia and other parts of Australia. It prefers open country areas and grasslands in arid and semi-arid Australia where there are tree-lined streams or water courses. It roosts by day in the high canopy of leafy trees. (Birdlife 2019).	**Moderate likelihood of occurrence**

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Falco hypoleucos Grey falcon		P1	LC	Occurs in arid and semi-arid Australia including Western Australia. Mainly found where rainfall is less than 500mm, except when wet years are followed by drought, when the species becomes more widespread. During non-breeding season they head toward northern and coastal areas. The species frequents timberland lowland plains, particularly acacia shrublands. Other habitat types they frequent include tussock grassland and open woodland (DoE 2019).	**Moderate likelihood of occurrence**
Falco peregrinus Peregrine Falcon		P1	LC	Found across Australia in most habitats, from rainforests to the arid zone, and at most altitudes, from the coast to alpine areas. Prefers coastal and inland cliffs or open woodland near water. Feeds on small birds, rabbits and other day-active mammals. Tree hollows are suitable nesting sites in addition to cliff faces (Birdlife 2019b).	**Moderate likelihood of occurrence**
Ixobrychus dubius Australian Little Bittern		P4	LC	Some scattered records are found in coastal locations in the Kimberley region. Feeding mainly on aquatic invertebrates such as crustaceans and small vertebrates. Mainly found in freshwater wetlands, where they inhabit dense emergent vegetation of reeds and sedges, and inundated shrub thickets. They are also occasionally found in brackish and saline wetlands such as mangrove swamps, salt marsh and wooded margins of coastal lagoons (Atlas of living Australia 2019).	**Moderate likelihood of occurrence**
Ixobrychus flavicollis Black Bittern		P2	LC	Black Bitterns are found in coastal south-western, northern and eastern Australia south to far eastern Victoria. They roost and nest in trees and are found in tree-lined wetlands and in mangroves. They mainly forage from shady trees over water but have also been seen in open areas of short marshy	**Moderate likelihood of occurrence**

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				vegetation and along creeks in shrubby vegetation (Australian Museum 2019).	
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit	V	VU		Bar-tailed Godwits are long-distance migratory shorebirds. About a third of the global population migrate to Australia during the non-breeding season where they occur in the north-west and east (Wilson *et al* 2007). It is found mainly in coastal habitats such as intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays (Marchant & Higgins 1993).	**High likelihood of occurrence** Species or species habitat known to occur within area. Roebuck Bay, near the BBF area is considered an Australian site of international importance (Bamford *et al* 2008).
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri)	E	VU		The bar-tailed godwit (northern Siberian) is a large migratory shorebird. It has been recorded in the coastal areas of all Australian states. During the non-breeding period, the distribution if *L. l. menziberi* is predominately in the north and north-west of Western Australia and in south- eastern Asia (Bamford *et al* 2008). It occurs mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays.	**High likelihood of occurrence** Species or species habitat known to occur within area.
Ninox connivens Barking Owl		P3	LC	The barking owl feeds on a variety of small to medium-sized mammals, birds, reptiles and insects. Most hunting is performed at night and dawn, preferring to hunt in clearings, including waterways and other open areas. They nest in hollow tree trunks, are found in open woodlands and the edges of forests, usually in forests dominated by eucalyptus species, particularly the red gum, and, in the tropic's paperbark species (Birdlife 2019a).	**Moderate likelihood of occurrence**
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew	CE, M, Ma	VU	EN	The Eastern Curlew is predominately coastal during the non-breeding season occurring at estuaries, mangrove swamps, saltmarshes, and intertidal flats, particularly those with extensive seagrass meadows	**High likelihood of occurrence** Species or species habitat known to occur within area.

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				(Birdlife International 2017). In Australia it is widespread in coastal regions in the north-east and south of Australia.	
Papasula abbotti Abbott's Booby	E, Ma		EN	Abbott's Booby is a marine species. It spends much of its time at sea but needs to come into shore to breed. It nests in tall rainforest trees and most trees are associated with uneven terrain created by gullies, hillsides or cliffs. The nature of the Abbott Booby nest site is determined by the topography and nature of the canopy, resulting in a patchy distribution (Nelson and Powell 1986). Abbott's Booby is mainly seen year-round on Christmas Island (Andrew, McBride & Thomas 2011).	**High likelihood of occurrence** Species or species habitat may occur within area. One recorded at Eco Beach south of Broome in December 1999. This is the first Australian record other than at Christmas Island (O'Connor 2003) (Andrew *et al* 2011).
Pluvialis fulva Pacific Golden Plover	M, Ma		LC	Records BMT (2018)	**High likelihood of occurrence** Species or species habitat may occur within area.
Pluvialis squatarola Grey Plover	M, Ma		LC	Records BMT (2018)	**High likelihood of occurrence** Species or species habitat may occur within area.
Polytelis alexandrae Princess Parrot, Alexandra's Parrot	V	P4	NT	The princess Parrot inhabits sand dunes and sand flats in the arid zone of Western and central Australia. It occurs in open savanna woodlands and shrublands that usually consist of scattered stands of trees, an understory of shrubs, and a ground cover (Allen 1987).	**Low likelihood of occurrence** Species or species habitat likely to occur within area. The BBF area is outside the current known range of the Princess Parrot and therefore would be highly unlikely to occur in the BBF area.
Puffinus huttoni Hutton's Shearwater		EN	EN	In the non-breeding season this species migrates to waters of southern, western and north-western Australia. The species digs burrows on gentle to steep mountain slopes at 1,200-1,800m under tussock grass or low alpine scrubland (Marchant and Higgins 1990).	**Moderate likelihood of occurrence**

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Rostratula Australia Australian Painted Snipe	E, Ma	EN	EN	The Australian Panted Snipe has been recorded at wetlands in all states of Australia (Barrett et al. 2003; Blakers et al. 1984; Hall 1910b). the Australian Painted Snipe generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (Marchant & Higgins 1993).	**Moderate likelihood of occurrence** Species or species habitat may occur within area. There are no wetlands within the BBF area and the Snipe would be highly unlikely to occur in the BBF area. However, the BBF area is approximately 10km to the west of the Roebuck Bay Wetland of International Importance.
Tringa brevipes Grey tailed Tattler		P4		Records (BMT 2018)	**High likelihood of occurrence** Records BMT (2018)
Tyto novaehollandiae Kimberli Masked Owl (northern)	V	P1		The distribution of the Masked Owl is poorly known (Woinarski 2004). A subpopulation has been suggested in the Kimberley region in Western Australia (Garnett *et al.* 2011). In northern Australia, the Masked Owl has been recorded from the riparian forest, open forest, *Melaleuca* swamps and the edges of mangroves (Higgins 1999; Nielsen 1996; Storr 1977, 1980).	**High likelihood of occurrence** Species or species habitat may occur within area. There are historical records of the specie from near Broome, however it is expected to be uncommon in this area (Crossman 1910).
Xenus cinereus Terek Sandpiper	M, Ma		LC	Records (BMT 2018)	**High likelihood of occurrence** Records BMT (2018)

Terrestrial Mammals

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Dasyurus hallucatus Northern Quoll		EN	EN	The Northern Quoll occurs in the northern regions of Australia. However current distribution is discontinuous across northern Australia, with core	**Low likelihood to occur**

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				populations is rocky and/or high rainfall areas. Habitat areas include rocky outcrops, tree hollows, hollow logs, termite mounds (Hill 2010).	Species or species habitat likely to occur within area.
Macrtis lagotis Greater Bilby	V	VU	VU	Wild populations of the Greater Bilby are declining and in Western Australia are restricted predominately to The Gibson Desert, Little Sandy Desert, Great Sandy Desert and parts of the Pilbara and Southern Kimberley (GHD 2014).	**High likelihood to occur** Species or species habitat known to occur within area.
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat	V			In Australia all confirmed roosting records are from long deep tree hollows in the poplar gum *Eucalyptus platyphylla,* Darwin woolybutt E. *miniate* and Darwin stringybark *E. tetrodonta.* The hollows in these trees are used as maternity roosts. They forage over canopy or along the edge of a variety of woodland, open forest and closed forest types (Schultz 2007)	**Low likelihood to occur** Species or species habitat likely to occur within area.
Mormopterus lumsdenae Northern Free – Tailed Bat		P1	LC	This bat occurs in the northern half of Australia within 700km of the coast, encompassing areas with annual rainfall from 200mm to over 1,500mm. This species is found in a variety of habitats including eucalypt woodlands, often near natural watercourses and dams, and over rainforest, riverine and floodplain margins, woodland and savannah (Reardon 2017).	**Low likelihood to occur** Species or species habitat likely to occur within area.
Trichosurus vulpecula arnhemensis Northern brushtail possum		VU	NT	The brushtail possum occurs across Australia, this species occurs in tropical northern Australia, including the Pilbara and Kimberley of Western Australia. It is known to occupy a variety of habitats including forest and woodlands that provide sufficient trees with hollows, to ground refuges such as hollow logs. They are nocturnal animals and are herbivores mainly consisting of a diet of leaves such as *Eucalyptus* (DEC 2012).	**Low likelihood to occur** Species or species habitat likely to occur within area.
Wyulda squamicaudata Scaly-tailed Possum		P4	NT	Restricted to the west Kimberley, Western Australia. Most records are from near-coastal, high-rainfall	**Low likelihood to occur**

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				north-western Kimberley. Occurs in rugged sandstones with adjacent open woodland or closed forest, sometimes with rainforest elements. Forages mainly in trees but may venture into open areas to feed on flowers, fruits, seeds and leaves (Burbidge 2016).	Species or species habitat likely to occur within area.
Hydromys chrysogaster Water-rat, Rakali		P4	LC	Generally, occurs in permanent fresh or brackish water, although can also be found in marine environments. Largely carnivorous species with a diet inclusive of insects, crustaceans, fish and small fauna (CSIRO 2004).	**Low likelihood to occur** Species or species habitat likely to occur within area.
Mesembriomys macrurus Golden backed tree rat		P4	NT	This species has been recorded from the top end of the Northern Territory (NT) and the Kimberley and Pilbara in Western Australia (WA). However since 1903 all known records have come from the higher rainfall areas of the north-west Kimberley (Threatened Species Scientific Committee 2019).	**Low likelihood to occur** Species or species habitat likely to occur within area.

Terrestrial Reptiles

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
Ctenotus angusticeps Airlie Island Ctenotus	V	P4		The Airlie Island Ctenotus is known from approximately 12 locations in north-west WA including Willie Creek in Broome. Populations of the species is fragmented, the habitat in which it occurs is unique and fragmented within the landscape (Maryan *et al.* 2013). The Airlie Island Ctenotus generally inhabits the landward fringe of saltmarsh communities in samphire shrubland or marine couch grassland (Maryan *et al.* 2013) in the intertidal zone along mangrove (Grey Mangrove (*Avicennia marina*) and	**High likelihood to occur** Species or species habitat likely to occur within area.

Species Name	EPBC Act Status	BC Act Status	IUCN Status	Habitat Preference	Likelihood of Occurrence
				Red Mangrove (*Rhizophora stylosa*)) margins, however subtle differences in vegetation /topography exist among sites where the species has been recorded (Biologic 2012).	
Lerista separanda Dampierland plain slider		P2	LC	In Australia endemic species is found in Dampier Land in the south-west Kimberley ranges. Found in consolidated coastal sand dunes. It is known to burrow in loose soil or sand beneath stones, logs, termite mounds etc (Cogger 2014).	**Low likelihood to occur** Species or species habitat likely to occur
Simoselaps minimus Dampier land Burrowing Snake		P2	LC	In Australia this species is found in Dampier Land in the Western Australia, covering wider areas of the Dampier peninsula. It has been recorded in open areas with few trees (Cogger 2014).	**Low likelihood to occur** Species or species habitat likely to occur

Migratory Birds

Class	Species	Common Name	EPBC Act Status	BC Act Status	IUCN
Birds	*Actitis hypoleucos*	Common Sandpiper	M, Ma		LC
Birds	*Anous stolidus*	Common Noddy	MM		LC
Birds	*Apus pacificus*	Fork-tailed Swift	MM		LC
Birds	*Arenaria interpres*	Ruddy Turnstone	Ma, M		LC
Bird	*Calidris acuminata*	Sharp-tailed Sandpiper	Ma, M		LC
Bird	*Calidris alba*	Sanderling	Ma, M		LC
Bird	*Calidris melanotos*	Pectrol Sandpiper	Ma, M		LC
Bird	*Calidris ruficollis*	Red-necked Stint	M, Ma		NT
Bird	*Calidris subminuta*	Long-toed stint	M		
Bird	*Calonectris leucomelas*	Streaked Shearwater	MM, M		NT

Class	Species	Common Name	EPBC Act Status	BC Act Status	IUCN
Bird	*Cecropis daurica*	Red-rumped Swallow	M, Ma		LC
Bird	*Charadrius bicinctus*	Double-banded Plover	M, Ma		LC
Bird	*Charadrius dubius*	Little Ringed plover	M		
Bird	*Charadrius veredus*	Oriental Plover	M, Ma		LC
Bird	*Childonias leucopterus*	White winged Black tern, white winged tern	M		
Bird	*Cuculus optatus*	Oriental Cuckoo, Horsfield's Cuckoo	M		
Birds	*Fregata ariel*	Lesser Frigatebird, Least Frigatebird	MM		LC
Birds	*Fregata minor*	Great Frigatebird, Greater Frigatebird	MM		LC
Bird	*Gallinago megala*	Swinhoe's Snipe	Ma, M		LC
Bird	*Gallinago stenura*	Pin-tailed Snipe	Ma, M		LC
Bird	*Gelochelidon nilotica*	Gull-billed tern	M		
Bird	*Glareola maldivarum*	Oriental Pratincole	M, Ma		LC
Bird	*Hirundo rustica*	Barn Swallow	M, Ma		LC
Bird	*Hydroprogne caspia*	Caspian tern	M		
Bird	*Limicola falcinellus*	Broad-billed Sandpiper	M, Ma		LC
Bird	*Limnodromus semipalmatus*	Asian Dowitcher	M, Ma		NT
Bird	*Limosa limosa*	Black-tailed Godwit	M, Ma		NT
Bird	*Motacilla cinereal*	Grey Wagtail	M, Ma		LC
Bird	*Motacilla flava*	Yellow Wagtail	M, Ma		
Bird	*Numenius minutus*	Little Curlew, Little Whimbrel	M, Ma		LC
Bird	*Numenius phaeopus*	Whimbrel	M, Ma		LC
Bird	*Oceanites oceanicus*	Wilsons Storm petrel	M		
Bird	*Onychoprion anaethetus*	Bridled tern	M		

Class	Species	Common Name	EPBC Act Status	BC Act Status	IUCN
Bird	*Pandion haliaetus*	Osprey	M, Ma		LC
Bird	*Philomachus pugnax*	Ruff, reeve	M		
Bird	*Plegadis falcinellus*	Glossy Ibis	M		
Bird	*Pluvialis fulva*	Pacific Golden Plover	M, Ma		LC
Bird	*Pluvialis squatarola*	Grey Plover	M, Ma		LC
Bird	*Sternula albifrons*	Little Tern	M, Ma		LC
Bird	*Sterna dougallii*	Roseate Tern	M		
Bird	*Sterna hirundo*	Common Tern	M		
Bird	*Sula leucogaster*	Brown Booby	M		
Bird	*Thalasseis bergii*	Crested Tern	M		
Bird	*Tringa glareola*	Wood Sandpiper	M, Ma		LC
Bird	*Tringa nebularia*	Common Greenshank	M, Ma		LC
Bird	*Tringa stagnatilis*	Marsh Sandpiper, little greenshank	M, Ma		LC
Bird	*Tringa totanus*	Common redshank, redshank	M, Ma		LC
Bird	*Xenus cinereus*	Terek Sandpiper	M, Ma		LC

BROOME
BOATING FACILITY

The Proposed Entrance Point
Broome Boating Facility

COMMUNITY SURVEY REPORT

August 2020

Broome Boating Facitlity - Artist's Impression

A special project by

Department of Transport

Shire of Broome
people • place • prosperity

KIMBERLEY PORTS

KIMBERLEY

Engaged with

YAWURU

Yawuru PBC have worked with all parties to arrive at the agreed concept design and location

Broome Boating Facitlity - Artist’s Impression

CONTENTS

Broome Boating Facility Community Consultation Overview

- Open for public comment from 18 March to 16 April, 2020
- Website developed for the Broome Boating Facility project to provide detailed information to the community: broomeboatingfacility.com.au

The website includes a number of concept designs and a Frequently Asked Questions section.

- Survey questions:

Please rate your support for the proposed Broome Boating Facility	• Not supportive • Neutral • Supportive • Highly Supportive
Do you own a boat or regularly go boating?	• Yes • No
Do you want to provide any comments or suggestions on the proposal?	

Community information displays were placed at several locations around Broome*:

- Shire Offices
- Broome Boulevard
- Nyamba Buru Yawuru Offices
- Broome Fishing Club
- Tackle Word
- Kimberley Camping and Outback Supplies
- Broome Recreation and Aquatic Centre (BRAC)
- Library
- Department of Transport Offices

*Unfortunately, a number of these locations had to be closed during the consultation period due to COVID-19 restrictions.

Community Information Sessions

- Community information sessions planned for the Broome Fishing Club and Broome Boulevard were cancelled due to the COVID-19 crisis. Additional project informtion was released on social media in response to these cancellations.

Broome Boating Facilty Mailing List

- Several community members have registered for the Broome Boating Facility mailing list. Project updates will be provided to this group.

Consultation Communications

18 MARCH 2020
SHIRE OF BROOME FACEBOOK POST
ADVERTISING OPENING OF COMMUNITY SURVEY.

18 MARCH 2020
MEDIA RELEASE
ENCOURAGING COMPLETION OF THE SURVEY.

25 MARCH 2020
SHIRE OF BROOME ENEWSLETTER
ENCOURAGING COMPLETION OF THE SURVEY.

25 MARCH 2020
SHIRE OF BROOME FACEBOOK POST
REQUESTING QUESTIONS FROM THE COMMUNITY.

26 MARCH 2020
ADVERT IN THE BROOME ADVERTISER
ENCOURAGING COMPLETION OF THE SURVEY.

30 MARCH 2020
SHIRE OF BROOME FACEBOOK POST
VIDEO INTERVIEW WITH HAROLD TRACEY, SHIRE PRESIDENT.

12 APRIL 2020
SHIRE OF BROOME FACEBOOK POST
VIDEO INTERVIEW WITH WES FRANKS, BROOME FISHING CLUB PRESIDENT.

15 APRIL 2020
SHIRE OF BROOME FACEBOOK POST
REMINDER TO COMPLETE THE SURVEY POST

26 APRIL 2020
MEDIA RELEASE
PUBLICATION OF SURVEY RESULTS.

26 APRIL 2020
SHIRE OF BROOME FACEBOOK POST
POST-SURVEY POST, OVERVIEW OF RESULTS.

26 APRIL 2020
ADVERT IN THE BROOME ADVERTISER
PUBLICATION OF SURVEY RESULTS.

18 MAY 2020
SHIRE OF BROOME ENEWSLETTER
PUBLICATION OF THE SURVEY RESULTS.

KEY THEMES

EXISTING ASSETS
- Cultural significance
- Existing vegetation
- Rock formations
- Dinosaur tracks
- Existing memorial plaques

SUPPLY OF AMENITIES
- Shelter & seating
- Toilets/public amenities
- Waste management
- Opportunity for kiosk
- Space for pop-up food options
- Fishing/viewing platforms
- Fish cleaning

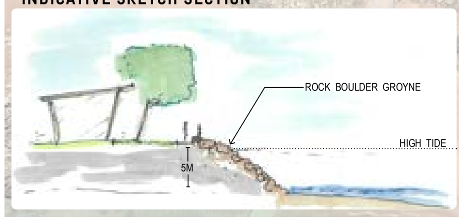
INTERPRETIVE OPPORTUNITIES
- How can the cultural heritage significance and values, the Dinosaur Coast and the unique environment be reflected through interpretive elements?

ACCESS TO THE BEACH
- Beach & rock fishing
- Dog walking
- Swimming
- Incorporating universal access
- Possible vehicle access

ENVIRONMENTAL PROCESSES
- Tidal movements
- Marine impact
- Coastal processes, waves, currents and sand movement
- Seasonal cyclones

DESIGN & FUNCTION
- Vehicle & pedestrian circulation
- Parking
- Improved boat launching & retrieval
- Safety and access

INDICATIVE SKETCH SECTION



IMAGES SHOWN ARE EXAMPLES ONLY

BROOME BOATING FACILITY
INDICATIVE CONCEPT MASTERPLAN

0m 40m 80m 160m

N

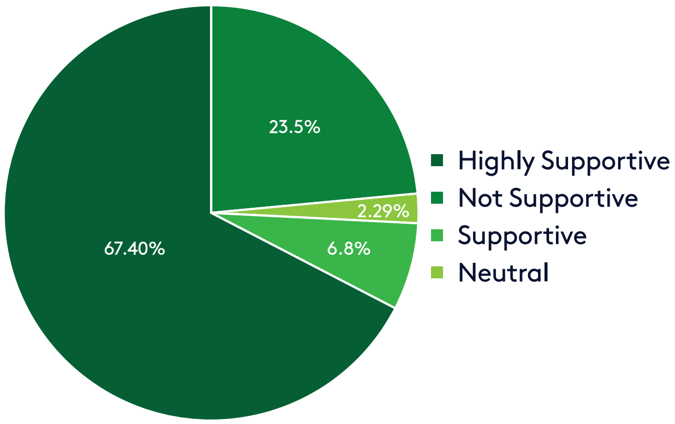
udla pty. ltd. www.udla.com.au +61 8 9336 7577 Level 1A, 3-5 Josephson St, Fremantle, 6160.

DRAFT

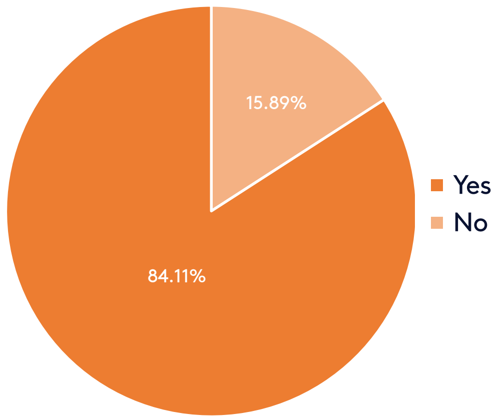
PROJECT	CLIENT	DRAWN	SCALE	DRAWING #	ISSUE DATE	REVISION
Broome Boating Facility	DoT	KT	NTS	MP-01	August 2020	C

Overview of Results

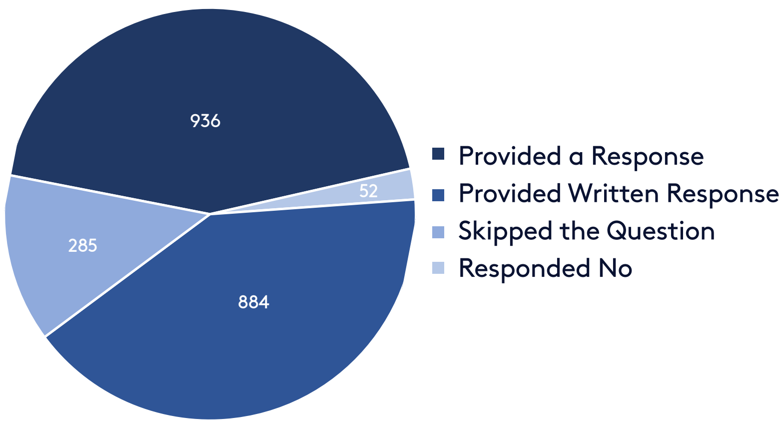
Please rate your support for the proposed Broome Boating Facility?



Do you own a boat or regularly go boating?



Do you want to provide any comments or suggestions on the proposed concept design below?



The 884 written responses are provided in Attachment 1. Each of the responses have been collated into key themes. These are detailed below. Where required, individual responses have been provided. Please note that key themes are not listed in order of importance.

Major design changes following community consultation include;

- Improved boat launching and retrial
- Avoidance of dinosaur tracks
- Retention of rock formations
- Creation of public spaces / picnic areas / seating / shelter
- Fishing / viewing platforms
- Fish cleaning
- Universal access to beach areas
- Artwork and interpretation
- Public toilets

1 KEY THEME ONE

- Facilities adequate as they are.
- Upgrade existing facilities.
- Improve safety for launching and retrieving.
- Lack of infrastructure for larger boats and marina.

2 KEY THEME TWO

- Safety concerns related to proximity to the shipping channel.

3 KEY THEME THREE

- Cost of project and future maintenance.

4 KEY THEME FOUR

- Entrance Point location.
- Visual impact of the project.
- Scale and footprint of the project is too large.

5 KEY THEME FIVE

- Alternative locations for the Broome Boating Facility and slipway site.

6 KEY THEME SIX

Environmental and heritage impacts:

- Impact on dinosaur trackways.
- Impact on a popular family beach.
- Impact on marine life / sand movements / fish stock / reef systems / sea birds.
- Impact on Aboriginal land.
- West Kimberley National Heritage Zone.
- Consideration of memorial plaques.
- Preservation of beach area and natural rocks.
- Retention of cave.

7 KEY THEME SEVEN

Design considerations:

- Ramp design.
- Carpark design.
- Jetty design.
- Requirement to protect from swell and breaking waves.

8 KEY THEME EIGHT

- Alternative boat launching and retrieving facilities during construction.
- Timeframes for construction.
- Use of local contractors.
- Source of rocks.

9 KEY THEME NINE

- Landscape design elements and amenities.

Key Theme 1

- FACILITIES ADEQUATE AS THEY ARE
- UPGRADE EXISTING FACILITIES
- IMPROVE SAFETY FOR LAUNCHING AND RETRIEVING
- LACK OF INFRASTRUCTURE FOR LARGER BOATS AND MARINA

Broome is renowned for its long and rich maritime history, particularly around the pearling industry and, in more recent decades, as the gateway to marine tourism in the Kimberley. Most Australians would regard Broome as a proud maritime town.

Yet Broome does not have a boat harbour, marina or even a sheltered boat ramp. The only significant marine facility is the port's jetty, which is used by large visiting ships. Smaller commercial vessels and a substantial fleet of recreational boats based in Broome have only beaches and exposed concrete slabs from which to operate.

Adding to this lack of amenity, Broome has one of Australia's most extreme tides as well as strong currents, soft sand and, at times, significant wind and waves, which often make boating activity extremely hazardous. Some of these conditions can change very quickly or combine to create an extremely hazardous environment.

The argument has been made that local knowledge can help boaters avoid the challenges associated with large tides and soft sand. However, decades of complaints from locals and multiple serious incidents confirm the existing facilities are not up to appropriate standard and that even the most experienced boaters can get into trouble. It is also worth noting the main driver for better facilities and associated demands on government has come from within the community.

A common scenario for Broome boaters involves launching at low tide under calm conditions and returning on a higher tide when wind, waves and currents have increased significantly. In such cases, there is no sheltered location or alternative options for those trying to get back to shore. While boaters may decide not to launch if they feel it's not safe, they can't choose not to return when conditions deteriorate.

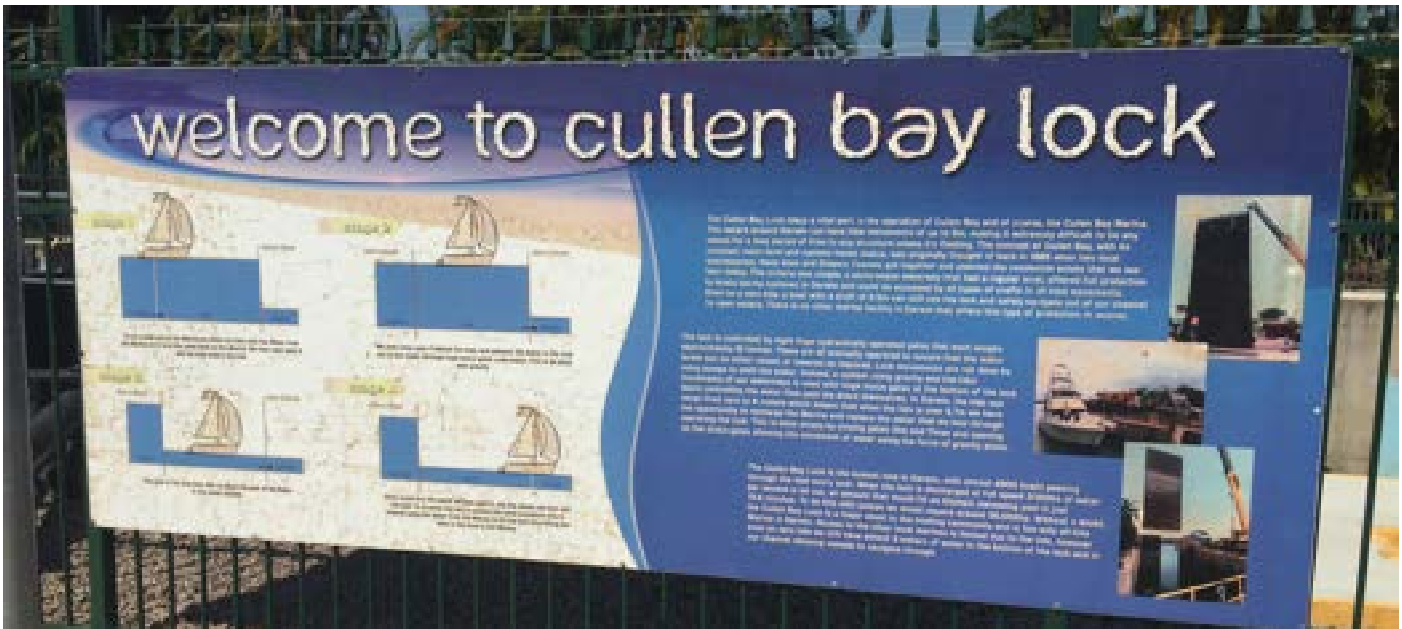
The design and development of small boating facilities in Australia has been guided by Australian Standards (including AS3962-2001) which have been adopted by nearly all local authorities and developers to build boating infrastructure, including community boating facilities. These standards prescribe criteria around shelter, wave protection and facility design. In most regards, the existing facilities in Broome fail to meet these standards. Upgrades to the existing facilities have also been suggested, and for all intents and purposes the proposed new boating facility represents the substantial upgrade necessary to meet contemporary design and operating standards in Australia.

Broome must address some unique and difficult challenges to provide facilities that meet these standards. These issues are the main reason why the town is behind most other regions in Australia in provision of safe and accessible boating facilities. Tides with a range of about 10m require much larger structures than are typically seen elsewhere in WA, adding to the cost and complexity of the design. Broome's exposure to cyclonic winds and waves, along with the need to acknowledge the sensitivities of building such a facility in a unique environment, exacerbate the design challenge.

This initiative responds to the safety issues and local demands for improvements while also addressing the standards considered appropriate elsewhere in Australia. The design also proposes allowing larger vessels of up to 20m to access the proposed jetties (under suitable conditions) for the transfer of passengers and light goods. This is considered important for many of the smaller commercial operators, such as tour and charter companies, which need to safely service their customers. Ultimately, the range of vessels that will be able to be serviced in Broome across the port's wharf, the Kimberley Marine Support Base's floating docks and this small boating facility will cover the majority of shipping, visiting vessels and local boating demands.

The possibility of naval operations from Broome has also been suggested in the past, particularly for visiting patrol vessels. While other facilities in Broome may be able to accommodate larger patrol vessels, this small boating facility could be used by smaller naval craft such as local sea rescue and marine safety vessels.

The final gap in marine facilities provision in Broome would then be boat pens, such as those provided within a marina. Proposals for the development of a marina in Broome, where permanent moorings could be provided, involve very complex and integrated maritime and town planning studies supported by significant private investment. Such a facility would likely rely on the use of a tidal lock system, which would not be suitable for the high volume trailer boat operations that make up most of Broome's current facility demand. The Cullen Bay marina development in Darwin would be a relevant example.



Key Theme 2

- **SAFETY CONCERNS RELATED TO PROXIMITY TO THE SHIPPING CHANNEL**

Questions have been raised about the proximity of the proposed facility to the shipping channel. The facility does not interfere with the existing shipping channel. As it would be built in an area that has for decades been used to launch boats, it would not introduce any significant changes to boating activity in the area.

The port is a key stakeholder and supporter of the boating facility project and a member of the Boating Facility Advisory Group and its advice and input is sought regularly. It is also worth noting that nearly all other ports typically have numerous small vessel movements within and through them under standard operations. Port Hedland and Fremantle are relevant examples in WA.

There are also several agencies in Broome that regulate the marine environment and boating activity. In many respects, the proposed facility will also assist them with their operations while also improving safety. Local agencies include Broome Sea Rescue, the Department of Transport (Marine Safety), the Kimberley Port Authority, Fisheries and the marine parks/ranger operations.

Key Theme 3

- **COST OF PROJECT AND FUTURE MAINTENANCE**

It has been acknowledged the capital cost of the project will be significant compared to other WA boating facilities offering similar levels of safety, amenity and access. Broome's tidal range, remote location, exposure to cyclones and a sensitive environment will all contribute to the cost of the project. Ultimately, the money spent must be weighed against the value placed on local safety, access to the marine environment and the range of economic benefits the facility will contribute to the community and region. At this stage, the full capital cost of the project has yet to be determined. This will be resolved with more detailed estimates of a final design and the value of contracts awarded through a competitive tendering process to build the facility.

The Shire of Broome is seeking funding through the State Government for the project.

As with all infrastructure built on the coast, allowance must be made for ongoing maintenance. This cost will be considered within the business case. Overall, the design process hopes to minimise future maintenance costs. A decision to remove a dredged channel (and therefore the cost of ongoing maintenance) and to ensure a robust structural design will significantly reduce operational maintenance costs.

Key Theme 4

- ENTRANCE POINT LOCATION
- VISUAL IMPACT OF THE PROJECT
- SCALE AND FOOTPRINT OF THE PROJECT TOO LARGE

Location

There is a long history of planning initiatives to deliver new boating infrastructure in Broome, including for boat harbours, marinas and boat launching facilities. Over the past three decades numerous sites have been considered and assessed, with some progressing to costed preliminary designs. In every instance there have been insurmountable challenges around project cost, environmental and heritage concerns, operational feasibility and engineering challenges, particularly around the extreme tidal range and periodic cyclones.

The current project has been relocated three times and scaled down significantly in response to similar issues. Starting out with initial plans for a much larger boat harbour, the project is now primarily a small boat launching facility that can address the safety and access problems faced by the majority of Broome's boating community.

Apart from significantly reducing the scale of the facility's footprint, the project has been able to work in closely with the existing environment, landform and bathymetry at Entrance Point, which removes the need to dredge.

The benefits of Entrance Point are:

1. Entrance Point already has boat launching infrastructure and this project represents an upgrade to the existing facilities that meets contemporary design standards.

2. The nearshore bathymetry at Entrance Point (unlike nearly all other coastal areas around Broome) drops into relatively deep water close to shore. This removes the requirement to either dredge channels or reclaim out a long way offshore to reach adequate depths. The current proposal achieves a close-to-all-tide access capability for small vessels.

3. The Entrance Point location sits within land and seabed currently under control of the Broome Port. Along with the adjacent Kimberley Marine Supply Base proposal and the port's wharf it consolidates the development of maritime facilities and infrastructure into a relatively compact location.

Visual Aspects

The extreme tidal range and the potential impact of storm surges and large waves from cyclones means designs for coastal infrastructure must be robust and also provide shelter during normal conditions. Australian design standards for boat ramps require that waves no larger than approximately 0.2m occur on the ramp. Exposure to waves, wind and currents at existing facilities, even under everyday conditions, are among the greatest concerns of boaters in Broome. Removing these hazards can only be achieved by providing sheltered structures such as breakwaters and rock walls.

Broome's tidal range means the upper level of these structures must be about 2m above the high-water level to be effective. The scale of this height can be visualised at the existing Entrance Point parking area, which is slightly above the high water line. Facilities of similar size and scale can be found in many other sites in Australia and around the world where similar large tides exist.

Key Theme 5

- **ALTERNATIVE LOCATIONS FOR THE BROOME BOATING FACILITY AND SLIPWAY SITE**

Between 2010 and 2013 extensive planning for a small boating facility was undertaken in the area around the existing slipway site in Roebuck Bay close to the port's jetty. The recent community survey generated several questions about why that location was no longer being considered. The slipway site has several challenges with suitability to be developed as a boat launching location. These include:

1. While the slipway can be used during periods of high tide there are long periods when the tide is not high enough for boats to be launched or retrieved. The solution requires either an extensive build out (reclamation) to reach deep water or dredging of a channel to reach deeper water. This problem does not exist at Entrance Point where good water depths exist closer to shore.

2. Dredging was investigated extensively and the fine silts and strong tidal currents in Roebuck Bay were not conducive to maintaining a stable channel. No dredging is proposed at Entrance Point.

3. Reclamation options were found to be overly expensive and raised environmental and heritage concerns.

4. The land area required to park boats and trailers, while also accommodating boat lifting and servicing, was not available.

Key Theme 6

- **ENVIRONMENTAL AND HERITAGE IMPACTS**

  IMPACT TO DINOSAUR TRACKWAYS

  IMPACT TO A POPULAR FAMILY BEACH

  IMPACT TO MARINE LIFE / SAND MOVEMENTS / FISH STOCK / REEF SYSTEMS / SEA BIRDS

  IMPACT ON ABORIGINAL LAND

  WEST KIMBERLEY NATIONAL HERITAGE ZONE

  CONSIDERATION OF MEMORIAL PLAQUES

  PRESERVATION OF BEACH AREA AND NATURAL ROCKS

  RETENTION OF CAVE

The proposed boating facility project is being carefully developed around all known environmental sensitivities and engagement has taken place with key stakeholders, interest groups and the environmental agencies at both a State and Commonwealth level. There is great appreciation of the sensitive nature of the environment in the Kimberley, the coast and in Broome and the appropriate investigations and studies have or are being conducted.

The boating facility project has spent more than two years collecting detailed coastal and hydrographic data, deploying instruments offshore and conducting regular bathymetric surveys. This data has established complex models that reproduce the marine environment including processes relating to waves, currents and sand movements around the proposed facility. These models enable testing and fine tuning of the facility design to ensure its performance and to ensure minimal environmental impact.

Environmental experts have been appointed to the project and it will be subject to regulatory referral and approval processes. Specific studies and investigations have also been undertaken or are scheduled around vegetation, seabed (benthic habitat), birds and dinosaur tracks. The issue of dinosaur tracks has been well reported in the media as a local concern.

This project launched an extensive study into dinosaur tracks in the media as a local concern. This project launched an extensive study into dinosaur tracks through Queensland University in 2016. That report was instrumental in the decision to shift the facility away from the initial site at Reddell Beach within the West Kimberley National Heritage Zone. The report identified concerns about the size of the facility, the need for dredging and damage to sandstone rock potentially holding tracks and prints. The design of the facility, now outside of the West Kimberley National Heritage Zone, has been scaled down by more than half, the need for dredging has been removed and no rock structures are proposed to be removed. The proposal sits adjacent to the small rock headland north of the existing boat ramp and care will be taken in the final design process to ensure there is minimal impact in the transition between the natural rock and the edge of the boating facility. There is no intention to remove any natural rock, caves or existing features. It is also recognised that the rock headlands have important value and meaning in the community, ranging from traditional use, swimming and fishing platforms and as a memorial site. The value placed on the beach in this area is also acknowledged, along with the expectation that the community will still be able to access the beach adjacent to the new facility. The design process to date has been mindful of the beach impact and refinements have been made to make the facility as compact as possible and to limit the extent of beach impacted as much as possible. However, the requirement to improve the shelter at the ramp and the ability to use the ramp under most tidal conditions means that some beach impact is unavoidable.

Rock headland and beach - Entrance Point

Notwithstanding the significant changes implemented within the evolving design it is acknowledged that concerns remain about possible impacts to offshore sections of Broome sandstone that are reported to contain dinosaur tracks and prints. The design team remains committed to mitigating impacts in any practical manner and continuing to engage with experts. The facility will provide an excellent platform to access the area, including signage and interpretive information about the dinosaur tracks and potentially display real samples, noting that most prints are offshore and under water except during extreme low tides.

The project has also made considerable efforts to work with and around local cultural and heritage issues and concerns, including working closely with the local Yawuru community to map areas of sensitivities and adopt changes to the site location and layout in accordance with the Yawuru community's direction and wishes. The project concept and location received the support of the board of Nyamba Buru Yawuru in early 2020.

Key Theme 7

- **DESIGN CONSIDERATIONS**

  RAMP DESIGN

  CARPARK DESIGN

  JETTY DESIGN

  REQUIREMENT TO PROTECT FROM SWELL AND BREAKING WAVES

The boating facility project has spent more than two years collecting detailed coastal and hydrographic data, deploying data collection instruments offshore and conducting regular bathymetric surveys. This information has enabled complex models to be established that represent the marine environment, including processes relating to waves, currents and sand movements. These models enable testing and fine tuning of the facility's design to ensure its performance along with minimising the environmental impact.

The design process starts with the development of a concept based on several key coastal engineering and maritime facility planning standards and guidelines and is then refined through computer model checks and detailed engineering. Other factors also influence the design, including community feedback, environmental and cultural and heritage sensitivities.

The coastal structures are carefully engineered with respect to extreme storm events, wave heights and tide levels, while the functionality of the ramps, jetties and carparks are planned around set guidelines and Australian Standards, including the updated Australian Standard 3962-2020 which provides detailed guidance on parking configurations and capacity. There are a few key principles that need to be considered and applied when designing new boat launching facilities.

1. Providing wave shelter at the boat ramp is a critical safety factor. AS3962 states that wave heights should be below 0.2m. Achieving this in Broome requires shelter structures to be built. The structures, as per the design concept, will be carefully tested and adjusted as needed to meet or exceed the criteria under normal conditions.

2. The cost of the protective breakwaters is significant and as such the design should ensure there is some capacity to meet a future increase in demand.

3. Parking capacity needs to be sufficient to accommodate peak periods with some allowance for growth.

4. A worst-case scenario for a boat launching facility could occur when there is extreme congestion on busy days and there are long wait times to launch and retrieve vessels. This congestion can be addressed in several ways, including:

- Good layout and design of the roads and parking, including keeping trailer parking bays as close as possible to the ramps;

- Providing an adequate number of parking bays;

- Providing an adequate number of ramp lanes, potentially allowing for separate launch and retrieval lanes; and

- Providing jetties for boat holding, noting that the length of the jetties and the number of vessels that can be accommodated would greatly assist in managing congestion.

All these guidelines, standards and factors will be refined and applied in the final design configuration.

Jetties

The inclusion of jetties on boat ramps serves several important purposes:

1. They provide a holding structure to tie up a boat so that people do not have to be in the water trying to hold a mobile vessel, thereby improving safety.

2. They provide a safer means to transfer people and light equipment between vessels and the shore.

3. They offer safety and efficiency improvements when launching and retrieving.

4. They improve the speed at which boats can be launched and retrieved and fewer people are required to manage the process.

For these reasons it is highly desirable that the new facility includes a jetty or jetties. Typically, new boat launching facilities use floating (pontoon) jetties as these ensure a consistent and similar level between the boat and the jetty, making boarding easier.

Floating jetties are preferred and are being investigated for inclusion at the Broome facility. The challenges to their use include Broome's extreme tidal range and the potential for cyclone damage. Both factors means a very robust design would need to be considered. The alternative to floating jetties are fixed jetties. However, with Broome's large tides these structures would need to include several level stages to accommodate different water levels.

Floating Jetty Example (DoT WA)

Multi Stage Fixed Jetty - Point Samson

Key Theme 8

- **ALTERNATIVE BOAT LAUNCHING AND RETRIEVING FACILITIES DURING CONSTRUCTION**
- **TIMEFRAMES FOR CONSTRUCTION**
- **USE OF LOCAL CONTRACTORS**
- **SOURCE OF ROCKS**

Several questions have been raised around the construction process for the new boating facility. What alternate boat launching and retrieval facilities will be available during construction and timeframes for construction?
Commencement of construction activity on the project will be subject to several factors. These include:

- Government approval to provide the funding;
- Securing the appropriate approvals for the works; and
- Securing contractors through government tender processes to undertake the works.

Construction work is likely to take approximately 12 months and it is anticipated that access to Entrance Point will be heavily restricted during that time. The length of the disruption will be determined once the appointed contractor/s schedules and work programs are received. The Shire, Port and Department of Transport will liaise closely with the contractors to determine their schedules and the length of disruption. Work contracts will specifically identify the need to minimise disruption and access constraints. However, with a single access road and heavy equipment and storage requirements for plant and materials onsite it would not be safe to allow public access to the area during the early works phase.

- **Local contractors**

The State Government has strict procurement policies to promote the use of local contractors wherever possible to assist with regional prosperity and employment. Project briefings are provided for local businesses to ensure they are fully informed of the opportunities and requirements ahead of tendering processes. The State will undertake a competitive public tendering process to secure the contracts for the work and local companies would be strongly encouraged to apply.

- **Rock supply**

The proposed design for the boating facility incorporates a significant amount of rock for wave protection. The size (and weight) of the rock required is calculated based on strict coastal engineering principles to ensure the facility is strong enough to withstand occasional extreme events, including cyclones. Indicatively, this translates to rock (armour) sizes ranging from 2 to 8 tonnes, with larger rocks required for the detached breakwater and outside arms of the ramp breakwater.

A significant number of studies have been conducted on the availability and supply of rock suitable for the project and there are some key findings to note.

1. Local rock is primarily a layered sandstone and it has some technical limitations. Its layered (slab-like) nature is not ideal to achieve strong interlocking between rocks, particularly where large waves could occur. This rock has been used effectively at Town Beach and is likely to be suitable for some elements of the facility.

2. The sandstone becomes somewhat brittle over a certain size and is prone to breaking.

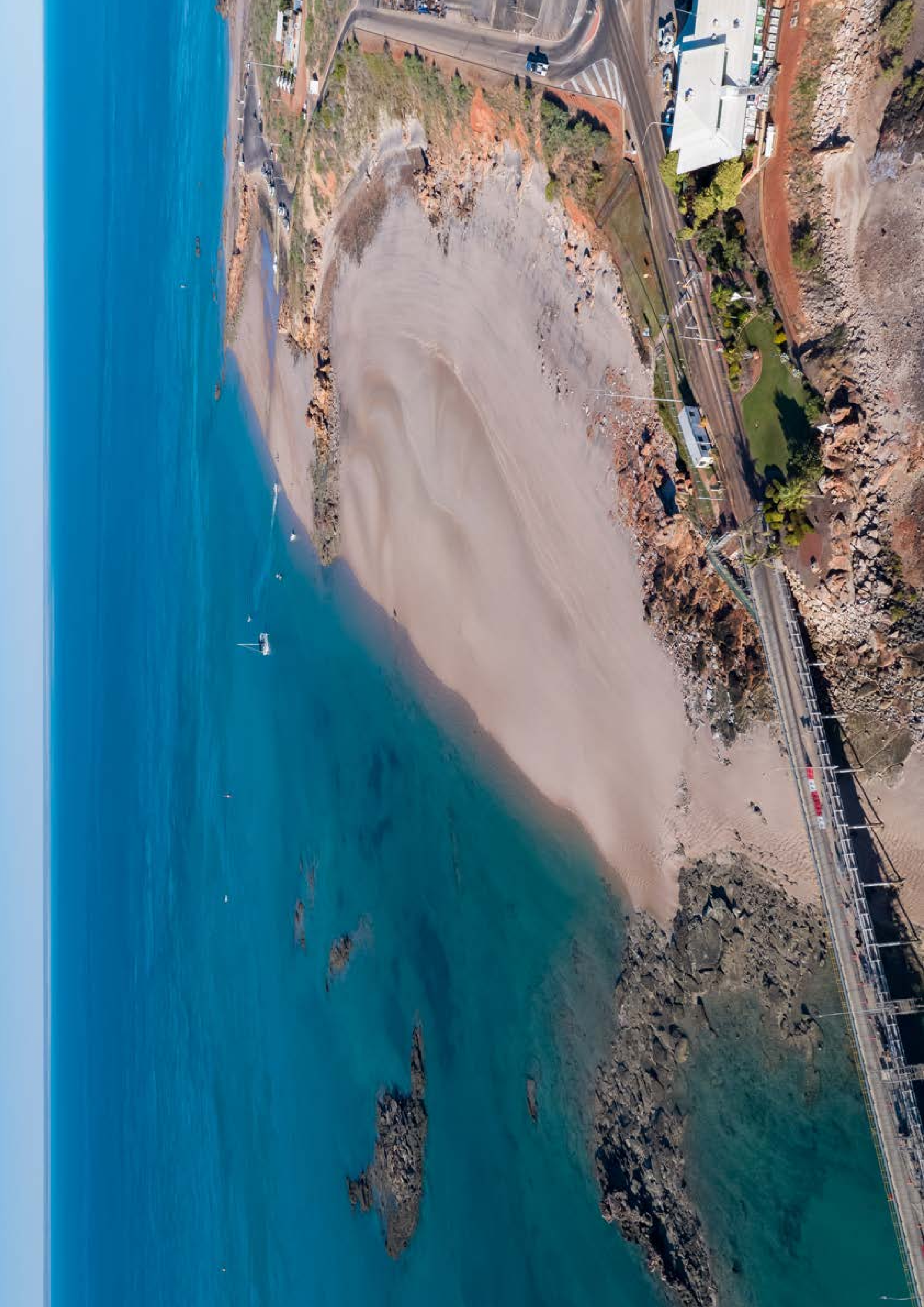
3. There are no nearby sources of granite rock which is more suitable for use as large armour.

4. The ultimate design may be a hybrid of local materials, supplemented by granite or similar rock transported in and placed in a careful and aesthetic way.

5. The final mix and type of materials will be determined by the contractors tendering for the works to identify and propose for approval.

6. The works contract will demand a very high standard of quality and aesthetics for the rock works.

7. Entrance Point currently includes a diverse mix or rock types and colours, with offshore rocks predominantly dark in colour while rock headlands are more reddish / orange or lighter.



Key Theme 9

- **LANDSCAPE DESIGN ELEMENTS AND AMENITIES**

Once the final footprint of the proposed facility is confirmed through coastal engineering checks attention will be given to the overall range of facilities and amenities that will be provided, many of which will benefit the community as a whole. Many queries and suggestions have been received through the consultation phase and these will be carefully considered for inclusion. Suggestions include:

Pedestrian bridge to the detached breakwater

The breakwater is needed to shelter the ramp from waves and vessels. Under most tidal conditions access is available by entering and exiting the ramps from either the northern or southern end. A bridge at either end would be an impediment to taller vessels and would be a relatively high cost / high maintenance structure. Also, having to make formal provisions for the public to access the offshore breakwater would significantly increase its structural design and overall cost. It is not likely to be a suggestion progressed in the proposal. However, it may be re-visited as a future development.

What type of facilities and amenities will be included?

The facility will be designed to accommodate a range of amenities for the community beyond those who own a boat. The finer details will be developed through the design and landscape design phases, however the following are priority inclusions and items that will receive strong consideration:

- Public amenities
- Artwork and interpretive information and displays
- Lighting
- Information / operational signage
- Shade structures / seating
- Shared-use paths / bicycle parking
- Bins, drinking fountains
- Beach access points
- Single vehicle parking bays

Additional suggestions that require further consideration by the Boating Facility Advisory Group and the shire include:

- Provision of beach access for vehicles
- Provision of wash down facilities and fish cleaning facilities
- Establishing a kiosk
- The inclusion of a fishing and or swimming platforms
- The inclusion of a grassed picnic area

Additional Comments and Questions

Inclusion of depth contours on the concept design

Depth contours can be easily added to the concept plan and future versions will incorporate one or more that show the contour lines. The Department of Transport regularly performs detailed hydrographic surveys in the project area as part of annual assessments for the Broome port and holds detailed and very accurate bathymetric (sea floor mapping) records. This data has been a key design input to the boating facility concept and has helped to site the facility. It has also confirmed natural water depths at the boat ramp toe of approximately +0.5 metres Chart Datum, which translates to approximately 99% of the time being below water without the need to dredge or maintain a channel.

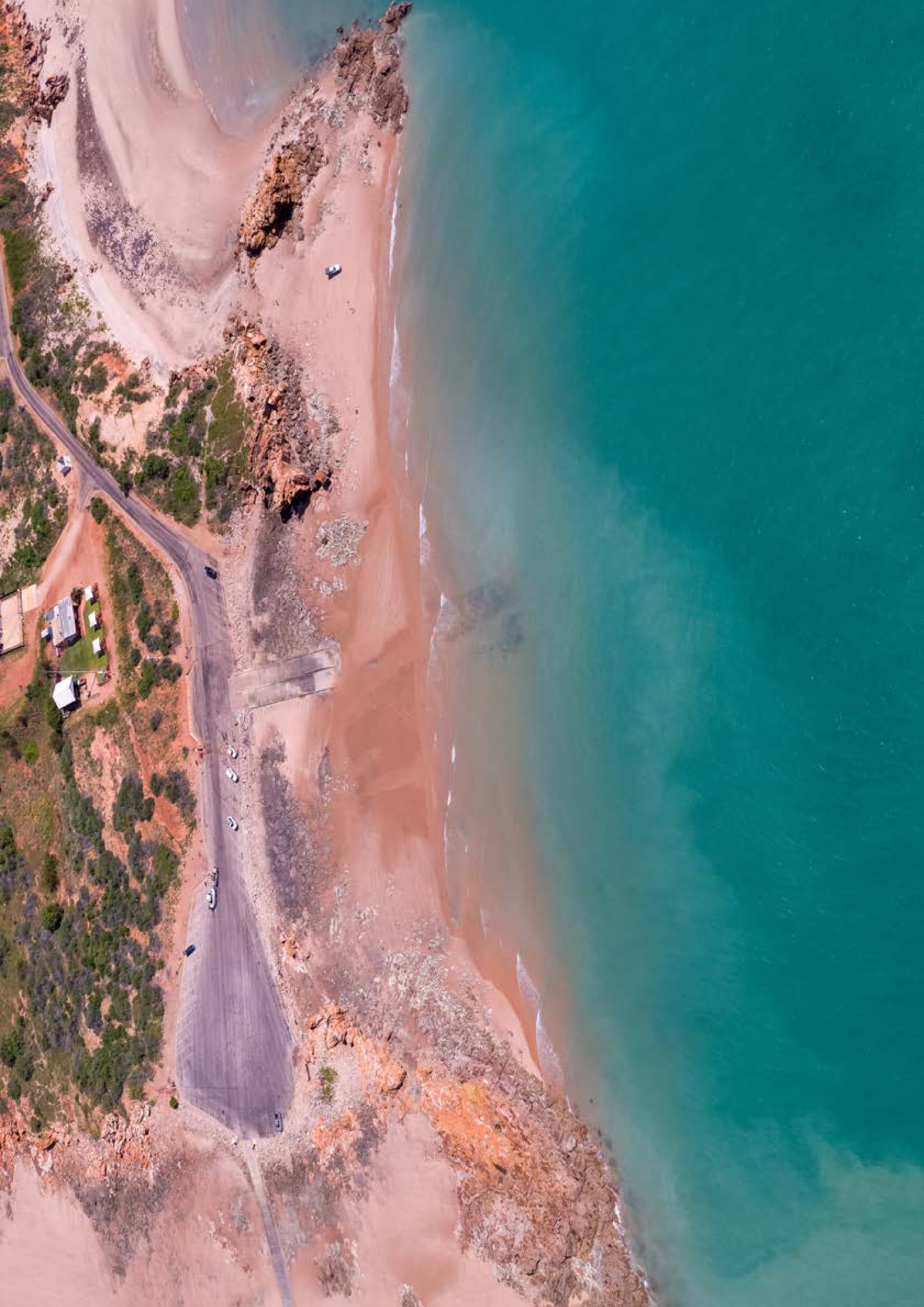
Fish stocks

Questions have been raised about the potential impact to fish stocks as a result of improving the boat launching facilities. This is understood to mean that increased boating activity may mean more people fishing and diminished local fish stocks. In other areas of the State (including Cockburn Sound in Perth) fish stocks have been effectively managed (and in many instances improved) through the introduction of quotas, seasons and size limits, some of which already apply in Broome.

Road alignment

The project team has been contemplating the opportunity to include a new access road to the boating facility. There are several key reasons to consider this. These include:

- The new facility provides the opportunity to establish a recreational community precinct separate from the existing port operation under which the facilities at Entrance Point currently exist. Ideally this could be enhanced by the separation of heavy commercial port traffic.
- The development of the Kimberley Marine Support Base will likely impact the existing road access to Entrance Point and adjustments to the existing access road are likely to be required.
- A new access road could improve access to areas that are not currently readily accessible, including Reddell Beach where a recent dinosaur trackway study identified tracks and prints that are accessible and of significant tourism value. Additional work is required before all the viable options for a new road access option can be resolved.



Individual Comments and Responses

Individual responses have been provided where information has not been covered adequately in the key themes.

"I'd like to know more about how this may or may not affect Roebuck Bay. Will it change the channels, will it affect Dampier Creek?"

The proposed facility will not affect Roebuck Bay or Dampier Creek. Extensive investigations have been carried out and of most significance is the finding that tidal currents predominantly flow out from Roebuck Bay past Entrance Point. Any local impacts are expected to be minor and the facility is located well away from Roebuck Bay.

"How much will it cost? Who will own and run the project? Who will own and run the facility? Who will pay for upkeep and maintenance? Where will the access road go, and why isn't it on any of the maps?"

The total cost of the project will be resolved through the detailed design process and determined through the contracting and tender process. It is hoped that local companies will vie for the work, generating employment and reducing costs.

The project will be delivered by the Department of Transport in collaboration with the Shire of Broome. The business case will make allowance for ongoing operational costs and resolve the asset ownership issue between the State and the Shire, recognising that the site is currently under the control of the Kimberley Port Authority.

The access road is subject to its own planning process.

"What is the recreation precinct, as mentioned on the website? Are there further plans for the development of Entrance Point? What recreation is envisaged? How will water traffic using the proposed facility interact with commercial and industrial water traffic?"

Entrance Point and the existing boat ramps are currently within the land and water space controlled by the Kimberley Port Authority. The Port Authority's masterplan recognises the potential to excise Entrance Point from its commercial operation. Given the existing uses of the Entrance Point area is for community access and recreation the term "recreation precinct" has been suggested as a more appropriate definition. Recreational activities in this area include boating, fishing, beach access, swimming, interpretive displays and tour operations.

The water traffic issue has been addressed in the key themes section of this report.

"I would have thought that even before we arrived at this stage that some evidence of the need would have been provided. For example: how many vehicles have been bogged or not recovered and why, was it negligence on the part of the owners not reading the tides? How many days has it not been possible for boats to be launched from this area/ Gantheaume/port slipway? Is there going to be any cost recovery from boat owners to use the ramp? I note that boat owners are charged annually for the use of a pen. I guess my main objection is the consideration that the amount of money being spent on this for the benefit of a few could be better spent on housing, in particular, which would go a long way to improving the social conditions of many."

There is a long history of boating-related incidents and accidents in Broome related to tides, waves, strong currents and soft sand. These matters have continually driven local demands for improved facilities to a standard available in most other areas over several decades. The proposed facility largely resolves those issues but is expensive due to the engineering challenges. There is a State Government commitment to progress planning for such a facility that responds to years of local demands supported by local authorities, sea rescue and community groups. There is currently no suggestion or intention to charge fees for use of the facility.

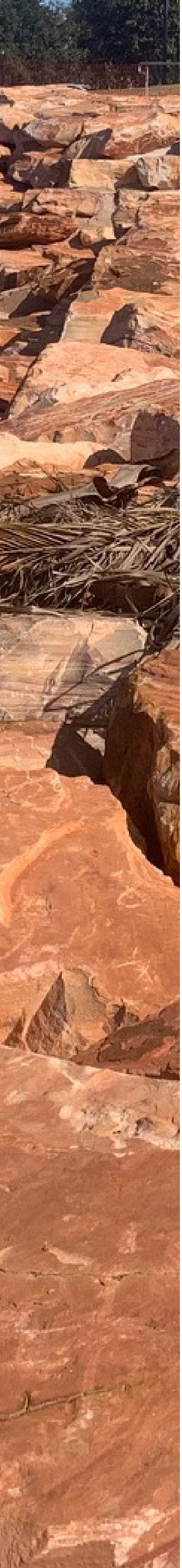
The Broome Boating Facility is included in the Shire of Broome's Strategic Community Plan as a priority.

"It is Phil's belief that the Entrance Point part of the new facility should have capability to host a strong naval presence if needed, including maintenance of submarines. Phil mentioned that during WWII there were no facilities capable of maintaining naval submarines between Perth and Broome.
Where the slipway is currently as you come into the port area would be better suited to the new public boating facility. Phil believes that you should be contacting Kim Beazley, former defence minister for his opinion on the matter as Mr (Beazley) had established the Curtin Airbase and has a good working knowledge of defence requirements."

The naval issue has been partly responded to in the key themes section. The Commonwealth Government undertakes its own planning for naval and military facilities and there has been no indication that there is any interest in developing a maritime presence in Broome. Previous planning for the development of a small harbour explored the possibility of facilities capable of accommodating naval patrol vessels with a potential funding interest from the Commonwealth. However, there was no indication of support. Previous applications for Commonwealth funding assistance for new maritime facilities in Broome have also been unsuccessful.

"What is the cost? What is the impact on our rates? Can the town afford this?"

The capital works to build the facility would be funded by the State Government, potentially through the Royalties for Regions Scheme and not via Shire reserves. No related impact to Shire rates is anticipated.



"Does the design make any allowance for rising sea levels due to climate change? How will this affect the size and time the facility is able to be used? Where will the required rock come from? Will a toll be charged for ordinary users, and will commercial users help contribute to the cost?"

The design height of the structures and facility overall applies best practice coastal engineering design, which includes an appropriate allowance for a sea level rise. The sea level rise allowance adds a small percentage to the cost of the works, noting also that sea level rise will impact the existing infrastructure at Entrance Point, requiring improvements at some point regardless. Sea level rises will over time improve the accessibility to the facility for larger vessels. No public user fees have been planned or considered for the new facility. No fees for commercial operators have been considered yet but this may be a possibility depending on demand and the value the facility provides to commercial operations.

"My two concerns are: 1. Cost to ratepayers. Can the shire guarantee that ratepayers won't be footing any of the design, construction, maintenance and end-of-life disposal costs? 2. Access. If the new floating facility is built where will the access road be located, and will this require further intrusion on the dunes?"

Ratepayers won't be required to fund the design or construction of the facility. This funding is proposed to come from State Government programs. Maintenance costs will be considered in the business case but are not expected to be significant and may be partially offset through commercial opportunities. End-of-life disposal costs are typically addressed through depreciation allowances, noting the facility would have a design life of between 50 and 100 years.
The Kimberley Marine Supply Base development proposal is required to resolve and maintain road access to Entrance Point. Several options have been considered by the project and by the port, which has previously supported a re-alignment of Kabbarli Road to behind the sorghum shed.

"I've just observed the flooding of the Entrance Point carpark on the two recent high tides. Can you explain where that water will go when it's high tide and this project is built? Is there risk to flooding in other locations, or larger effects on water movement and consequent sand, silt and erosion?"

Sea level rise is a well-known problem and current coastal planning policies and coastal engineering practices make adequate allowance for this. As has been noted parts of the existing carpark at Entrance Point are very low and subject to occasional inundation. The proposed facility will remedy this, protecting the shoreline, and will make allowance for future rise in accordance with planning and design policies. Overall, the new facility will not cause flooding elsewhere and detailed studies of sand movement, waves and currents has been undertaken to ensure minimal adverse impacts.

"Where is the access road and why isn't it marked on the map? What size armour is required? What size waves are predicted? What impact will rising sea levels have on the proposal? When will the proposed detailed cost be provided? What is the approximate length of the ramps? What data has been used to estimate demand? Is this data publicly available, and if so where? What is the predicted increase /decrease in boat usage over the projected life of the project? Can the same goal / capacity be achieved by two ramps each with a pull out loop?"

Access to the boating facility site is guaranteed either as maintenance of the existing access or as an improved alternative. A final decision on the access road alignment has yet to be made and may also be associated with the final development concept of the Kimberley Marine Supply Base proposal.

The forecast significant wave sizes at the outer extent of the facility are <1m under typical conditions and 3m to 4m under extreme (cyclonic) conditions. These values are used to calculate "armour" sizing. The mean armour size could be up to 8 tonnes depending on the rock type used and the final design.
The design will include sea level rise allowances in accordance with planning and design guidelines and standards.

The detailed costing will be prepared to a "P90" standard. That is, a probabilistic cost estimate that will ensure a 90% chance that the final cost will be below the estimate. Preparation of this cost estimate requires very detailed inputs of every element. This is a complex task starting with the main structures. This work is in progress and a detailed estimate is expected mid to late-2020. The final cost will be determined through the tender and contract process.

The length of the ramps is defined by the upper elevation and the bathymetry at the toe of the ramp and a ramp grade of approximately 1 in 8. In this instance the ramps are approximately 85m long.

Demand for the facility is derived from several sources but typically increases at a steady rate similar to population growth and growth in tourism. Demand statistics have been collected through local vessel registrations tracked annually, surveys of the existing facilities on peak days, monitoring by Department of Fisheries and the Department of Transport and local reports including from the adjacent fishing club and sea rescue operation. The Department of Transport has previously prepared a boating demand study for Broome and holds statistics that are updated annually.

Contact maritimeplanning@transport.wa.gov.au if you would like copies of this information.

Boating demand in Broome is increasing at about 3% each year.

The proposed facility includes capacity for growth in demand with the width of the ramp allowing for four lanes. Limiting the potential allowance for growth in the initial design could result in the need to build a second facility in the near future. Having to find a second site and duplicate the high expense of each of these facilities is not recommended.

"It is better to spend a smaller amount securing improved access at various locations to provide all weather options. It's likely that launching and retrieving will remain challenging given the overall nature of the location. Does this plan guarantee no safety risks in all wind, tides, waves etc and will it encourage down south mob to go out in dodgy weather and then expect to be rescued? More education and promotion of safety practices required. Will this be included in the budget?"

The extreme tidal range in Broome means there is no cheap option to provide a sheltered boat ramp that can be used under most conditions. The existing situation in Broome where there are a number of unprotected ramps that are frequently not accessible or safe represents the best efforts (to date) to provide facilities at a range of locations. A significant design and capital cost is unavoidable if the problem is to be addressed.

The proposal cannot guarantee to meet design standards all the time, especially during cyclonic events, but will achieve a very high opportunity of safety and access well above any existing ramp location in Broome.
It is likely that a significant improvement in the facilities will attract greater use and visitation from non-locals. Critically, the new facility will provide a sheltered refuge at the ramp for returning vessels which has been a key point of difficulty and hazard for all boat operators in Broome.
The facility will feature significant promotion and safety signage, and this will be included in the budget. The facility will also be a major improvement in accessibility and safety for the local sea rescue and marine safety operations to use.

"Please provide a full concept image of Entrance Point to the public, inclusive of the floating facility on the other side of the boat launching concept. This will provide full transparency to the community which I believe we are yet to see from the shire. Please also provide the environmental impact report with full transparency on who paid for the report to be done. I don't believe the shire is giving the community the full picture, which is an incredibly sad and disheartening thought."

Concepts and visualisations of the facility will continue to be produced and updated on the project website. The inclusion of the Kimberley Marine Supply Base development proposal will also be included on future plans where appropriate noting that a final design for that project is not currently available.

The environmental studies are being funded through the State Government's Royalties for Regions program and the project will be subject to all typical environmental and regulatory approvals that include a public review process.

A note to Engawa Architects

Thank you for your detailed comments and support for the project.

Your suggestions are welcomed and align very well with the project outcomes and intended use of the site and facility. Ultimately the facility will include a range of facilities and amenities that extend well beyond the immediate boating needs to ensure it caters for the broader community and visitors. Your suggestions as marked up on the plan will be carefully considered by the design team in the next phase of design work.

Additional Survey Results

Twenty-nine 'not supportive' responses were received from one IP address. This IP address may be from an organisation rather than a residential address.

Written responses from the single IP address are below:

Opposed to location, will destroy beautiful beach we use regularly for picnics, fishing and walks.

Risky proposition to site ramp on open ocean side of point....likely to only encourage gung-ho and foolhardy boaties from out of town to get amongst in during inappropriate weather conditions...a possible safety disaster in the making.

How high are the ramps and island above the level of the current surface? How will they effect the water flow of the area, especially at big tides? If they are to be used at ALL TIDES how do people get into their boats at low tides? How much will it cost to use the ramps? Why were the Nationally Heritage listed dinosaur tracks not taken into consideration, the areas they are located in has been publicly available since March last year; the Shires SBH report? Does Broome really need 4 ramps... where is the data for this?

Why wreck another bit of coast to keep an interest group happy. There is already a jetty there, use your brains and work out how it can be put to better use.

Will destroy Entrance Point beach that I currently use 4 to 5 times a week with family to fish and relax. Car park size is completely inappropriate for the location - reduce the number of lanes and make the car park smaller. No identification of an access road, how will people access the point once new floating facility is built. Flyover doesn't give a sense of scale, need more detail. And no more bloody palm trees please.

Another project that wrecks Broome's landscape and destroys our unique heritage and coast.

Inappropriate to invest all resources in a single location, more appropriate to have multiple access points for differing tides, winds and conditions. Effect on beach totally unacceptable - large rock walls will ruin the amenity and likely to have impact on sand movements and tidal flows. Inappropriate location so close to existing port and proposed new floating marine base - create high risk location. Insufficient detail on website - no real cost details, no information on water movement and no details on who will own, operate and maintain.

Another million dollars wasted on a pretty picture and no details about who will own it, who will pay for it, who will look after it and who really wants it. Why does the Shire keep speaking to the same people (eg fishing club top brass) rather than getting out and asking what the people of Broome want?

How high are the ramps and island above the level of the current surface? How will they effect the water flow of the area, especially at big tides? If they are to be used at ALL TIDES how do people get into their boats at low tides? How much will it cost to use the ramps? Why were the Nationally Heritage listed dinosaur tracks not taken into consideration, the areas they are located in has been publicly available since March last year; the Shires SBH report? Does Broome really need 4 ramps… where is the data for this?

More misuse of our rates to prop up one segment of the population and the construction industry. How many actual jobs will this project create in the long term? (Not including construction works) I'm sick of constant rate increases making it unaffordable to live in this town.

Can the size of the facility be reduced to cut down some of the competition for fishing? With 4 lanes likely we will be waiting even longer for every Tom, Dick and Harriet to learn how to reverse their trailer. I would prefer the money to be spent on multiple access points so that people who know how to read a tide and weather chart can launch and retrieve safely at the best location - rather than (trying) to use engineering to solve the problem of lack of knowledge and education. Finally, who will deal with the increased distress calls when people have launched without considering the conditions and end up in trouble?

This appears to be another cockamamey scheme cooked up by the Shire President and the Fishing Club to pour public money down the drain on their wet dream of a magical boat launching facility that will somehow make it safe to launch in all weather. Who is really benefiting from this project - locals who fish and can read the weather or construction companies and commercial marine operations?

What is the cost? What is the impact on our rates? Can the town afford this?

Does the design make any allowance for rising sea levels due to climate change? How will this affect the size and time the facility is able to be used? Where will the required rock come from? Will a toll be charged for ordinary users, and will commercial users help comtribute to the cost?

My two concerns are 1. Cost to ratepayers - can the Shire guarantee that ratepayers womt be footing amy of the design, construction, maintenance and end of life disposal costs? 2. Access - if the new floating facility is built where will the access road be located and will this require further intrusion on the dunes?

Just observed the flooding of the Entrance Point Car park on the two recent high tides...can you explain where that water will go when its high tide and this project is built? Is there risk to flooding in other locations, or larger effects on water movement and consequent sand, silt and erosion?

Where is the access road and why isn't it marked on the map? What size armor is required? That is what size waves are predicted? What impact will rising sea levels have on the proposal? When will the proposed detailed cost be provided? What is the approximate length of the ramps? What data has been used to estimate demand? Is this data publicly available, and if so where? What is the predicted increase / decrease in boat usage over the projected life of the project? Can the same goal/capacity be achieved by 2 ramps each with a pull out loop?

What is the cost? Will our rates go up to build and maintain this? Will there be a toll / charge? Will commercial operators pay anything towards it? The image and flyover shows some beach will remain north of the ramp before Entrance Point, will this beach be accessible to the public...and if so how? Please no more palm trees.

Better to spend a smaller amount securing improved access at various locations to provide all weather options. Likely that launching and retrieving will remain challenging given the overall nature of the location - does this plan guarantee no safety risks in all wind, tides, waves etc and will it encourage down south mob to go out in dodgy weather and then expect to be rescued. More education and promotion of safety practices required - will this be included in the budget?

Waste of money...better to invest in something productive that generates income for the community over the long term.


Broome Boating Facitlity - Artist's Impression

KIMBERLEY PORTS AUTHORITY

Your ref:

Our ref: CRE74/185850
Enquiries: C Faulkner

Attn: Steve Jenkins
Executive Director Maritime
Department of Transport
5 Newman Court
FREMANTLE WA 6160

Email: Steve.Jenkins@transport.wa.gov.au

Dear Steve,

RE: LETTER OF SUPPORT, BROOME BOATING FACILITY – ENTRANCE POINT

The Kimberley Port Authority (**KPA**) is writing to express support for the Broome Boating Facility as proposed for Entrance Point.

The KPA has worked closely with the Department of Transport and the Shire of Broome through all stages of the project to reach the current design and location. The Chief Executive Officer of the KPA has held a place on the Broome Boating Facility Advisory Group (previously Broome Boating Harbour Advisory Group) since its commencement and the KPA Board has been regularly briefed on the project and is supportive.

The proposed facility is located on land and seabed under control of the Port at the location of the existing boating facilities at Entrance Point and is supported by KPA for the following reasons:

- It addresses long standing small vessel safety issues at the existing facilities
- It brings shared responsibility for the community facilities at Entrance Point
- It provides an option to establish a new access road to Entrance Point that will provide safer separation of public and commercial traffic and land use with associated benefits to the Port
- It provides an opportunity to establish improved security at the Port through the exclusion of the public to industrial areas
- It provides an opportunity for the Port to optimise its operations

The KPA notes that the Business Case proposes a management model where the KPA retains the Entrance Point boating facility as its asset. Subject to agreements between the Department of Transport, KPA and the Shire of Broome for its ongoing care and maintenance, and as long as the management model is appropriate and agreed between KPA, the State Government and the Shire of Broome, KPA is supportive of this approach.

This project is critical to address existing small vessel safety issues in Broome and the Kimberley Port Authority looks forward to continuing to work will all stakeholders to ensure successful project delivery.

Yours sincerely

Reece Waldock AM
CHAIRMAN

13 OCTOBER 2020

Our ref: NR: CTE33

Shire of Broome
people • place • prosperity

30 September 2020

Mr Steve Jenkins
Executive Director, Maritime
Department of Transport
5 Newman Court
FREMANTLE WA 6160

Dear Steve,

LETTER OF SUPPORT, BROOME BOATING FACILITY ENTRANCE POINT

The Shire of Broome is writing to express support for the Broome Boating Facility proposed for Entrance Point.

The Broome community has been requesting the assistance of successive state governments over several decades to improve the standard of facilities in Broome, to respond to unsafe boating conditions and facilities which have seen numerous accident and incidents.

The facilities in Broome do not meet the standards currently expected of boating facilities in Australia and are below the standard in most other regional towns. A boating facility for Broome has been considered in various forms for more than 30 years.

A safe boat launching facility has been included as a priority project in the Shire's strategic planning documents for several years; most recently the Strategic Community Plan 2019-2029 and the 3-year Broome COVID-19 Recovery Plan.

The Shire of Broome and Department of Transport (DoT) have worked closely with Nyamba Buru Yawuru, Broome Fishing Club, Kimberley Port Authority, Dinosaur Coast Management group and the broader Broome community to reach the current design and location.

The Shire agreed to lead the Broome Boating Facility community consultation process. The community survey questions were developed in collaboration with DoT and the survey open to the public from 18 March – 16 April 2020. A dedicated project website was also developed www.broomeboatingfacility.com.au

The Shire received an overwhelming response to the survey with 1221 responses and 74.2% of respondents in support of the project. 884 detailed written responses were received from the community survey and these were reviewed by SoB and DoT officers. A detailed Community Survey Report was prepared in response to submissions and where possible the concept designs were altered. Major design changes included:

- Reduction in size and shape of the offshore breakwater to avoid all dinosaur trackways and natural reef areas
- Change to boat and car parking footprint to avoid dinosaur footprints
- Universal path and stair access to beach areas
- Addition of public spaces and amenities to the concept designs
- Addition of a viewing / fishing platform

- Fish cleaning areas
- Opportunity for public art and interpretive information
- Retention of as much of the beach area as possible
- Retention of rock / cliff formations

The Shire of Broome undertook a Community Perceptions Survey in June 2020 to gauge the public's sentiment about our town, the Shire's performance and what priorities for the future should be. A total of 1046 residents, business operators and ratepayers completed the survey. The second highest community priority identified in the survey was the need for better boating facilities and safe all tide boat ramps.

At the Ordinary Meeting of Council on the 23 September 2020 it was resolved:

That Council:

1. *Notes the Broome Boating Facility Advisory Group minutes and recommendation from the 11 August 2020 meeting (Attachment 3);*
2. *Endorse the Broome Boating Facility Community Survey Report (Attachment 1);*
3. *Endorse the revised Broome Boating Facility Concept Design for inclusion in the Department of Transport Business Case (Attachment 2);*
4. *Subject to funding from the Department of Transport, request the Chief Executive Officer to progress landscape, artwork and interpretation designs with Nyamba Buru Yawuru, Dinosaur Coast Management Group and other key stakeholders.*
5. *Requests the CEO to formally thank all members of the Broome Boating Facility Advisory Group for their input throughout the site selection and concept design process and acknowledge the efforts of the Department of Transport.*

This project will bring numerous benefits Broome community including:

- The provision of a sheltered boating launching facility in Broome that meets Australian Standards.
- A facility that provides close to all tide access (98%) against the best existing tidal access at a ramp of about 30% tidal access.
- A facility that includes floating holding structures (jetties) to improve safety and access. No jetties on ramps exist in Broome at present. Floating jetties aid accessible use of the facility.
- A facility that supports the local charter industry with passenger and equipment transfer
- A facility that provides a range of ancillary amenities onshore to improve traffic / parking and public amenities.
- A facility that includes substantial community amenity in a unique landscape setting including interpretative elements.
- A facility that provides an option for a more functional and safer option for the lifting of larger vessels from the water for service, repair or cyclone refuge.
- A facility that has secured a very high percentage of community support (74%) and responds to one of the highest community priorities being an improved boat ramp.

This is a very important project for the Broome community. After decades of work a site has now been selected and agreement given from all key stakeholders. The Shire will continue to work closely with DoT to ensure the Broome Boating Facility can be successfully delivered to the community.

If you require any additional information on this project, please contact me on the details above.

Yours sincerely

S Mastrolembo

SAM MASTROLEMBO
CHIEF EXECUTIVE OFFICER

14 th September 2020

NYAMBA BURU
YAWURU

Mr Sam Mastrolembo
Chief Executive Officer
Shire of Broome
PO Box 44
BROOME WA 6725

Dear Sam,

Re: Broome Boating Facility – Entrance Point

Nyamba Buru Yawuru (NBY) are writing to express support for the Broome Boating Facility proposed for Entrance Point. Our support is based on the following:

In November 2019 the Shire of Broome (SoB) and Department of Transport (DoT) commenced an engagement process with Yawuru community members and Yawuru Law Bosses to review the location and impact of the original boat facility location. We acknowledge that the NBY Chief Executive Officer held a place on the Broome Boating Facility Advisory Group (previously Broome Boating Harbour Advisory Group) since its commencement however the process agreed to in November provided senior Yawuru community members the opportunity to fully understandassess the project based on their traditional knowledge and values of the area.

A Memorandum of Understanding (MOU) was agreed with the SoB, DoT and NBY to undertake a Multi Objective Land Allocation (MOLA) analysis for concept design development. The MOLA analysis collated cultural, environmental and spatial data to create a heat value map. This information helped to inform areas to avoid of high cultural and environmental impact and areas that were least impact for development.

The MOLA analysis recommended locating the Broome Boating Facility in the current location, avoiding most cultural and environmental values.

Entrance Point is a culturally significant location for the Yawuru community. There are registered and unregistered Aboriginal heritage sites in the area.

Yawuru people grew up fishing for food, learning about country and the seasons on the reefs adjacent to the jetty and is the only significant reef system in Yawuru country Many Yawuru people were taken to these reefs as kids by their parents and grand parents where their social and cultural connections were made and continue today with their own kids and grandkids.

Boat safety has been identified in the Broome community as an area of concern for over 30 years. This project will provide safe and accessible boat access to the whole community.

This project provides several opportunities for the Yawuru community including:

- Safe boat launching and retrieving facilities;
- Commercial opportunities – arrival point for cruise ships, kiosk and pop up shops, tours, Welcome to Country spaces;
- Interpretive information and Yawuru artwork; and
- Potential additional fishing platforms, access to the reefs and local indigenous community fish cleaning area.

In the most recent consultations Yawuru community members stressed the importance of making sure Yawuru people were comfortable in their own country when using the facility by the creation of the above features and ensuring an opportunity for Yawuru to continue to work with the Shire and DOT to further refine the cultural landscape of the boat ramp.

The support is also on the basis that the SoB and DoT continue to work closely with NBY in the development of landscaping designs, interpretation and artwork designs for the area. This collaboration will help ensure creation of a public space that can be enjoyed by the local community as well as tourists.

Yours sincerely,

Susan Bergesen
Chief Executive Officer

PH: 61-8-9193 6623
FAX: 61-8-9192 7298
MB: 0429 616 701

PO BOX 1957
BROOME WA 6725

ENTRANCE POINT
PORT DRIVE
BROOME

06/10/2020

Mr Sam Mastrolembo
Chief Executive Officer
Shire of Broome
PO Box 44
BROOME WA 6725

Dear Sam,

Re: Letter of Support, Broome Boating Facility – Entrance Point

Broome Fishing Club are writing to express support for the Broome Boating Facility proposed at Entrance Point.

The Shire of Broome and Department of Transport have worked closely with the Broome Fishing Club in all stages of the project to reach the current design and location. The President has held a place on the Broome Boating Facility Advisory Group (previously Broome Boating Harbour Advisory Group) since its commencement.

The development of a new boating facility in Broome has long been considered as essential to address critical safety and access issues. This is particularly associated with boating launch and retrieval, and transfer between vessels and shore. Large tides, strong currents, wind and waves can at times create hazardous conditions at the existing exposed beaches and boat ramps where conditions can change very quickly.

Successive governments and community groups have been trying to solve this problem for at least the last 30 years. The current site proposed for Entrance Point has support from Nyamba Buru Yawuru, Dinosaur Coast Management Group, Kimberley Port Authority and most importantly the broader Broome community.

The Broome Fishing Club currently has 760 members, and it is important to note that the Broome Fishing Club averages 945 local and intrastate visitors every weekend all of whom support the build of this facility. The Club embraces sustainable and responsible fishing practices and supports various research programs including a 2015 Western Australian Marine Science (WAMSI) study that determined that there are over 6,000 launch and retrievals occurring at Entrance Point each year or 12,000 ramp movements. Given the Broome Fishing Club's close proximity to the existing facility, the club is regularly contacted by our members and non-members with safety issues, incidents and ever-increasing concerns associated with boat launching and retrieval.

The current boating facilities provide approximately 30% tidal access and are particularly difficult for launching and retrieving larger boats, the BFC holds an annual Billfish Competition that has become known worldwide as the bench mark in tag and release billfish namely Sailfish and the BFC have no doubt that the build of this facility will increase the larger boat numbers dramatically increasing the already significant revenue generated for local Broome businesses by this 32 yearlong competition.

This project will bring several benefits to the boating and broader Broome community including:

- Sheltered and safe boat launching and retrieving facilities.
- Floating jetties which will allow access to community members with a disability and families.
- 98% tide access for boat launching and retrieval.
- A standard of boat facilities like most other coastal towns across Western Australia.
- Development of public spaces across the area that can be enjoyed by the whole community including fishing platform, green spaces, picnic areas, fish cleaning, artwork and interpretation.

This is a critical project for the Broome community and the Broome Fishing Club looks forward to working closely with all parties to see the project delivered.

Yours sincerely,

Wes Francks
President
Broome Fishing Club
0429 616 701
president@broomefishingclub.com.au

recfishwest

Mr Sam Mastrolembo
Chief Executive Officer
Shire of Broome
PO Box 44
BROOME WA 6725

Dear Sam,

LETTER OF SUPPORT FOR BROOME BOATING FACILITY AT ENTRANCE POINT

Recfishwest is the recognised peak body for recreational fishing in Western Australia providing representation and consultation on behalf of the one in three Western Australians who go fishing each year. On behalf of the 750,000 Western Australians whose recreational fishing activities inject $2.4 billion into WA's local economies each year Recfishwest are committed to ensuring great fishing experiences for all in the WA community forever. I would like to provide this letter of support for the proposed Broome Boating Facility at Entrance Point.

Broome is an iconic Western Australian destination, and like many other coastal towns in the north west, recreational fishing is an integral part of the Kimberley lifestyle and a key driver of visitation to the region, helping to attract visitors from around the state, country and the world. However, the current boat launching facilities available in Broome are below the standard expected of a premier tourist destination that can offer such a wide range of great fishing opportunities.

The Broome community has been requesting the assistance of successive state governments over several decades to improve the standard of facilities in Broome, in response to unsafe boating conditions and facilities which have seen numerous accident and incidents. Recfishwest support the chosen Entrance Point site for the new Broome boating facility and believe it will be a great asset for the town.

Due to the large tidal movement, boating in the region can be challenging at the best of times especially for inexperienced and first-time boaters wanting to launch in Broome. The proposed boating facilities will provide several benefits to recreational fishers and the community, including, a sheltered boat launching facility to Australian standards that will allow launching access in 98% of tide situations, floating holding structures (jetties) to improve safety and access, and a facility that provides a range of additional amenities onshore to improve traffic/parking and public amenities.

In addition, safe and accessible boating facilities are important community assets to regional towns and ensure access to foreshore areas for people with all abilities. The fishing platform will also provide safe land-based fishing opportunities for those without access to boats. Recfishwest sees this as an important project for the Broome community and other West Australians who visit the town with their own boats in tow. We look forward to seeing it delivered and will continue to provide support to the project as it develops. Should you require any further information in this regard, please do not hesitate to contact me on 9246 3366.

Yours sincerely

Leyland Campbell
Operations Manager

6 October 2020

DINOSAURCOAST
MANAGEMENT GROUP

Dinosaur Coast Management Group Inc.
PO Box 2478, Broome WA 6725
dinosaurcmg@gmail.com
ABN 64 562 730 699

Mr Sam Mastrolembo
Chief Executive Officer
Shire of Broome
Cnr Weld and Haas Street
Broome WA 6725

Dear Sam Sam

Proposed Broome Boating Facility Entrance Point

The Dinosaur Coast Management Group (DCMG) writes this letter to express optimism that the proposed Broome Boating Facility, to be located at Entrance Point, will not impact on National Heritage Listed (NHL) dinosaur tracks of the Broome Sandstone that are exposed in the intertidal zone of Entrance Point and adjoining coastlines.

Following a 2018 survey of the area between Reddell Beach and the southern end of Simpsons Beach, Dr Salisbury from The University of Queensland advised the area in the immediate vicinity of Entrance Point was of high scientific significance, preserving "one of the highest single concentrations of tracks made by carnivorous dinosaurs that we are aware of in the Broome Sandstone."

The recently released artist's impression of the realigned boat ramps and protection groynes show structures are no longer to be built over the immediate offshore track-bearing reef and on shore trackways.

The Committee resolution of 27 August 2020 which has been forwarded to you seeks further clarification on a number of issues, these can be summarised as three key matters. One, reviewing the Coastal Movement Modelling report to confirm there are no adverse impacts in the immediate and adjacent coastal environment when all proposed development is in place. Two, clarifying the design details of the onshore carpark, infrastructure and access points to nearby beaches and trackways. Three, ensuring dinosaur tracks and track-bearing surfaces are not damaged during the construction process.

The DCMG appreciated the recent opportunity to show DoT and Shire of Broome Officers some of the tracks on the off shore reef and looks forward to working with both parties to ensure the NHL dinosaur tracks can be enjoyed by future generations.

Michelle Teoh
Secretary

Wednesday 23 September 2020

Mr Sam Mastrolembo
Chief Executive Officer
Shire of Broome
PO Box 44
BROOME WA 6725

5 October 2020

Dear Sam,

Re: Letter of Support, Broome Boating Facility – Entrance Point

Broome Volunteer Sea Rescue Group (Inc) are writing to express support for the Broome Boating Facility proposed for Entrance Point.

Broome Volunteer Sea Rescue Group (Inc) provide an important role in sea search and rescue as well as training, patrols and education. The group was formed in 1996 and is comprised of volunteers dedicated to the safety of lives at sea.

The Broome community has been requesting the assistance of successive state governments over several decades to improve the standard of facilities in Broome, to respond to unsafe boating conditions and facilities which have seen numerous accident and incidents.

The facilities in Broome do not meet the standards currently expected of boating facilities in Australia and are below the standard in most other regional towns. A boating facility for Broome has been considered in various forms for more than 30 years.

The proposed Broome Boating Facility at Entrance Point is in close proximity to the Broome Volunteer Sea Rescue headquarters. Once complete the facility will bring several benefits to the Broome community including:

- The provision of a sheltered boating launching facility in Broome that meets Australian Standards.
- A facility that provides close to all tide access (98%) against the best existing tidal access at a ramp of about 30% tidal access.
- A facility that includes floating holding structures (jetties) to improve safety and access. No jetties on ramps exist in Broome at present. Floating jetties aid accessible use of the facility.

Once complete the Broom Boating Facility will assist with safety and operations for launching and retrieving Sea Rescue vessels.

This project is critical to address existing small vessel safety issues in Broome. We look forward to seeing this important community project delivered.

Yours sincerely,

K May

Krisma May
Deputy Commander
Marine Rescue Broome

Broome Boating Facility

Coastal Processes Report

12 November 2020 | 13111.101.R2.Rev0

Innovation Engineered.

baird.com

Broome Boating Facility

Coastal Processes Report

Prepared for:

Prepared by:

Department of Transport
5 Newman Court
Fremantle WA 6160

Baird Australia Pty Ltd as Trustee for the Baird Australia Unit Trust
ACN 161 683 889 | ABN 92 798 128 010

For further information, please contact
Jim Churchill at +61 8 6255 5080
jchurchill@baird.com
www.baird.com

13111.101.R2.Rev0

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Revision	Date	Status	Comments	Prepared	Reviewed	Approved
A	11/05/2020	Draft	Issued for Client Review	RW	JC	JC
B	3/9/2020	Draft	Updated for adopted layout developed case. Issued for Client Review	JC	DT	JC
0	12/11//2020	Final	Final Comments Addressed. Issued for Use	JC	DT	JC

Executive Summary

Baird Australia (Baird) have completed a coastal processes assessment for the proposed Broome Boating Facility (BBF) at Entrance Point on behalf of the Department of Transport (DoT). The preferred concept is located south of the existing Broome wharf overlaying the existing carpark and boat ramp structures on the Southeast-facing beach compartment of Entrance Point. The design provides a four-lane boat ramp and launch area protected by breakwaters on its north and south side as well as a detached offshore breakwater.

A range of measured data and historical information has informed the development of numerical models to assess hydrodynamics (water levels, currents), wave conditions and impacts on sediment transport and coastal morphology for the developed BBF concept. The analysis has been completed for conditions in wet season and dry season periods and for both the operational conditions (non-cyclonic) and extreme (cyclonic) conditions. Wave conditions at the BBF have been analysed using both a spectral wave model (SWAN) and a phase resolving model (MIKE21BW) as part of the concept design and evaluation (Baird 2020b).

The validated numerical model system was applied to assess the BBF design providing:

- Analysis of the hydrodynamic conditions (current speed and direction) for navigation and launch conditions around the boat ramp in typical spring and neap tides;
- Cyclonic design criteria along the engineering structures for the 1yr, 20yr, 50yr and 100yr average recurrence interval (ARI);
- Investigation of wave penetration around structures and wave conditions at the base of the boat ramp for the developed case; and
- Analysis of sediment transport processes at the development site and the potential impact of the coastal structures on sediment transport and coastal morphology.

In summary, the currents at the boat ramp are significantly reduced with the detached breakwater providing an effective means of maintaining the current speeds through the nearshore area to prevent potential sedimentation. The design offers good protection from general wave conditions for vessels using the boat ramp under a range of conditions in the wet and dry season. The projected downtime for the ramp where safe boating conditions (based on AS3962) are achieved over a one-year hindcast of conditions at the boat ramp toe is calculated at 5.4% annually, weighted toward the dry season (7.1% of the time in dry season, 3.6% of the time in wet season).

The sediment transport processes around Entrance Point are highly complex, driven by the extreme tide range, strong tidal currents and seasonal influence of winds and waves. The introduction of the BBF structures will alter the beach compartments to the south and north of the development. Along shore sediment transport fluxes are relatively low and there is expected to be net sedimentation and realignment of the beach to the south of the BBF, whilst for the northern beach compartment there may be a decrease in sediment supply. Accumulation of fine sediments in the launch area is predicted. A rigorous monitoring program post-development would be required to inform the long-term planning and maintenance strategy for the BBF and adjacent beach compartments.

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1. Introduction

1.1 Overview of Project

Baird Australia (Baird) are providing advice to the Department of Transport (DoT) for the establishment of a new Broome Boating Facility (BBF) at Entrance Point.

Evaluation of a range of layout configurations for the BBF at two different site locations on the east side of Entrance Point have been completed for the project as reported in Baird (2019) and Baird (2020a). Baird delivered coastal processes investigations and numerical modelling analysis of the design concepts to support optimisation of the design, leading to the final decision of a preferred BBF layout by the DoT in mid-2020.

The preferred concept is located south of the existing Broome wharf overlaying the existing carpark and boat ramp structures on the Southeast-facing beach compartment of Entrance Point as shown in Figure 1.1. The coastal processes investigations and analysis of the preferred BBF layout is detailed in this report.

Figure 1.1: Adopted Broome Boating Facility (BBF) design – preferred option at Entrance Point

1.2 Project Brief

1.2.1 Purpose

Baird have been contracted (DOT404017c038) to provide expert advice to the DoT on local coastal processes in Broome that will inform and influence the design of the BBF. The details of the project brief are summarised in this section.

The information gained from this body of work is intended to be:

1. Used directly and relied upon by third party consultant(s) and contractor(s), such as Marine Engineers who may be appointed by Government to undertake associated works and/or subsequent stages of this project.

2. Used directly and relied upon by DoT as a basis for future planning, consultation, investigations, design work and development of a funding Business Case.
3. Provided for information and background to project stakeholders including but not limited to the Shire of Broome (Shire), Kimberley Ports Authority (KPA), and the Broome Boat Harbour Advisory Group (BBHAG)
4. Used to develop capital and operating cost estimates for the proposed facility.

1.2.2 Services to be Provided under the Contract

In April 2019 Baird commenced contract DOT404017c038. Baird developed calibrated models capable of representing existing coastal processes at the proposed boating facility site in Broome for the initial BBF concept as reported in Baird (2019). These models were subsequently required to be extended to inform, test and optimise the performance of concept designs for the boating facility. Baird's scope included:

1. Review existing data / reports
2. Develop well calibrated models to reflect existing coastal processes including for but not limited to waves, currents, tides and sediment transport.
3. Utilise the developed models and knowledge to assist in the development of optimised concept designs for the boating facility.

In March 2020 DoT prepared a revised BBF concept design for Entrance Point in Broome and engaged Baird to undertake additional numerical modelling of the concept design based on model systems and analysis techniques previously delivered under contract DOT404017c038.

The scope of work is as follows:

1. Review and make any required changes to the existing numerical models developed under the contract to accurately simulate the new concept design in the new location, both with and without the offshore breakwater (refer Figure 1.2)
2. Simulate the same set of ambient and extreme wave and current conditions as was recently simulated (Baird , 2019) for the existing configuration for the new concept design both with and without the offshore breakwater:
   - 2.1 Ambient waves during Nov 2017 (representative wet season month)
   - 2.2 Ambient waves during July 2013 (representative dry season month)
   - 2.3 Extreme waves for the same 20-year, 50-year and 100-year conditions as previously simulated but for output points applicable to the new concept design
   - 2.4 Ambient currents during Dec 2018-Jan 2019 (same as previously run)
3. Prepare and provide spatial plots of peak ebb and peak flood tidal currents for an area covering from the shoreline out to the edge of the KPA shipping channel, both with and without the offshore breakwater.
4. Prepare and provide wave and current roses and Joint Frequency Tables for the ambient simulations (2a, 2b and 2d above) at a spread of output points similar to that output for the previous design (Baird , 2019) but applicable to the new concept design, both with and without the offshore breakwater. Locations to be agreed with DoT before commencement of work.
5. Undertake analysis for the new concept design, both with and without the offshore breakwater, similar to what was completed for the previous design but applicable to the new concept design, for the following:
   - 5.1 Operational conditions at the base of the ramp
   - 5.2 Operational waves for navigation
   - 5.3 Operational currents for navigation
6. HOLD POINT: meeting where Baird is to present the wave and current results and provide advice on any refinements/modifications to the concept design that would improve facility performance with regard to waves and currents. If DoT decides at this point that changes to the concept design are to be

adopted prior to undertaking sediment modelling, then items 1-5 above may need to be repeated for the modified design before proceeding to item 7 and beyond (repeat is included as an optional cost item).

7. Review the available sediment size information and advise if additional sediment sampling and PSD testing is required to inform sediment transport modelling of the new concept design.
8. Undertake sediment transport modelling, maintenance dredging assessment and sedimentation analysis, similar to that completed for the previous design, but modified to be applicable to the new concept design, both with and without the offshore breakwater.
9. Prepare a new coastal processes report which details all the work undertaken, results, conclusions and any recommendations.
10. Meeting where Baird is to present all additional results and provide advice on any refinements/modifications to the concept design that would improve facility performance with regard to coastal processes.

1.3 Design Optimisation

There were six (6) design options for the BBF assessed in the design evaluation and optimisation phase completed for the project (Baird (2019) and Baird , 2020a). A summary of the design options which led to the preferred BBF layout is summarised in Table 1.1 with the concepts shown in Figure 1.2.

Table 1.1: Summary of BBF Design Options

<table>
<tr><th>Design Concept</th><th>Breakwater Configuration</th><th>Location</th><th>Report</th></tr>
<tr><td>Option 1</td><td>Detached offshore Breakwater</td><td rowspan="4">Beach Compartment North of the existing boat ramp on Entrance Point</td><td rowspan="4">Baird (2019)</td></tr>
<tr><td>Option 2a</td><td>Integrated breakwater – North</td></tr>
<tr><td>Option 2b</td><td>Integrated Breakwater - South</td></tr>
<tr><td>Option 3</td><td>No offshore breakwater. Landside structures Only</td></tr>
<tr><td>Option 1a</td><td>Detached offshore Breakwater</td><td rowspan="3">Overlaying Existing Boat Ramp on Entrance Point</td><td>Baird (2020a)</td></tr>
<tr><td>Option 1b</td><td>No offshore breakwater. Landside structures Only</td><td>Baird (2020a)</td></tr>
<tr><td>Option 1c</td><td>Detached offshore breakwater. Rotation of landside concept anti-clockwise. Offshore breakwater southern section removed</td><td>Current Report</td></tr>
</table>

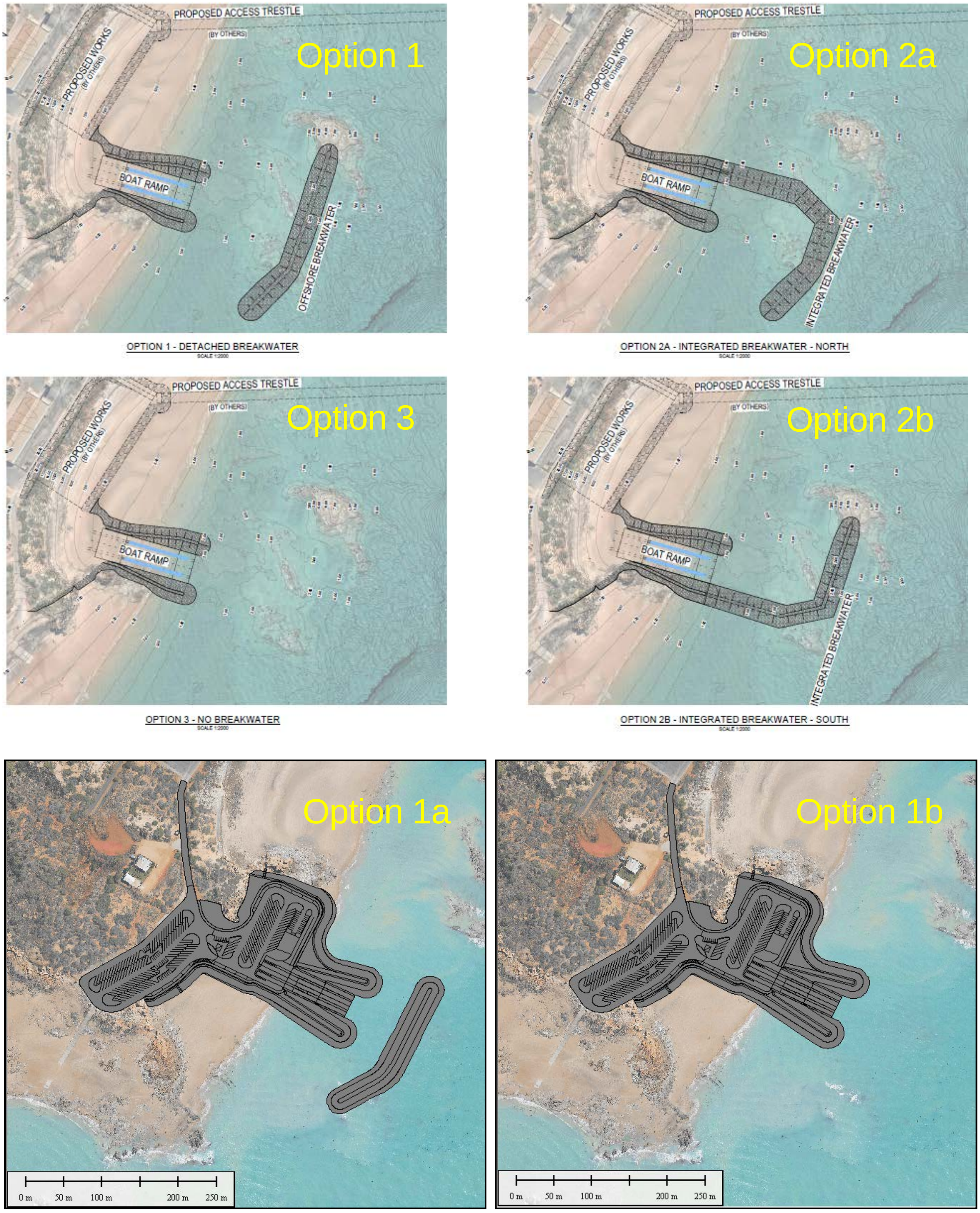


Figure 1.2: Summary of the design layouts evaluated in the BBF design optimisation phase.

1.4 Measured Data

Many previous data collection campaigns and projects have investigated the metocean conditions around Entrance point. This has included investigations for a similar boating facility located north of the existing Broome Wharf in 2013 -2014 as well as other recent studies completed by the Shire of Broome and the Kimberly Marine Support Base (KMSB) project.

A review of the existing data was completed by Baird to examine the key sources of information for the project in Baird (2019). The review is presented in Appendix A as a memo with the data sources that are referenced in the current document. A summary figure of the measured data locations around the project site is shown in Figure 1.3.

Figure 1.3: Summary of Metocean Data Collection Sites around the proposed boating facility

2. Local Setting and Metocean Influences

2.1 Site Overview

The proposed boating facility site is located on the east side of Entrance Point in Broome, Western Australia (Figure 2.1). The shoreline is east to southeast facing toward Roebuck Bay with exposed reef and rock features in the nearshore. At the back of the beach there is the current boat ramp, road access and parking facilities. At the northern end of the beach and the southern end of the beach compartment are natural rock features which serve as a natural headland (Figure 2.2).

Figure 2.1: Site of Proposed Broome Boating Facility. Photo is taken at a low tide showing the exposed rocks in the nearshore areas

There are two existing public boat ramps in close vicinity to the site which are tidally restricted and exposed to wave and current conditions. Informal launching of vessels from the beach using 4WD is known to occur.

The Kimberley Marine Support Base (KMSB) project is planned for the section of the beach immediately north of the BBF. The design of the BBF will deliver a public boat launch facility to function alongside the requirements of the KMSB project and those of Kimberley Ports at Entrance Point.

Figure 2.2: Photos taken at site during Site Visit January 15 2020. Upper – high tide looking NE over boat ramp with natural headland feature in background. Middle – Low Tide looking SW over toe of ramp with natural headland feature in background. Lower – Reef structure exposed at low tide

2.2 Bathymetry

There is an excellent description of the depths around the Entrance Point shoreline and elevation over the land side from recent multibeam survey, land-based survey and LiDAR data completed by the DoT, including a post dredge survey of offshore regions through the navigation channel and port area completed by Kimberley Ports Authority and Department of Transport in September 2019.

The combined survey data is shown in Figure 2.3 to the datum of Chart Datum (m CD, see Table 2.1). In Figure 2.3 the flat beach areas on the east and west of Entrance Point drop steeply below the 0m CD contour into a natural deep channel which provides vessel access to the existing Broome wharf in most tides. The shoreline areas inside Roebuck Bay are shallow tidal flat areas.

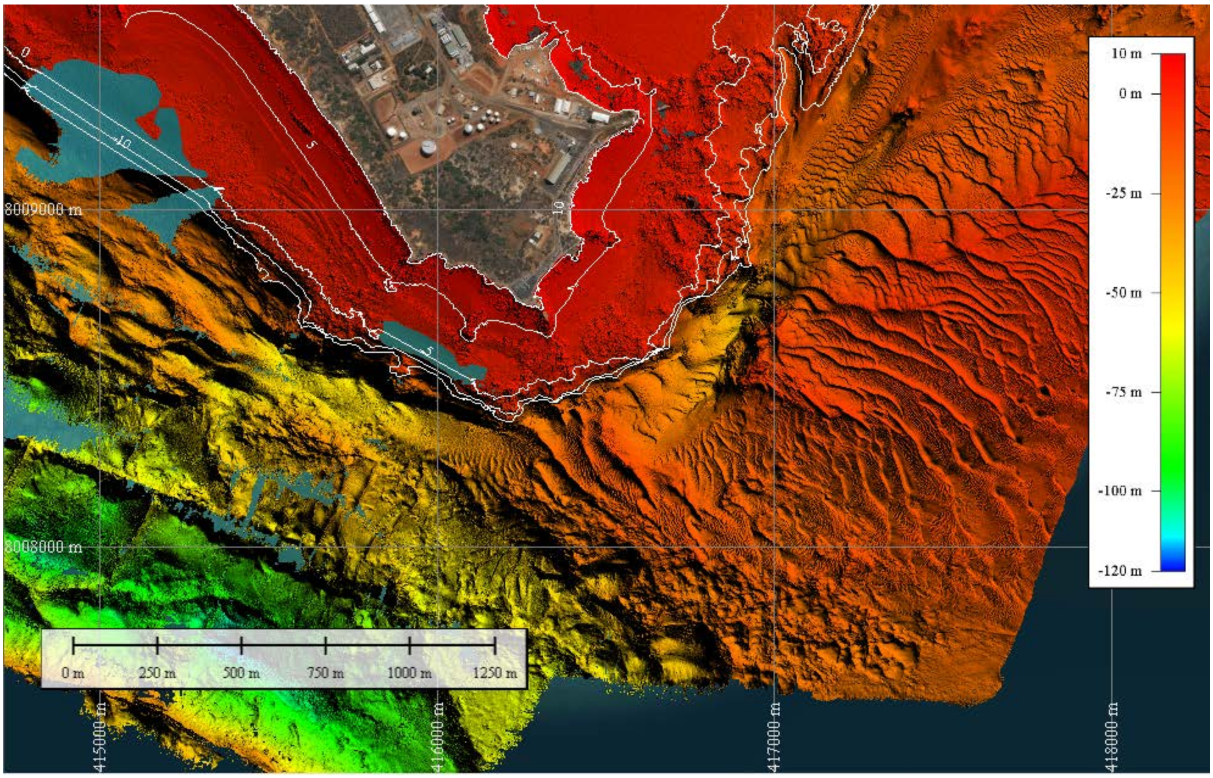


Figure 2.3: Combined Survey and Multibeam Data Description of Entrance Point (Datum m CD). Contours at 5m intervals are shown between +10m CD and -10m CD. There is a steep transition in the bathymetry below 0m CD to depths greater than 50m offshore of Entrance Point.

As part of the Broome Shoreline Monitoring Project, there was UAV flown over the site on the low tide of February 13 2020 which describes the beach compartment at the site in high resolution as shown in Figure 2.4 (Baird 2020b).

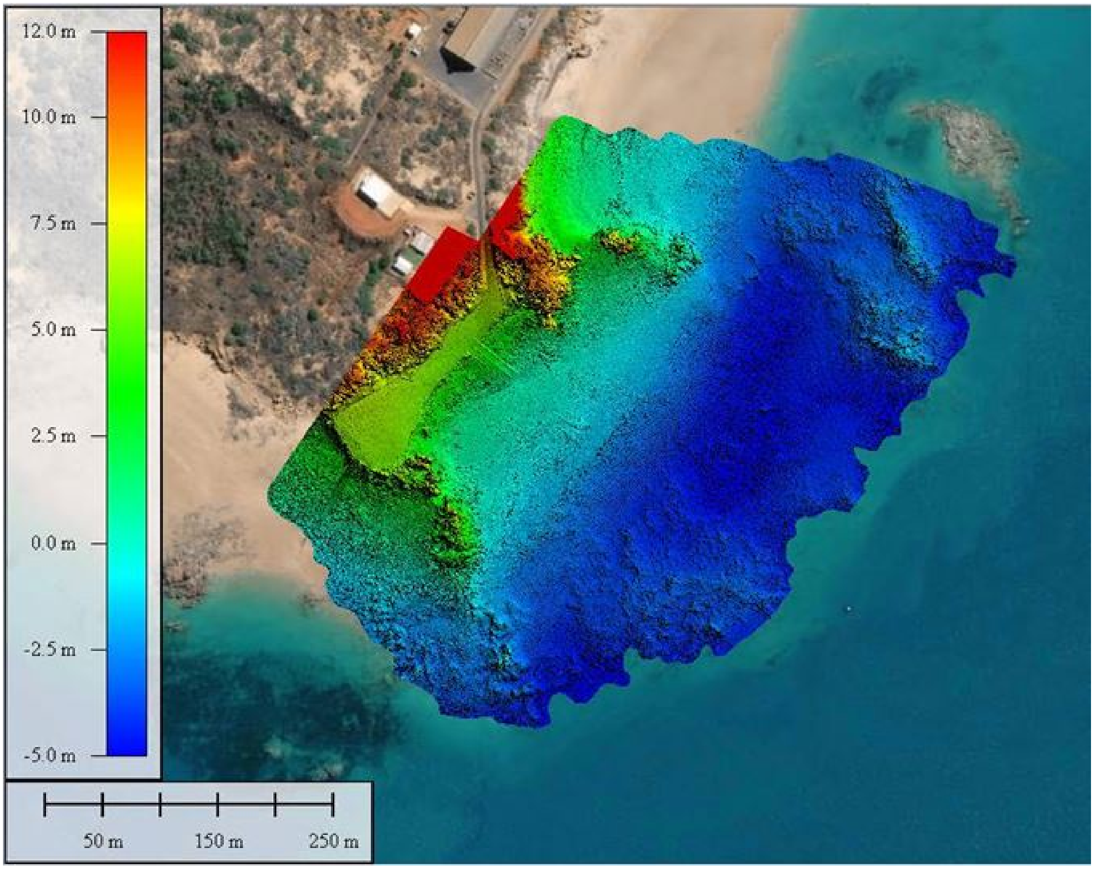


Figure 2.4: Extents of the UAV elevation surface captured at low tide at the project location on 13 February 2020 (datum m AHD).

2.3 Metocean Conditions Overview

2.3.1 Astronomical Tide

Broome's tides are semi-diurnal, with high tide occurring twice daily. The Broome tidal planes are summarised in Table 2.1 and the submergence curve is shown in Figure 2.5.

The large tide range is a major factor influencing the design of the proposed BBF. With a typical spring-tidal range of 8m and a typical neap tidal range of 2m the tides are a key influence on the wave and current conditions that impact the site. The complex bathymetry and strong tidal currents around Entrance Point affect the propagation, refraction and dissipation of waves at the proposed BBF location.

Table 2.1: Tidal Planes

Tidal Level	Chart Datum (m CD)	Australian Height Datum (m AHD)
Highest Astronomical Tide (HAT)	10.61	5.29
Mean High Water Springs (MHWS)	9.33	4.01
Mean High Water Neaps (MHWN)	6.37	1.05
Mean Sea Level (MSL)	5.46	0.14
Australian Height Datum (AHD)	5.32	0.00
Mean Low Water Neaps (MLWN)	4.56	-0.76
Mean Low Water Springs (MLWS)	1.60	-3.72
Lowest Astronomical Tide (LAT)	0.12	-5.20
Chart Datum (LAT 2009)	0	-5.32

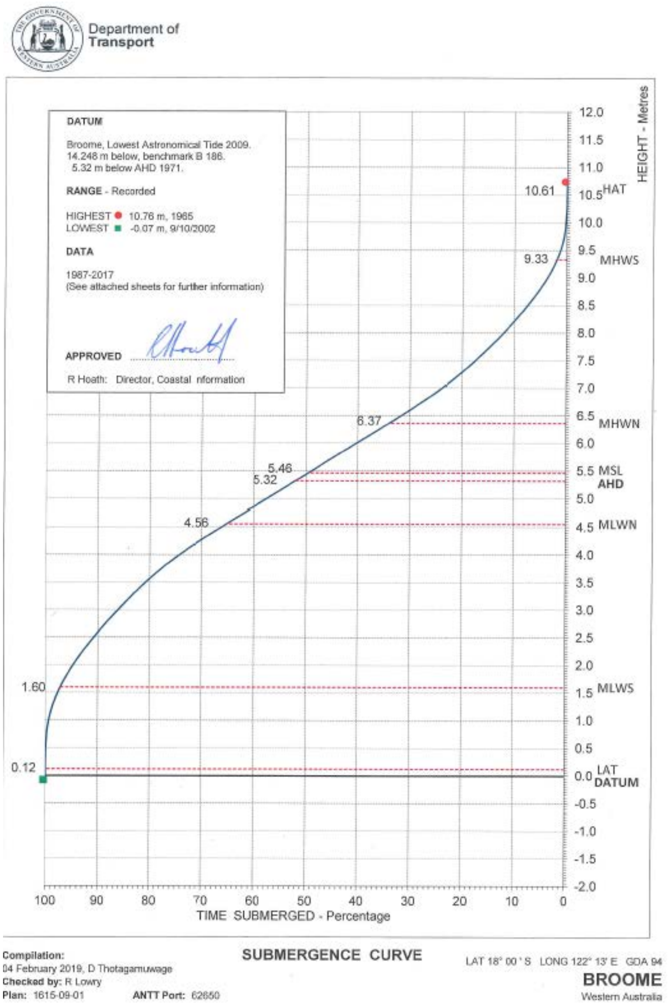


Figure 2.5: Broome Submergence Curve (DoT 2019)

2.3.2 Wet and Dry Season - Influence on Metocean Conditions

Broome is located on the southern edge of Australia's tropical savanna Köppen climate class (BoM 2005) and experiences the tropical seasons of wet (warm) and dry (cool), with the wet season running from approximately November to April, and the dry season from May to October. A general summary of the metocean conditions at the site by season is as follows:

- Wet Season (November to April):
  - The wet season is dominated by monsoon processes and tropical cyclones;
  - Broome's annual average rainfall is about 600 mm, occurring mostly in wet season months;
  - Low amplitude swell originating in the Southern Ocean and the south-east trade wind belt of the Indian Ocean propagates to the exposed Broome coast, however the site is protected from these due to the alignment of Entrance Point; and
  - Winds are generally from the western sector and vary around south west and northwest which create locally generated wind-sea conditions that can reach the site from exposed directions around Entrance Point.
- Dry season (May to October):
  - Little to no rainfall;
  - Swell originating from the Southern Ocean reaches the exposed sections of Broome's coast (low to moderate amplitude). The proposed BBF location is largely protected from swells due to the orientation of Entrance Point;
  - During the dry season south-east winds dominate, with sufficient fetch across Roebuck Bay to the proposed BBF site to generate short period, locally generated wind-sea which can be problematic for boat launch and retrieval at the existing boat ramps on Entrance Point; and
  - Toward the end of the dry season (July, August) the south-easterly winds are strongest, leading to persistent wind-sea waves at the BBF location from the E, SE and S directions.

2.3.3 Tropical Cyclones

The tropical cyclone season runs from November to April each year. The majority of cyclones affecting the region pass to the north and west of Broome, with winds causing north-west and westerly swells. Less frequently occurring cyclones that pass to the east or south can cause winds and waves that approach from the south-west quadrant and these will be critical for the cyclonic design of the proposed BBF.

Significant cyclone events that have affected Broome in recent years:

- TC Rosita (April 2000)
- TC Sam (December 2000)
- TC Chris (February 2002)
- TC Fay (March 2004)
- TC Hilda (December 2017)
- TC Veronica (March 2019)

3. Wind Climate

3.1 Measured Data

Analysis of the wind climate for the project site has examined the measured wind data record available from the Bureau of Meteorology (BoM) sites at:

- Broome Airport Site (half hourly measurements from 9 December 1993 to 29 August 2018); and
- Broome Automatic Weather Station (AWS) situated on the Broome Wharf (half hourly measurements from 16 May 2013 to 28 August 2018).

The location of these stations is shown in Figure 3.1. The Broome AWS data is more relevant to the proposed BBF site due to its proximity to the site, and due to the over-water nature of these measurements. The Broome Airport data has been included in the assessment as a reference due to the relative length of the record. Note that all wind data presented in this section is 10-minute averaged wind speed at 10m elevation.

Figure 3.1: Location of BoM measurement Stations in Broome at the Broome Airport and Broome Wharf (Broome AWS Site)

3.2 Operational Winds (non-cyclonic)

The operational wind data was extracted from the full measured BoM wind dataset, filtered to mask periods when tropical cyclones track within a 1000km range of the site (identified by the BoM Best Tracks database).

3.2.1 Wind Roses

Comparison of the annual non-cyclonic wind roses for the two BoM measurement locations in Figure 3.2 shows the open water AWS location is a more exposed location compared to the Broome Airport site. In summary:

- The winds at the Broome Airport site inland are generally distributed along the east to west axis and exhibit slower overall wind speeds accompanied by a greater percentage of calms (8.6%); and
- Winds at the Broome AWS are predominantly distributed along the east-southeast to west-northwest axis, with generally higher wind speeds and a smaller percentage of calms (0.5%).

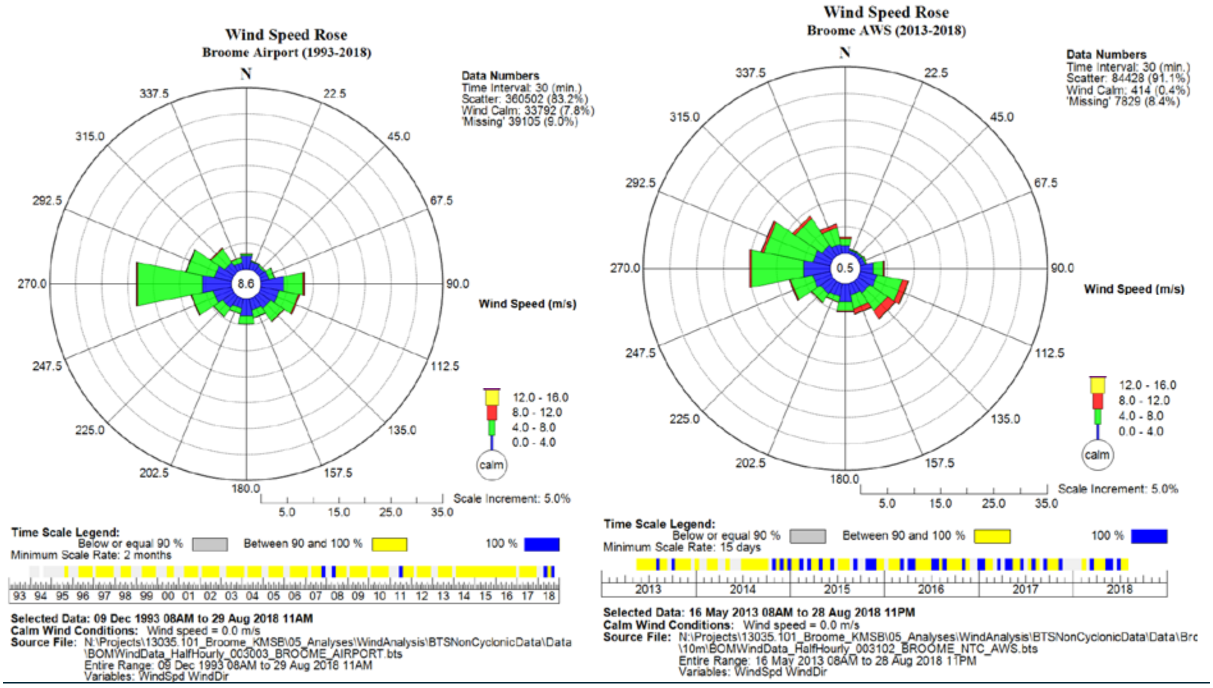


Figure 3.2: Annual wind roses for the Broome Airport (left) and Broome AWS (right)

For the operational winds the AWS site has been adopted due to its proximity to the project location. Further analysis of the Broome AWS data to examine the seasonal winds is shown in rose plots in Figure 3.3 for the wet season (months of November to April) and dry season (months of May to September). There is a distinct seasonality in the wind rose plots which shows:

- In the wet season the winds are dominated by winds from the west to north-northwest sector;
- In the dry season the winds are characterised by south easterly winds (SE and ESE) as well as winds from the west sector (northwest through south west); and
- Further analysis of the dry season wind regime by time of day indicates there is a distinct sea breeze effect (Figure 3.4). In the morning (before 12pm) the winds are generally from the southeast direction whilst in the afternoon (after 12pm) winds are dominated by the westerly direction.

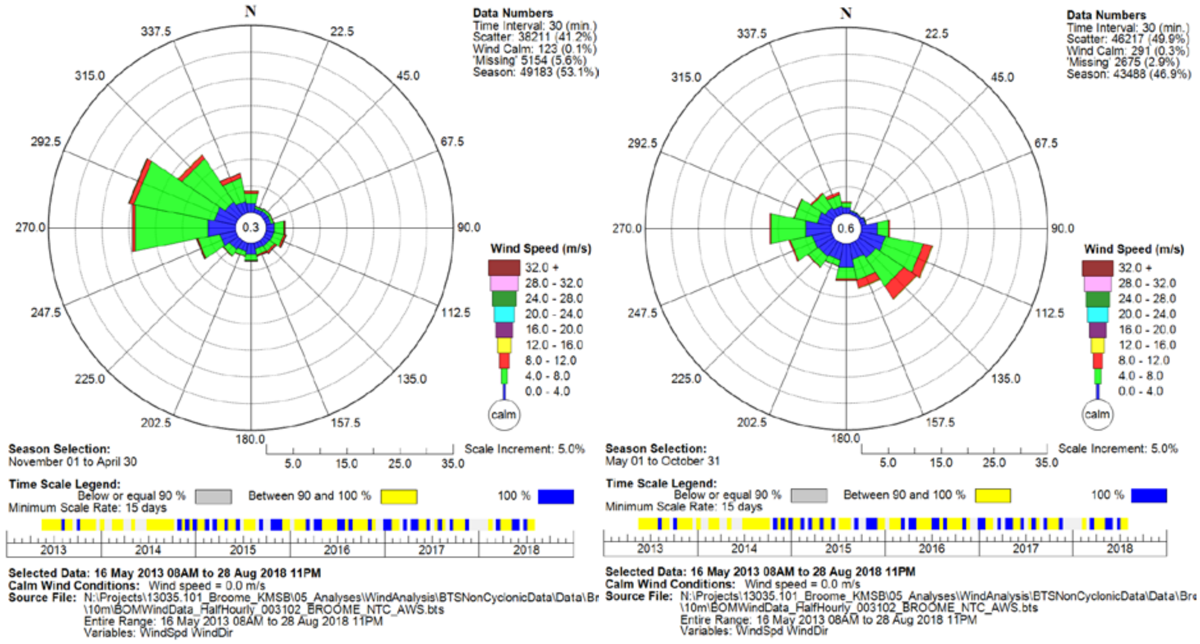


Figure 3.3: Broome Measured Data from AWS Site (2013 – 2018) showing non-cyclonic analysis of Wet Season wind regime (left) and Dry Season wind regime (right)

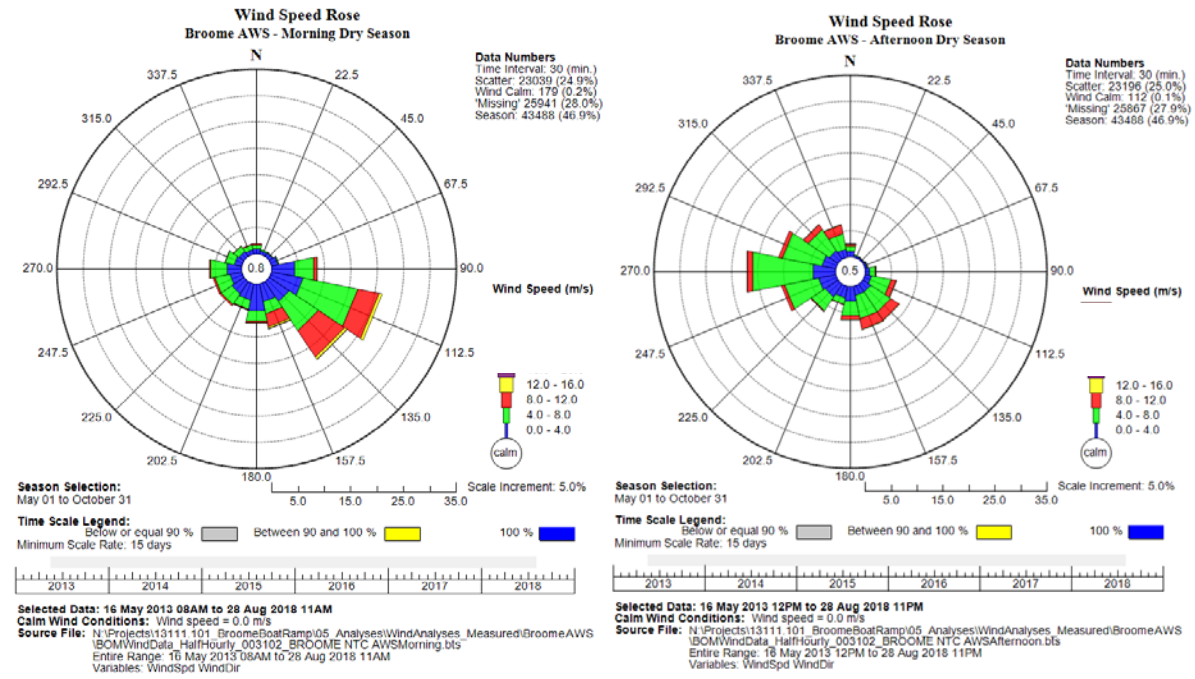


Figure 3.4: Measured winds from the Broome AWS site in the Dry Season shown for the morning (left) and the afternoon (right). In general winds from the southeast dominate in the morning and winds from the west dominate in the afternoon.

3.2.2 Wind Speed and Direction Analysis (Non-Cyclonic)

The wind data from the Broome AWS site has been analysed to determine the percentile wind speeds in the dataset as summarised in Table 3.1.

Table 3.1: Percentile wind speeds for the operational wind data set from Broome AWS (Wharf location, 2013 -2018, 10-minute average wind speed at 10m elevation)

	Wind Speed Velocity (ms^{-1}) Percentile								
	99	95	90	80	50	20	10	5	Dir (from)
Wind Speed[1] (ms^{-1})	10.6	8.9	7.6	6.6	4.6	2.8	2.0	1.3	All Directions
	11.2	9.4	8.4	7.1	4.6	2.3	1.3	0.5	N
	9.4	7.1	5.6	4.6	2.8	1.3	1	0.5	NE
	11.2	8.9	7.9	6.6	4.3	2.3	1.3	1.0	E
	12.2	10.4	9.4	7.9	5.6	2.8	2	1.3	SE
	11.2	8.4	7.6	6.1	3.3	2.0	1.3	1.0	S
	9.4	7.6	6.6	5.6	3.8	2.3	1.3	1.0	SW
	8.9	7.6	7.1	6.1	4.6	3.3	2.3	2.0	W
	10.4	8.4	7.6	7.1	5.3	3.3	2.8	2.0	NW

Note 1: $1ms^{-1}$ = 3.6km/h = 1.94 knots

An extreme value analysis (EVA) of the operational winds from the Broome AWS site to determine average recurrence interval (ARI) wind speeds at the site is summarised in Table 3.2. The 1yr ARI wind speeds were calculated by directional sector as presented in Table 3.3 showing winds are strongest from the east, south-east and south sectors.

Table 3.2: Omnidirectional ARI wind speeds for the operational wind data set from Broome AWS (Wharf location, 2013 - 2018, 10-minute average wind speed at 10m elevation)

ARI (yr)	Wind Speed (m/s) All directions
1	14.5
2	16.1
5	18.4
10	20.3

Table 3.3: Directional 1yr ARI wind speeds for the operational wind data set from Broome AWS (Wharf location, 2013 - 2018, 10minute average wind speed at 10m elevation)

Sector (Direction From)	Wind Speed (m/s)
N	12.0
NE	10.9
E	15.4
SE	16.1
S	15.3
SW	11.6
W	11.0
NW	12.4

3.3 Cyclonic Winds

The cyclonic wind conditions were developed through analysis of the measured wind data complemented by Baird's synthetic database for higher return periods.

The BoM data sites have the following key limitations with respect to their application to develop design local sea waves at the site:

- The airport wind data set is long duration; however, this data has significantly lower storm wind speeds compared to the recent concurrent data measured near the coastline at the Broome AWS. Based on Baird's analysis of peak storm wind speed data between 1993 and 2018, the airport data is approximately 50% under-bias of the open coast sustained wind speed measured at the Broome AWS.
- The data from the Broome AWS is 5-years duration so only applicable for design criteria to approximately 10-years ARI.

The Broome AWS data set has been used to define design winds for 1 to 5-years ARI.

Due to the limitations with the BoM measured data, Baird has focused on Baird's Monte Carlo wind data set which provided cyclone winds from over 28,000 synthetic events over the North West Shelf over a 10,000yr period and provides a robust and accurate 'overwater' cyclone wind data set. Baird's cyclone hazard model is presented in Burston (2015 and 2017) and Taylor *et al* (2018). Baird has a database location at the Boat Ramp site which has time series of sustained wind speed and direction acting over-water for over 28,000 synthetic cyclone events. This large sample size allows directional wind criteria to be defined with reasonable confidence limits.

The Monte Carlo data set has been analysed to determine design wind conditions for the east to south quadrant and determine design wind speeds between 10 years and 1000 years ARI. Figure 3.5 presents cyclonic winds for 10 to 1000 years ARI. The distribution is non-linear and due to the large sample size, ARI can be estimated based on plotting position (Goda, 2000).

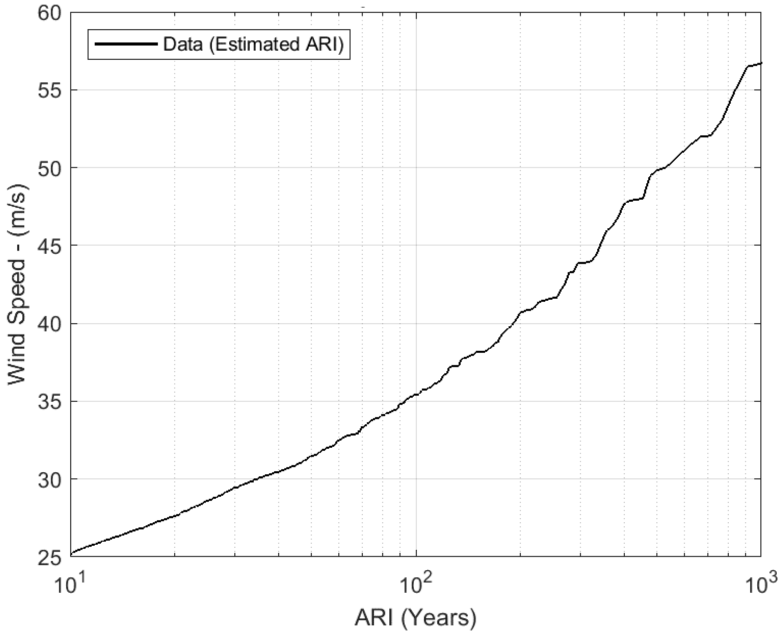


Figure 3.5: Cyclonic sustained wind speed (10-min Avg, 10 m elevation) for 10 to 1000 years ARI: East to South Quadrant

As a design criteria sensitivity, Baird also analysed the Monte Carlo winds for omni-directional wind speed. For the Entrance Point project location, cyclones tracking from the north or tracking east of Broome generally result in winds that are directed over short fetch distances across Roebuck Bay. With this consideration, Baird recommend adopting directional wave criteria for the boat ramp site rather than omni-directional wind wave criteria.

The calculated wind speeds from the East to South quadrant are summarised in Table 3.4. Approximate fetch distances across Roebuck Bay to the project location are shown in Figure 3.6. The wind speeds for the various ARI have been applied in the development of the cyclonic wave criteria (Section 7.4).

Table 3.4: Broome Extreme Wind Speed Estimates for Quadrants East through South

ARI	Estimated wind (m/s)
1	15.4
2	17.9
5	21.7
10	25. 0
20	27.8
50	31.6
100	34.6
200	41.0
500	50.0

Figure 3.6: Fetch Distance across Roebuck Bay for key wind directions affecting wave propagation to the site (Google Earth)

4. Water Level

4.1 Operational Water Levels (non-cyclonic)

Data from the Broome tide gauge (Figure 4.1) over the period 1991 to 2018, was filtered to determine non-cyclonic water levels over the period, with extreme value analysis (EVA) of the dataset used to determine operational water levels for the Broome tide gauge.

Average recurrence interval (ARI) values for non-cyclonic water levels for return periods of 1yr, 2yr, 5yr, 10yr, 20yr and 50yr were determined. The EVA utilised a Weibull distribution, based on the highest 50 independent operational water level observations, combined with a bootstrapping resampling method to obtain confidence intervals, resulting in the values outlined in Table 4.1.

Figure 4.1: Location of Broome tide gauge on Broome Wharf

Table 4.1: ARI water levels for the operational tidal data set from Broome tide gauge (Wharf location, 1991- 2018)

ARI (yr)	Water Level (m CD)	Water Level (m AHD)
1	10.33	5.01
2	10.39	5.07
5	10.47	5.15
10	10.52	5.2
20	10.57	5.25
50	10.64	5.32

4.2 Cyclonic Water Levels

Recent previous studies of extreme water level at Broome were reviewed and the work presented by Cardno in the Broome Coastal Vulnerability Study (Cardno, 2014) has been adopted for extreme (cyclonic) water levels. The design water levels in the Cardno study are calculated from measured BoM wind data at lower return periods (up to 10yr ARI) and from storm surge modelling of synthetic cyclone tracks in a 'Monte Carlo' based approach for higher return periods.

The cyclonic design water level criteria are shown in Table 4.2 and show very close agreement to the non-cyclonic water levels in Table 4.1 at the lower return periods. It is noted that the large tide range in Broome reduces the impact of extreme storm surge events on long term design water level criteria.

Table 4.2: Design water level criteria (from Cardno 2014)

ARI	Water Level (m CD)	Water Level (m AHD)
1	10.36	5.04
10	10.58	5.26
50	10.68	5.36
100	10.71	5.39
200	10.75	5.43
500	10.79	5.47

It is noted that wave setup is not included in the water level numbers in Table 4.2. At the 100yr ARI wave condition an additional allowance of 0.2m is recommended in Cardno 2014.

4.3 Sea Level Rise

Based on DoT recommendations (DoT, 2010), the sea level rise recommendations for future planning periods are as shown in Table 4.3.

Table 4.3: Sea Level Rise Recommendations

ARI	Water Level (m)
2040	+ 0.15
2070	+ 0.40
2110	+ 0.90

5. Tidal Currents

5.1 Overview of Influences on Tidal Currents

The tidal currents around Entrance Point are complex and driven by a range of influences including:

- Large tide range (approximately 8m difference in water level between mean high and mean low water in spring tides, refer Table 2.1);
- Significant bathymetry gradients around Entrance Point and the proposed BBF site (refer Figure 2.3); and
- The interaction of tidal flows through Roebuck Bay

5.2 Measured Data Analysis

The DoT have collected measured current data from locations around Entrance Point (refer Figure 1.3 and Appendix A). The measured data was analysed to characterise the direction of the tidal flows around the site. A summary of the measured current data is shown in Figure 5.1, with rose plots depicting the direction of the current flow. The data presented in Figure 5.1 shows the depth averaged results for current velocity and direction. The rose plots show current direction in the format 'direction going to'.

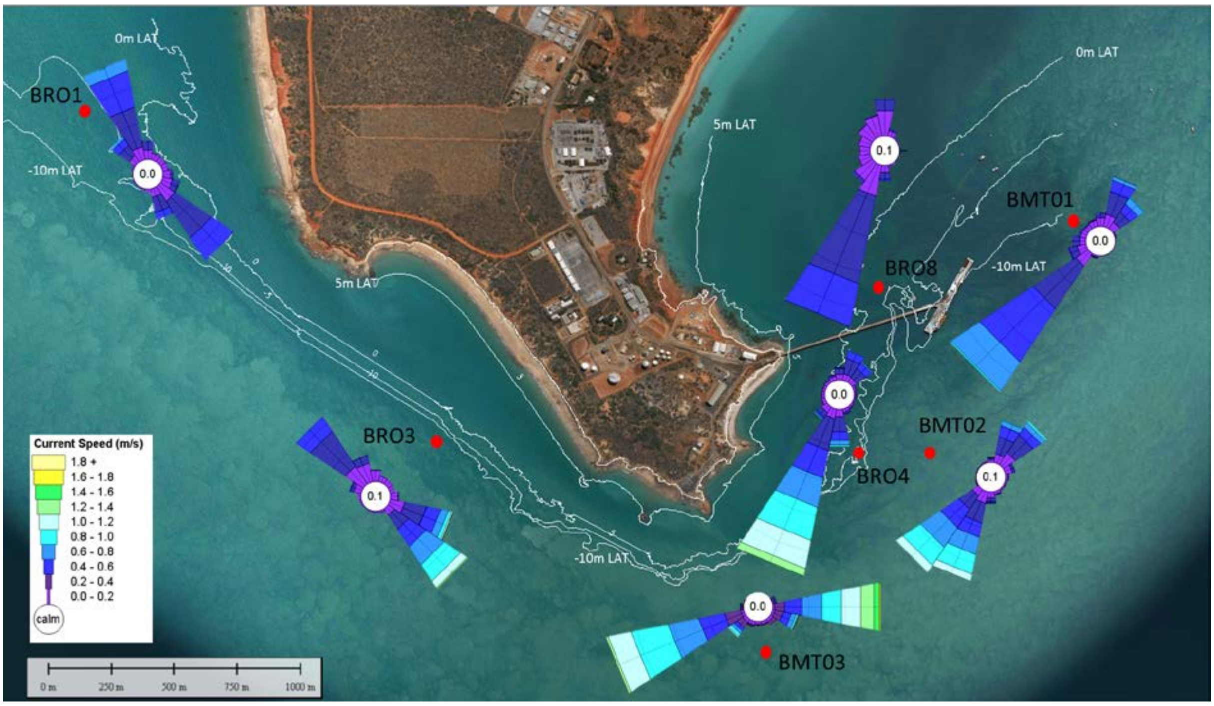


Figure 5.1: Measured Current Direction Around Entrance Point (Current Direction to)

The current roses in Figure 5.1 illustrate flow direction around Entrance Point in the vicinity of the project location and confirm:

- Tidal flows on the west side of Entrance Point at BRO1 and BRO3 are generally aligned along a northwest direction on the ebb tide and a southeast direction on the flood tide;
- The flow of tidal currents offshore on the outer side of the deep channel through BMT03 shows the tidal current moving into Roebuck Bay on the flood tide in an easterly direction and coming out on the ebb tide along a west-southwest direction. The measured data at BMT02 shows that the current speeds are strongest on the ebb tide with flow directed toward the SSW and SW direction. Flood tide currents flow towards the NNE and NE and are less prevalent and significantly lower than the ebb tide.

At site BMT01 the difference between the ebb and flood tides is even greater with the tidal flows flowing in the south-west direction the majority of the time; and

- At the location BRO4 in the nearshore area close to the BBF site, the currents are dominated by flows in the south-south west direction. During the flood tide the flows are directed along a NNE direction for a very short period early in the tide cycle, and then flow reverses due to the return current which is directed along the shoreline. Very similar current direction is noted at the nearshore location BRO8 on the north side of the wharf though there are much lower current velocities measured.

The flow regime at the sites shown in Figure 5.1 illustrates the key flow directions through the entrance to Roebuck Bay. On the flood tide, the incoming flow is directed along the section of deep water running parallel and offshore of Entrance Point. The incoming flows into Roebuck Bay setup an eddy structure on the lee side of Entrance Point west of the Broome Wharf, with flow reversing back along the shoreline. The return current that is created along the shoreline and nearshore areas of Entrance Point means that for the majority of the flood tide cycle the flow direction in the nearshore is aligned in the direction of the ebb tide flow. This phenomenon plays a critical role in the very directional nature of the currents experienced at the BBF site where tidal current flows are almost exclusively directed in the SSW direction throughout the full tide cycle as shown at BRO4 in Figure 5.1.

At the BRO4 location closest to the BBF project site, measured tidal currents reach 1ms^{-1} (2 knots) and above during the spring tide. These high current speeds will be of high importance to vessel navigation at the BBF as well as being a key driver of the sediment transport processes around the BBF project location.

5.3 Hydrodynamic Model

5.3.1 Model System

Baird's established and validated numerical model of the northwest region was used as a baseline for this study. This hydrodynamic model system has been applied for a number of similar studies in Broome and other locations on the northwest shelf and was developed by Baird using the Deltares numerical model *Delft3D*. The Delft3D modelling suite has been developed to offer a fully integrated modelling framework for a multi-disciplinary approach in coastal, river and estuarine areas (Deltares 2020). It can carry out simulations of flows, sediment transport, waves, water quality and morphological changes and has been applied in similar studies by Baird to determine waves, water levels and currents in both ambient and extreme cyclonic conditions.

Baird modified its existing Deft3D hydrodynamic and wave model that was developed for the Broome region to tailor the analysis of the hydrodynamic and wave conditions for the BBF location. The model system is dynamically coupled to a regional scale model extending across the north west shelf (NWS), with increasing resolution into the project site of the BBF where the finest model mesh is established on a rectangular grid size of 3.3m. The model grid setup is shown in Figure 5.2.

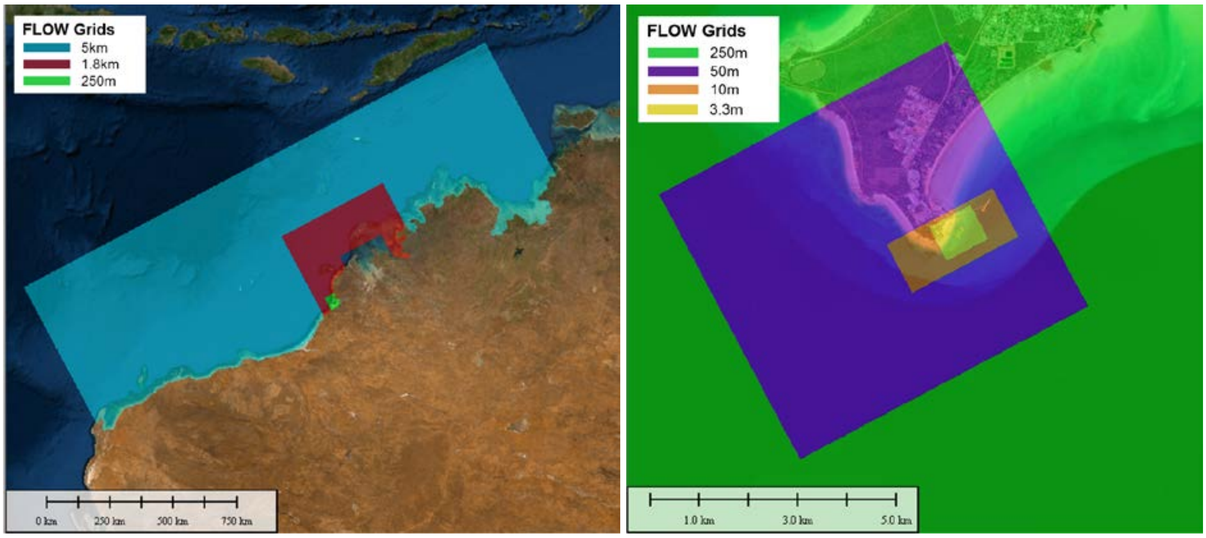


Figure 5.2: Hydrodynamic Model grids; North West Shelf coverage (left), zoomed to Broome (right)

5.3.2 Hydrodynamic Model Validation

Model validation is provided in Appendix B for the model hydrodynamics through a full tidal cycle against the available measured data from locations around the project site shown in Figure 5.1. The comparison plots show current speed, current direction, current X and Y components with statistical analysis of the model skill, RMS error, bias and scatter. The model vs measured statistics from the BRO4 location adjacent the BBF location is shown in Figure 5.3 for current speed and current direction showing very high correlation.

Overall agreement between the measured and modelled data in terms of current speed, current direction and timing and magnitude of the tide level is very strong. The complex eddy structures around Entrance Point in the vicinity of the project location in Roebuck Bay are reproduced well and the return current flow noted in the measured data location BRO4 adjacent the BBF site is simulated in the model with very high accuracy. Spatial mapping of modelled current flows around the BBF site are shown in Section 7 with further validation to the BRO4 measured data location.

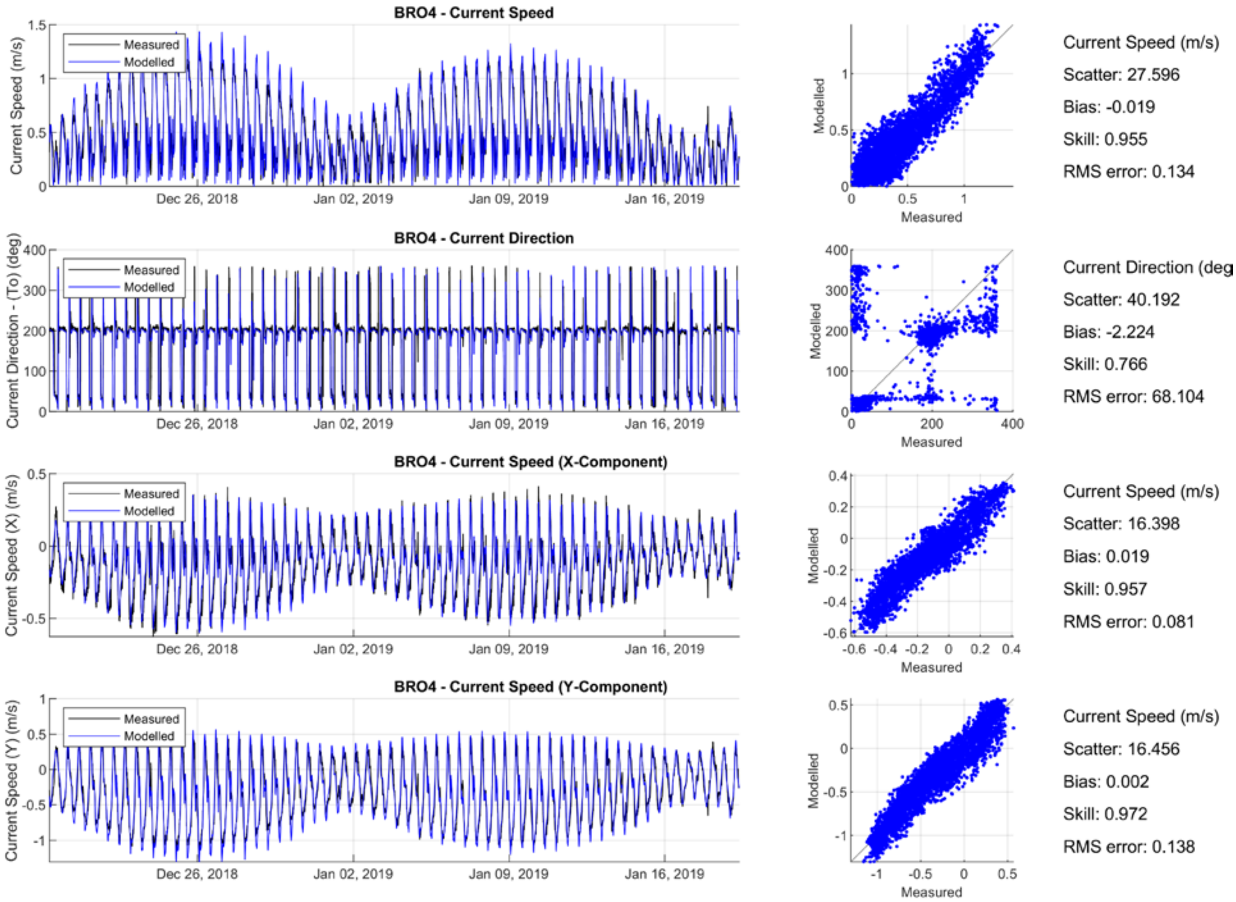


Figure 5.3: Hydrodynamic Model Validation plots for BRO4 location adjacent the BBF site

6. Wave conditions

6.1 Overview of Wave Conditions

The wave conditions around Broome are a mixture of short period wind-sea generated by the local winds and long period swell originating from the Southern Ocean that propagates across the north west shelf to the Broome shoreline.

For the BBF project site, the coast is south-east facing and Entrance Point provides an effective barrier to the long period swell arriving from the west, coupled with the sharp offshore bathymetry gradients which reflect and refract long period waves into Roebuck Bay. It is possible that low amplitude diffracted swell waves reach the site under certain conditions, however their influence is considered minor.

Analysis of the measured data from the measured location closest the boat ramp site (BRO4) indicate there is negligible swell wave energy in the record, with conditions dominated by wind-sea (periods of less than 8s). The chief influence on the wave conditions at the project site is the local winds.

The site is exposed to windsea from the directions north going clockwise through to west south west. For wind-sea arriving from the west and northwest quadrants, entrance Point serves as a barrier to the incoming waves.

- In dry season the main wave exposure for the location is from the East, South-east and South quadrant where winds are dominant.
- For the wet season the westerly wind patterns result in south-south west and southwest dominant wave directions

A summary of the wave exposure around Entrance Point is shown in Figure 6.1.

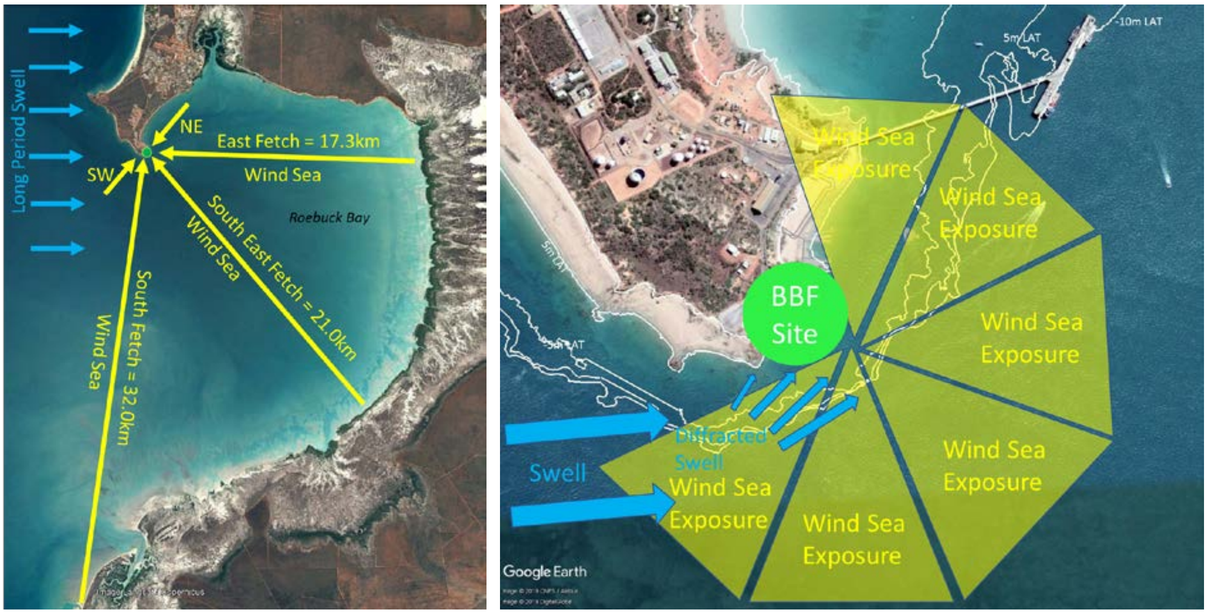


Figure 6.1: Schematic representation of the wave exposure at the site

Extreme cyclonic conditions are limited to being short crested at a peak period of between T_p=6s to 8s, with long range offshore generated seas from close tracking cyclones not able to reach the location due to the alignment of Entrance Point (Baird , 2020a).

An example of wave conditions arriving at the site from the primary direction for the wet season (from south-southwest) and dry season (east to southeast) from Google Earth historical imagery is shown in Figure 6.2 and Figure 6.3 respectively.

Figure 6.2: Example of typical wet season wave conditions - locally generated Wind-Sea Conditions from the South-Southwest (Google Earth 24 October 2018)

Figure 6.3: Example of typical dry season wave conditions - Locally Generated Wind-Sea Conditions from the East (Google Earth 26 June 2018)

6.2 Measured Wave Data

Measured wave, current velocity and water level data has been collected from the BRO4 AWAC location approximately 350m east of the proposed BBF location over the period December 2018 to June 2020. There have been 6 deployment periods to date.

- Based on discussions with the DoT there were issues with excessive tilt in the earliest deployment campaigns that may have affected accurate wave measurement. In the deployment period following 26 September 2019 this issue has been rectified.
- Analysis of the BRO4 data by the DoT was undertaken with a compiled dataset of measured waves provided to the project. This data has been analysed to characterise the wave conditions around the BBF location. The data collected over the most recent 12-month period was used to define the ambient wave climate at the site. It is noted that the year selected may not be representative of the long-term annual conditions at the BBF site – this could be determined through a longer duration measured data record or analysis of long term hindcast data.

A wave rose plot of the full 12 months of measured data (16 June 2019 to 15 June 2020) is shown in Figure 6.4. The Joint frequency table of wave height and direction is provided in Table 6.1.

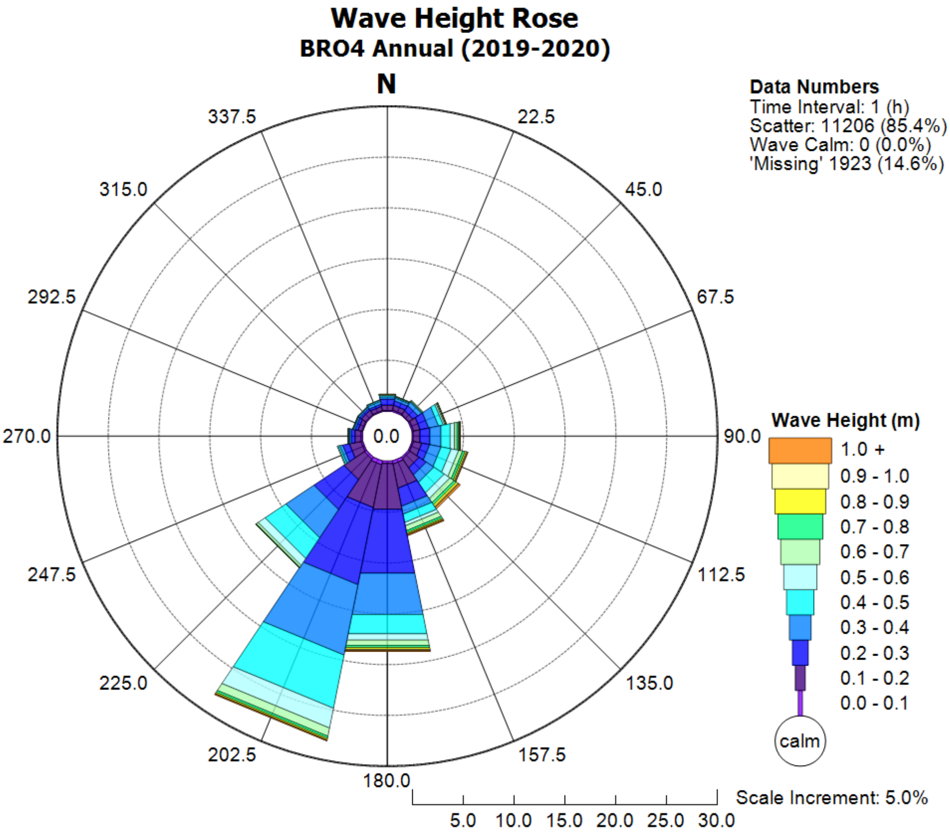


Figure 6.4: Annual Wave Rose at BRO4 location over the period 16 June 2019 to 15 June 2020. Cyclone periods removed.

Table 6.1: Joint Frequency Hs by Direction (%) at BRO4 (period 16 June 2019 to 15 June 2020)

Wave Height	Wave Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
0.0-0.1		0.12	0.21	0.09	0.22	0.10	0.20	0.27	0.44	0.34	0.52	0.35	0.24	0.24	0.10	0.14	0.13	3.73
0.1-0.2		0.63	0.51	0.59	0.64	0.80	1.03	1.26	2.79	5.42	4.91	2.66	1.24	0.71	0.43	0.58	0.54	24.71
0.2-0.3		0.54	0.38	0.54	0.67	0.97	0.75	0.93	1.92	6.42	7.63	3.60	0.61	0.38	0.33	0.25	0.26	26.16
0.3-0.4		0.21	0.30	0.38	0.80	0.95	1.18	1.09	0.84	4.40	6.76	2.71	0.20	0.24	0.21	0.13	0.30	20.68
0.4-0.5		0.24	0.07	0.09	0.34	0.78	0.86	1.31	0.99	2.05	4.81	1.26	0.10	0.07	0.07	0.08	0.12	13.24
0.5-0.6		0.07	0.04	0.04	0.12	0.27	0.78	0.68	0.31	0.73	1.86	0.42	0.03	0.01	-	-	-	5.36
0.6-0.7		0.01	0.03	0.03	0.09	0.12	0.41	0.46	0.50	0.65	0.88	0.05	-	0.01	0.01	0.01	0.01	3.27
0.7-0.8		-	-	-	0.04	0.13	0.21	0.20	0.16	0.22	0.21	0.03	-	-	-	-	-	1.19
0.8-0.9		0.01	-	-	0.01	0.03	0.12	0.17	0.10	0.17	0.18	-	-	-	-	-	-	0.80
0.9-1.0		-	-	-	-	0.01	0.12	0.07	0.04	0.07	0.03	-	-	-	-	-	-	0.33
1.0+		-	-	-	-	0.01	0.05	0.25	0.08	0.08	0.07	-	-	-	-	-	-	0.54
TOTAL		1.82	1.53	1.75	2.93	4.19	5.70	6.67	8.18	20.55	27.85	11.07	2.42	1.65	1.15	1.19	1.36	100.0

6.3 Seasonal Wave Conditions

The wave rose for the dry season months (May to September) is shown in Figure 6.5 with JFT in Table 6.2. The wave rose for the wet season months (October to April) is shown in Figure 6.6 with JFT in Table 6.3. The wave roses have been calculated for respective seasons in the 12-month period of data 16 June 2019 to 15 June 2020 for ambient conditions with periods where cyclones were active around Broome removed from the record.

Based on analysis of the BRO4 wave data there is a distinct seasonality to the wave direction distribution:

- In the wet season the wave conditions are dominated by directions from the S, SSW and SW; and
- In dry season wave conditions are influenced by the south-easterly and easterly winds typical of the season and waves approach the BBF from a wider range of directions ENE, E, ESE, SE, SSE, S and SSW

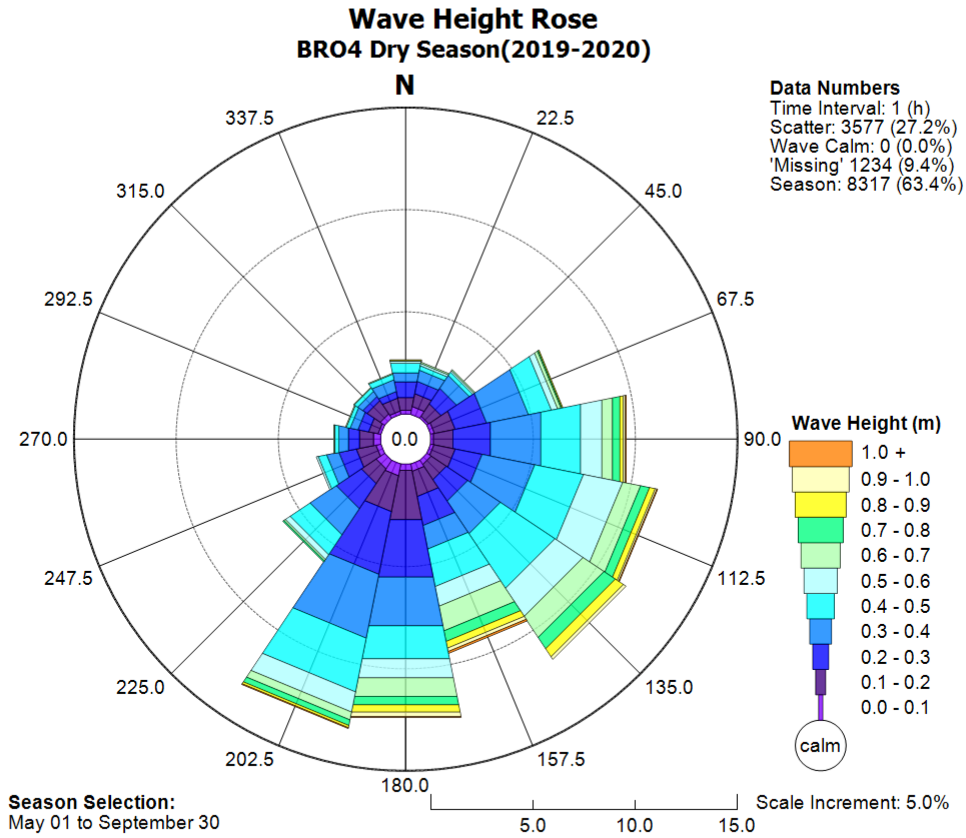


Figure 6.5: Dry Season Wave Rose at BRO4 location – Ambient wave conditions. For the months May to September over the period 16 June 2019 to 15 June 2020.

Table 6.2: Joint Frequency Hs by Direction (%) at BRO4 (Dry Season May to September)

Wave Height	Wave Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
0.0-0.1		0.25	0.51	0.14	0.25	0.18	0.22	0.33	0.43	0.40	0.72	0.61	0.29	0.47	0.18	0.33	0.22	5.53
0.1-0.2		0.79	0.76	0.90	1.08	1.16	1.26	0.90	1.41	2.93	2.24	0.90	0.98	0.87	0.54	0.87	0.83	18.42
0.2-0.3		0.90	0.69	0.83	1.26	1.66	1.26	1.34	1.48	3.58	3.65	1.34	0.79	0.65	0.61	0.29	0.36	20.70
0.3-0.4		0.51	0.65	0.72	1.59	2.17	2.67	2.20	1.30	2.53	3.54	1.19	0.40	0.61	0.47	0.29	0.72	21.57
0.4-0.5		0.61	0.18	0.18	0.83	1.73	1.95	3.22	2.13	1.91	3.07	1.05	0.29	0.14	0.18	0.22	0.29	17.99
0.5-0.6		0.14	0.11	0.11	0.18	0.65	1.81	1.48	0.87	0.98	1.08	0.22	0.04	0.04	-	-	-	7.70
0.6-0.7		0.04	0.07	-	0.14	0.18	0.76	1.08	1.05	1.08	0.36	0.04	-	0.04	0.04	0.04	0.04	4.95
0.7-0.8		-	-	-	0.07	0.11	0.25	0.43	0.36	0.36	0.25	0.04	-	-	-	-	-	1.88
0.8-0.9		0.04	-	-	-	-	0.11	0.22	0.18	0.25	0.11	-	-	-	-	-	-	0.90
0.9-1.0		-	-	-	-	0.04	0.07	-	0.11	0.07	-	-	-	-	-	-	-	0.29
1.0+		-	-	-	-	-	0.04	-	-	-	0.04	-	-	-	-	-	-	0.07
TOTAL		3.29	2.96	2.89	5.42	7.88	10.40	11.20	9.32	14.09	15.07	5.38	2.78	2.82	2.02	2.02	2.46	100.0

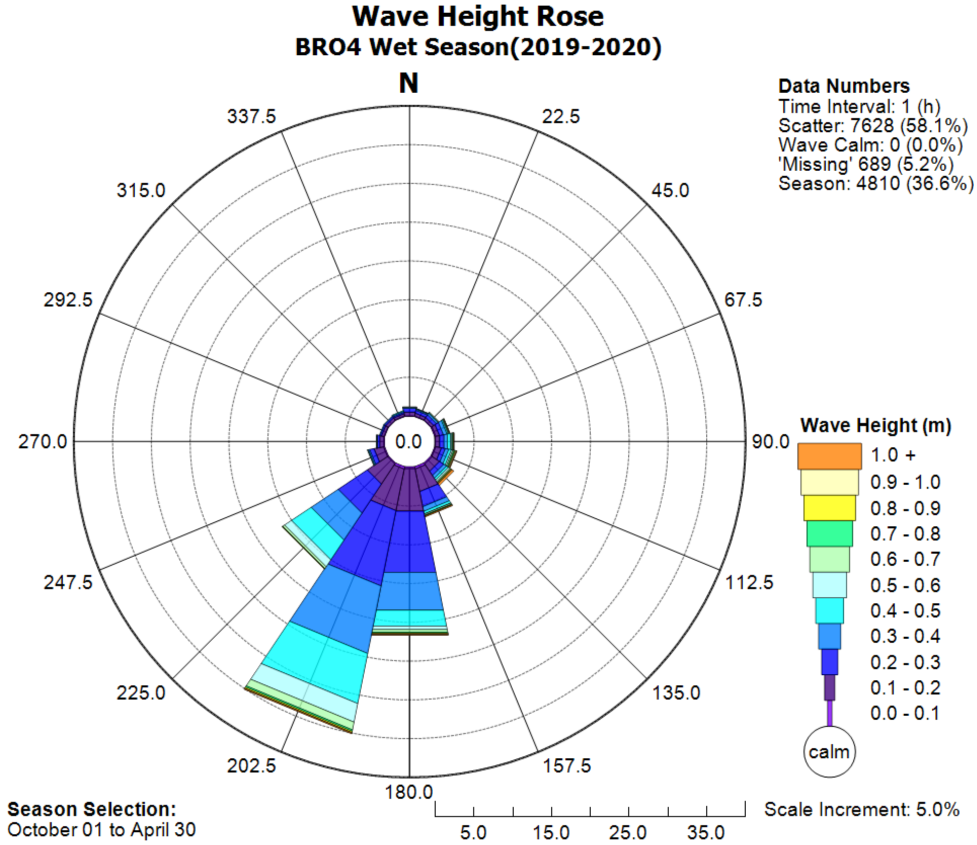


Figure 6.6: Wet Season Wave Rose at BRO4 location – Ambient. For the months October to April over the period 16 June 2019 to 15 June 2020. Cyclone periods removed.

Table 6.3: Joint Frequency Hs by Direction (%) at BRO4 (Wet Season October to April)

Wave Height	Wave Direction	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
0.0-0.1		0.06	0.04	0.06	0.20	0.06	0.18	0.25	0.45	0.33	0.43	0.20	0.20	0.12	0.08	0.04	0.08	**2.80**
0.1-0.2		0.55	0.37	0.41	0.39	0.61	0.92	1.45	3.57	6.82	6.43	3.63	1.39	0.61	0.37	0.43	0.37	**28.32**
0.2-0.3		0.33	0.20	0.37	0.35	0.57	0.45	0.69	2.21	8.00	9.84	4.86	0.51	0.22	0.16	0.22	0.20	**29.20**
0.3-0.4		0.04	0.10	0.18	0.35	0.31	0.35	0.47	0.57	5.43	8.56	3.55	0.08	0.02	0.06	0.04	0.06	**20.18**
0.4-0.5		0.02	-	0.04	0.06	0.25	0.25	0.22	0.35	2.12	5.78	1.37	-	0.02	-	-	0.02	**10.50**
0.5-0.6		0.02	-	-	0.08	0.06	0.20	0.22	-	0.59	2.29	0.53	0.02	-	-	-	-	**4.02**
0.6-0.7		-	-	0.04	0.06	0.08	0.20	0.10	0.18	0.41	1.16	0.06	-	-	-	-	-	**2.31**
0.7-0.8		-	-	-	0.02	0.14	0.18	0.06	0.04	0.14	0.18	0.02	-	-	-	-	-	**0.80**
0.8-0.9		-	-	-	0.02	0.04	0.12	0.14	0.06	0.12	0.22	-	-	-	-	-	-	**0.74**
0.9-1.0		-	-	-	-	-	0.14	0.10	-	0.06	0.04	-	-	-	-	-	-	**0.35**
1.0+		-	-	-	-	0.02	0.06	0.39	0.12	0.12	0.08	-	-	-	-	-	-	**0.80**
TOTAL		**1.02**	**0.71**	**1.10**	**1.53**	**2.14**	**3.06**	**4.10**	**7.56**	**24.16**	**35.02**	**14.23**	**2.21**	**1.00**	**0.67**	**0.74**	**0.74**	**100.0**

6.4 Wave Model

The wave model adopted for the simulation of wave conditions in this study is the industry standard SWAN wave model (Simulating Waves Near Shore) developed at Delft University of Technology in the Netherlands. SWAN is a third-generation spectral wave model which computes wave propagation, wave generation by wind, non-linear wave-wave interactions and dissipation, for a given bottom topography, wind field, water level and current field (Deltares 2020).

The SWAN model accounts for (refractive) propagation due to current and depth and represents the processes of wave generation by wind, dissipation due to white capping, bottom friction and depth-induced wave breaking and non-linear wave-wave interactions (both quadruplets and triads) explicitly with state-of-the-art formulations. Wave blocking by currents is also explicitly represented in the model (Deltares 2020).

Model configurations were developed for assessing the ambient wave conditions (operability, sediment transport) and extreme wave conditions (cyclonic design conditions). Model settings are summarised in Table 6.4 .

Table 6.4: SWAN Model Setup

Parameter	SWAN Settings Extreme Case	SWAN Settings Ambient Case
SWAN Version	4110	4110
Grid Size	3 Nested grid setup - Grid 1: 250m, Grid 2: 10m, Grid 3: 3.3m	Single grid at 3.3m resolution over Entrance Point and extending to BRO4
Bathymetry	Offshore bathymetry based on measured multibeam and survey data with the addition of the developed case BBF structures	
Spectral Resolution	Circular directional space with 36 directions	
Forcing Conditions	Extreme wind speeds by Return Period by quadrant (refer Table 3.4)	Measured waves from BRO4 for 1-year period (Mar 2019 –Feb 2020) Measured wind conditions (BoM)
Water Level	Extreme Water Level by return period (refer Table 4.2)	Measured Water level from Broome Tide gauge for 1-year period (Mar 2019 – Feb 2020)
Reflection from structures	No reflection from structures is modelled. Wave conditions from the model are incident wave height.	Reflection at target of 25% applied to the structures in the model

Bathymetry in the model has been assigned compiling recent survey and multibeam datasets captured around the site (refer Appendix A). The breakwater structures for the preferred BBF developed case design were developed with the following assumptions:

- Toe of boat ramp = +0.5m CD
- Boat Ramp slope = 1:8
- Crest of breakwaters = +12m CD
- Slope of breakwaters = 1:1.5

The SWAN model grid setup applied to model the extreme cyclonic conditions is shown in Figure 6.7.

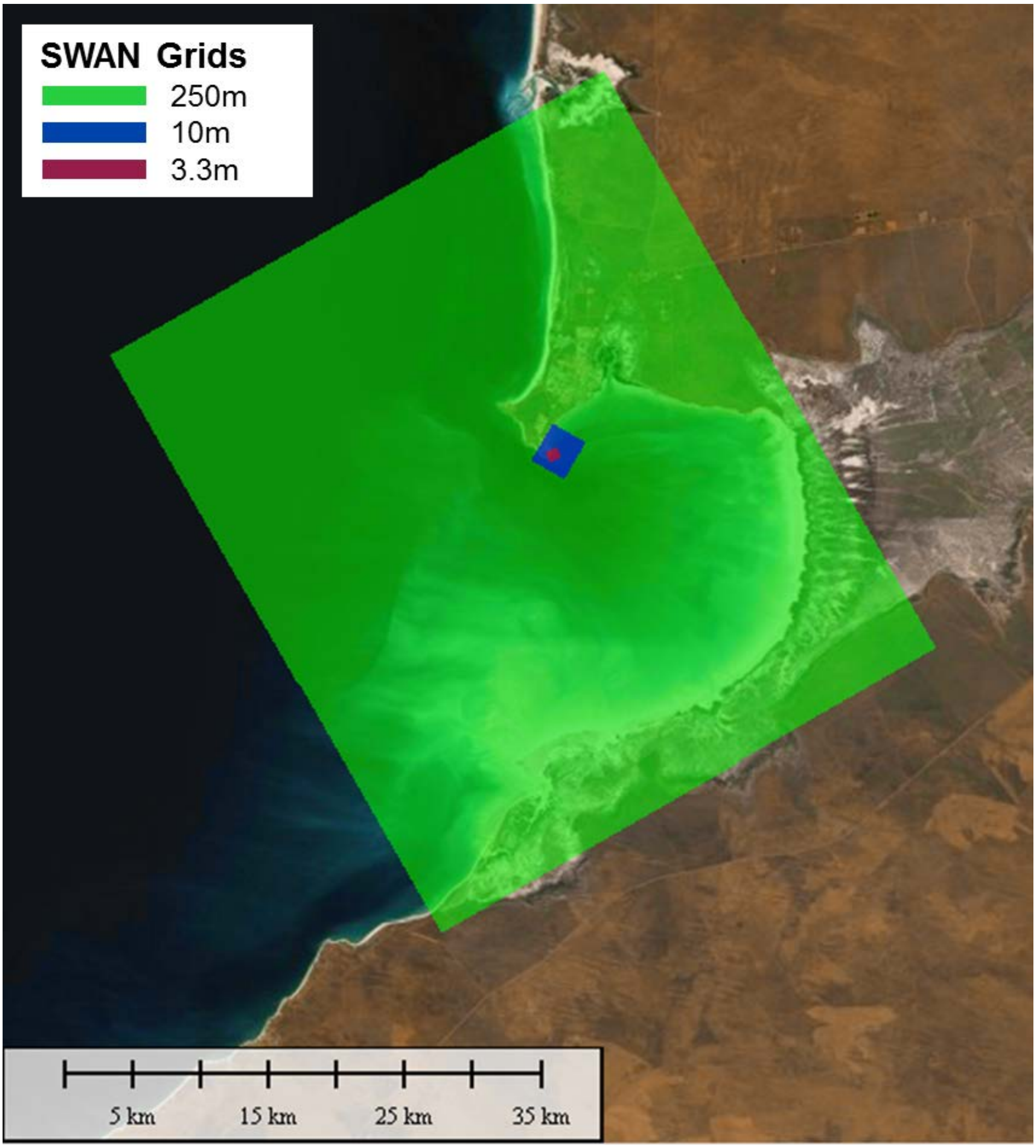


Figure 6.7: SWAN Model – 3 Nested Grid Setup applied in Extreme cyclonic cases

A SWAN model was established across the local region of Entrance Point at 3.3m resolution with the measured wave conditions from the BRO4 location used as a boundary condition and is shown in Figure 6.8.

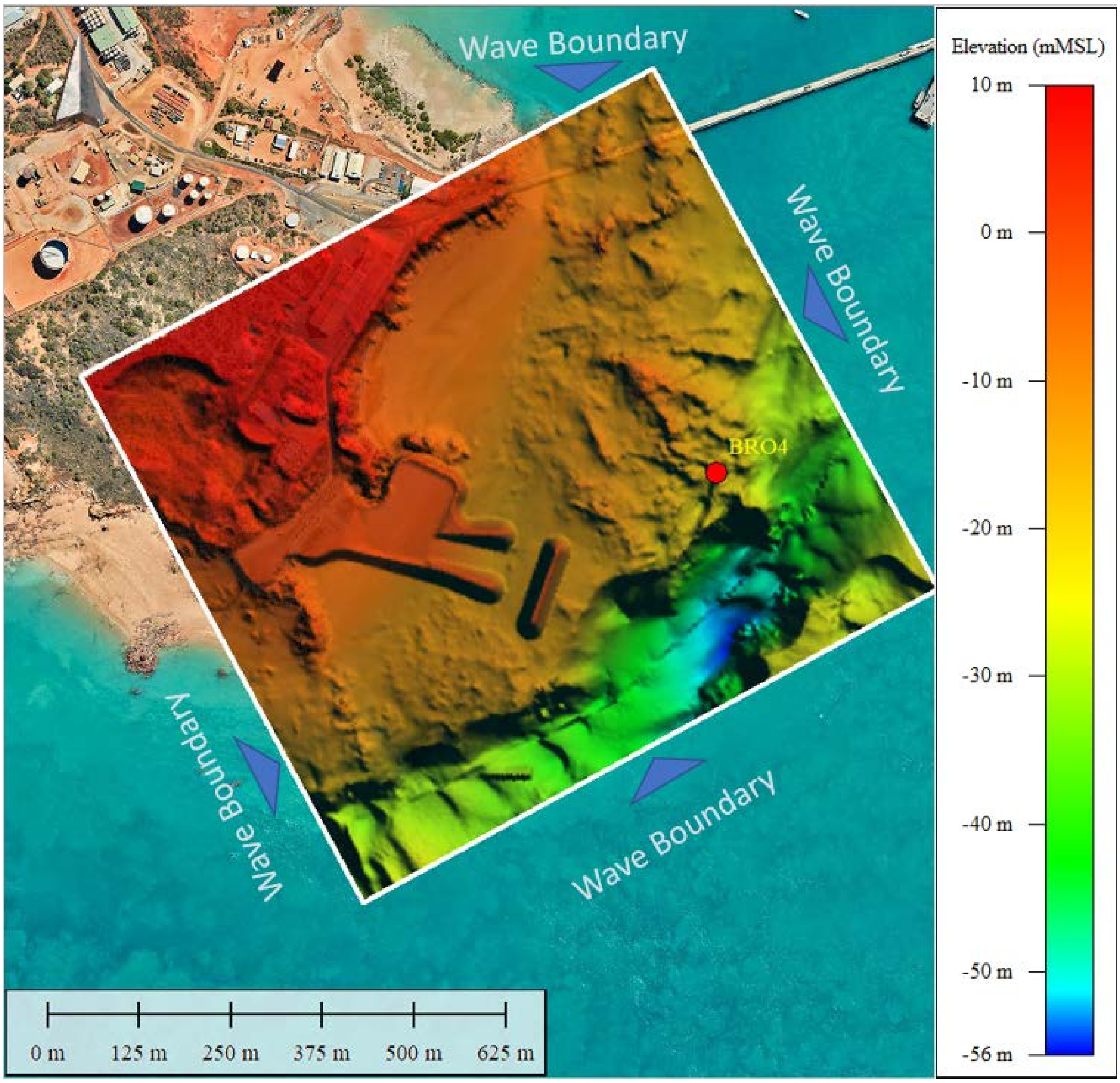


Figure 6.8: SWAN Domain applied in ambient cases and the one-year hindcast. The model bathymetry is shown for the developed case layout

6.4.1 One-Year Hindcast Model

A one-year hindcast of metocean conditions was established based on measured data from the following sources:

1. Measured waves from BRO4 AWAC (Hs, Tp, Dir)
2. Measured Water level from Broome Tide gauge
3. Measured wind conditions (wind speed / direction) compiled from the BoM Broome AWS and Airport locations

The hindcast data covers the period 1 March 2019 to 29 February 2020 at 1-hourly intervals and was applied to the SWAN model shown in Figure 6.8.

To assess the hindcast dataset against the long-term record, the wind speed is used. Wind speed is used as a proxy for wave conditions, due to their importance in developing the metocean conditions at the BBF location.

The one year hindcast period is compared against the long-term wind speed record from the Broome Airport in Figure 6.9. The comparison is presented in percentile wind speed calculated for the 1yr hindcast data record and compared against the approximate 26-year long-term record from Broome Airport (December 1993 to May 2020). The comparison shows the wind speed from the 1yr hindcast period dataset is marginally above the long-term average.

Analysis by season is shown in Figure 6.10. The seasonal analysis of wind speed in the wet season months (November to April) in the hindcast data against the long-term record shows a very close match. For the dry season months (May to October) the comparison of hindcast data against the long-term record shows the hindcast record is above average. This indicates the wave conditions in the dry season period are likely to be above the long-term average at the site.

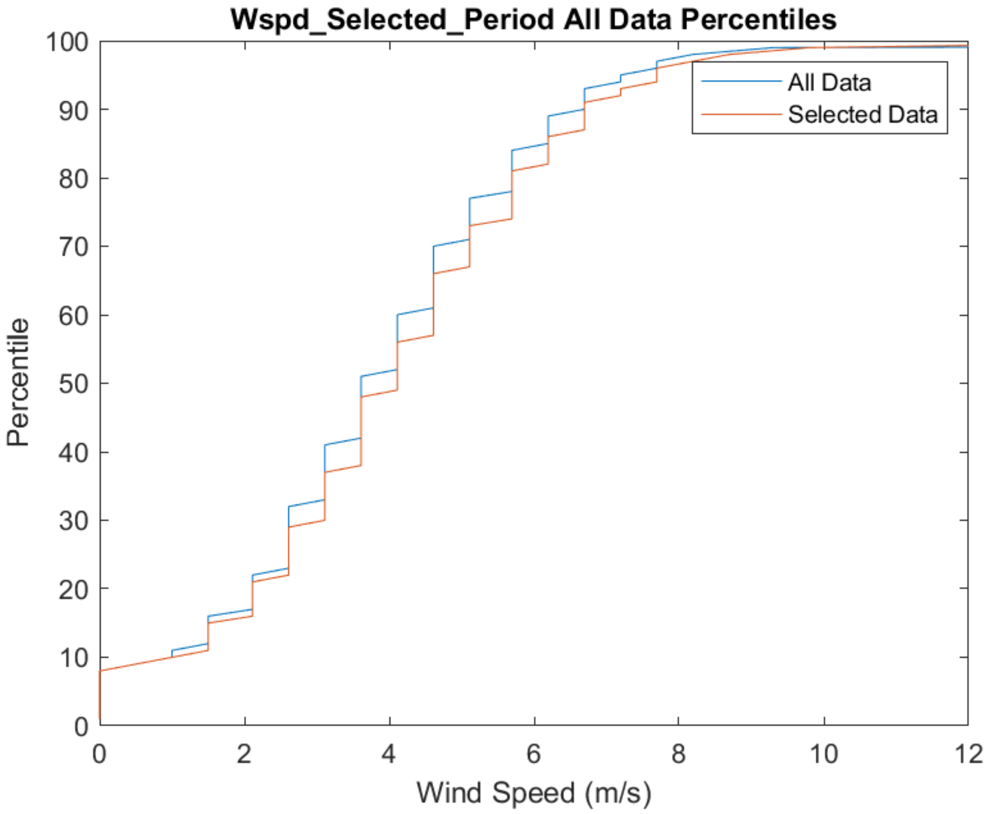
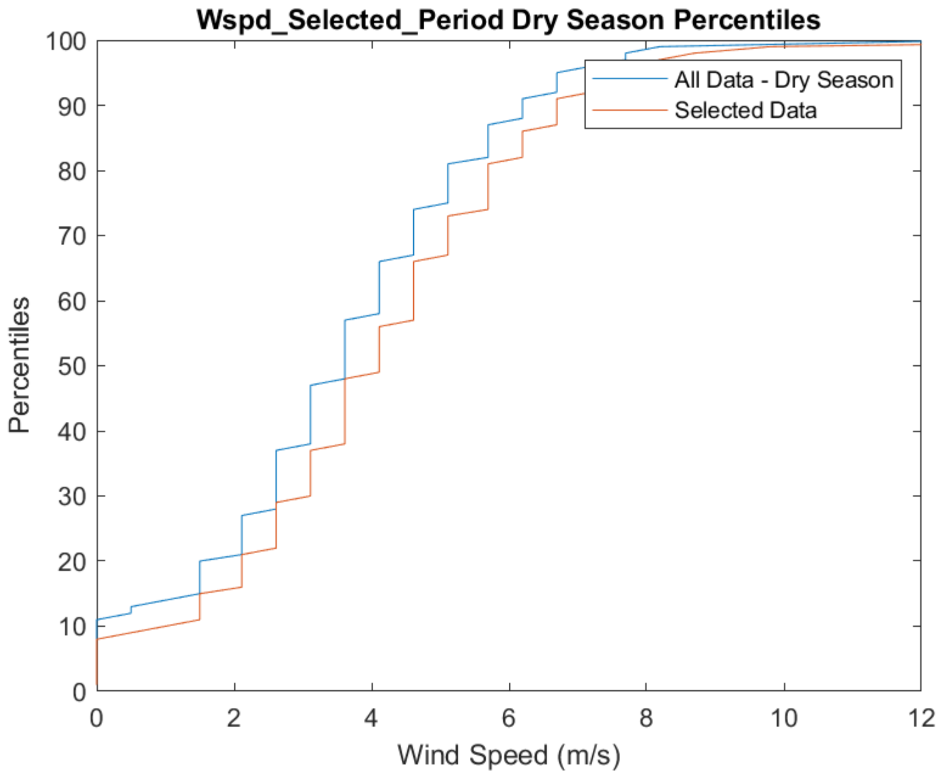


Figure 6.9: Comparison of wind data in hindcast record against the long term dataset. Analysis of percentile wind speed shows the hindcast data is marginally above the long-term record.



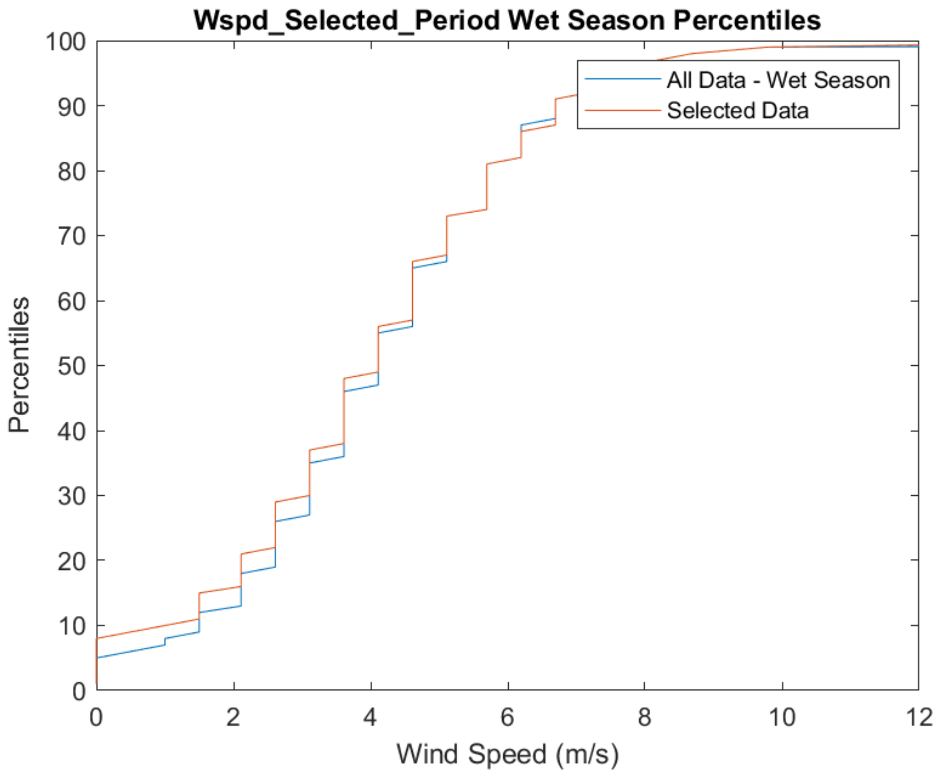


Figure 6.10: Comparison of wind data in hindcast record against the long term dataset for seasonal periods – Dry Season (upper plot) and Wet Season (lower plot).

6.4.2 Application of the Spectral Wave Model at the BBF

Investigation into the ability of SWAN to reproduce the waves penetrating around the BBF breakwater to the toe of the ramp was carried out through the application of analytical wave diffraction solutions for random seas as presented in Goda (2000). Analysis is shown in Appendix B.3.1 which confirms that diffraction processes affecting wave heights at the landside structures are being reproduced in SWAN, noting the waves reaching the structures are all relatively low period waves.

As part of the detailed wave studies completed for the BBF concept development, Baird modelled the key ambient wave conditions at the BBF using a phase resolving model (MIKE21BW) and compared the outcomes with the SWAN model, concluding that the two model systems produced similar outcomes for the low-period wind-sea conditions characteristic of the BBF project location (Baird 2020b).

7. Concept Analysis

The hydrodynamic model and wave model developed for the project location outlined in Section 5 and Section 6 have been applied to analyse the metocean conditions for the preferred BBF concept in this section.

7.1 Design Analysis Reporting Locations

The adopted BBF layout is shown in Figure 7.1. Reporting locations that were applied in the models and that are used for analysis of water levels, waves and currents are shown in Figure 7.1 and summarised in Table 7.1.

Table 7.1: Summary of Reporting Locations

Reporting Location	Location Name in Model
Southern Breakwater	BWS1, BWS2, BWS3, BWS4, BWS5,
Northern Breakwater	BWN1, BWN2, BWN3, BWN4
Breakwater Head	BWSH, BWNH
Breakwater Lee - Midway	BM1, BM2
Boat Ramp	BRT1, BRT2, BRM1, BRM2, BRTop1, BRTop2
Offshore Breakwater	OS1, OS2, OS3, OS4, OS5, OS6, OS7
Vessel Access Locations	A1, A2, A3, A4, A5
Access Channel North	C1, C2, C3

The BBF layout has been analysed for:

- Operational currents, wave and water level conditions around the BBF;
- Operability windows for safe launch and retrieval of vessels from the boat ramp based on one full year of conditions. The one-year hindcast data covers the period 1 March 2019 to 29 February 2020 at 1-hourly intervals based on measured data from the location (refer detail in Section 6.4.1);
- Navigability for vessels approaching or departing the BBF based on consideration of operational wave and tidal currents (non-cyclonic); and
- Cyclonic wave conditions experienced at the breakwater elements (breakwater head, trunk etc.) for a range of return periods (1yr ARI, 20yr ARI, 50yr ARI, 100yr ARI).

7.2 Operational Currents (non-cyclonic) for the BBF

7.2.1 Modelling of Currents around the BBF Location

The hydrodynamic model was applied to examine the non-cyclonic current conditions at the proposed BBF site, based on a 4-week simulation of tide (Dec 2018 – Jan 2019). The simulation period was selected as a time with large spring tides and the model included application of spatially varying winds based on NCEP's Climate Forecast System Reanalysis Version 2 (CFSR v2).

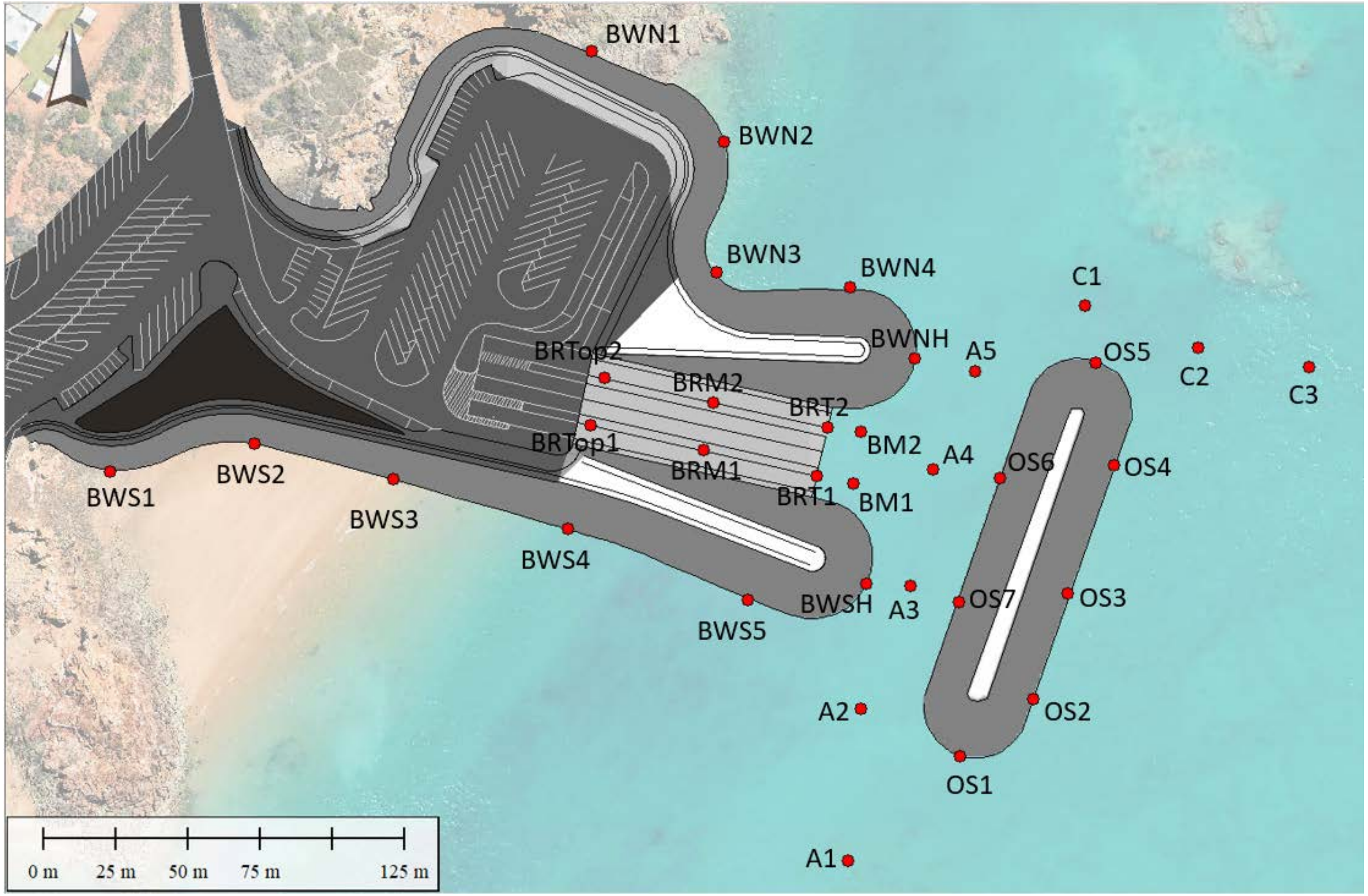


Figure 7.1: Reporting Locations for Analysis of Currents and Waves

7.2.2 Operational Currents

The modelled depth-averaged tidal currents were extracted from two locations assigned just offshore of the northern breakwater head (A5) and in the access corridor on the northern side of the offshore breakwater (C2). Time series current speed and direction were analysed over the simulation period and current roses produced for comparison of currents pre and post development at location A5 as shown in Figure 7.2 and C2 as shown in Figure 7.4.

- For location A5, the current speed is generally consistent between the existing case and developed case shown in Figure 7.2. The developed case structures align the current along a more southerly direction compared with the SSW direction in the existing case.
- For location C2 on the north side of the offshore breakwater the currents are deflected around the breakwater structure and the current rose in Figure 7.4 shows that the current speed increases compared with the existing case, as well as showing a distinct direction change for the tidal current as the flow is directed around the offshore breakwater to the SSE and SE predominantly.

Joint Frequency Tables for modelled current velocity and rose plots are presented in Appendix D.

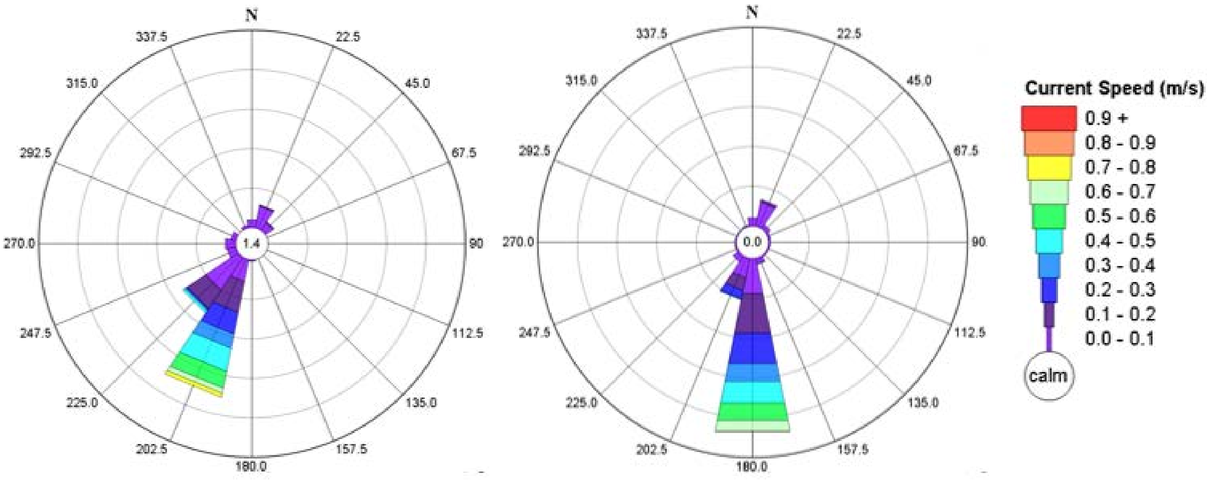


Figure 7.2: Modelled Current speed and direction for northern breakwater head location A5. Existing case (left) vs developed case (right). Plots show current format as direction going to.

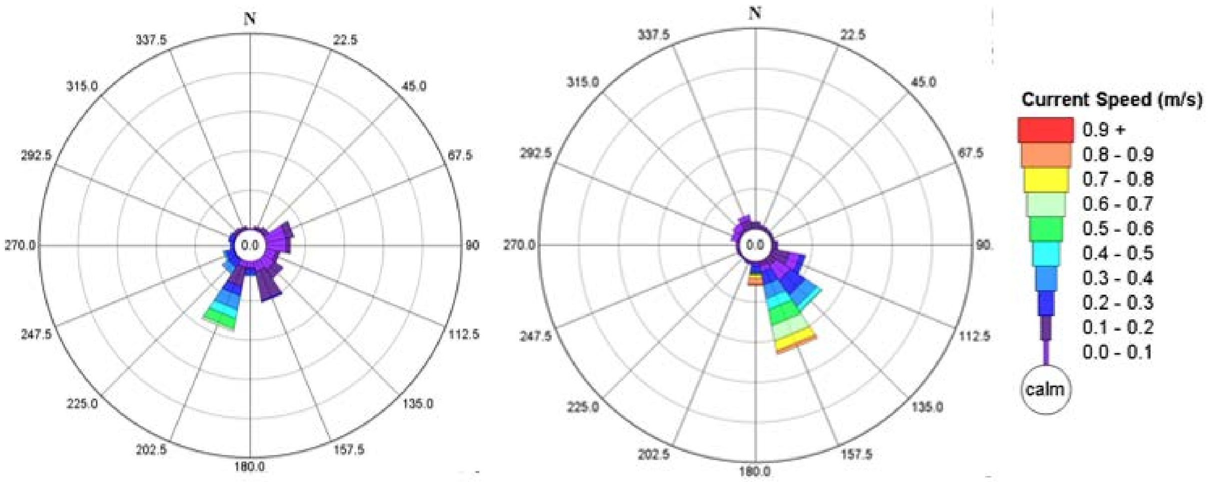


Figure 7.3: Modelled Current speed and direction for location on north side of offshore breakwater C2. Existing case (left) vs developed case (right).

The statistics for percentile current speed at location A5 is summarised on Table 7.2, for the existing case vs the developed case. At location A5 in the lee of the offshore breakwater and just seaward of the northern breakwater head, the current speed statistics are comparable to the existing case in Table 7.2 with a mean value of 0.21ms^{-1} in the existing case and 0.20ms^{-1} in the developed case. The current speed at the upper percentiles (P80, P90, P95, P99) in the developed case shows a reduction in current speed of 10% to 20% against the existing case.

Table 7.2: Depth-Averaged Current Statistics (analysis from 1 month of Modelled Data, Dec 2018 – Jan 2019). Location A5, seaward of the northern breakwater head.

	Depth-Averaged Current Speed (ms^{-1}) Percentile											Main Dir (to)
	Min	Max	Mean	99	95	90	80	50	20	10	5	
A5 Ext	0.00	0.83	0.21	0.79	0.66	0.56	0.44	0.11	0.04	0.02	0.00	SSW
A5 Dev	0.00	0.71	0.20	0.65	0.58	0.49	0.35	0.13	0.05	0.02	0.01	S

At location C2 a comparison of the statistics for current speed is shown in Table 7.3. There is a marked increase in the current speed at location C2 due to the developed case structures. The current speed increases from a mean value of 0.19ms^{-1} in the existing case to 0.28ms^{-1} in the developed case. At the upper percentile range (P80 and above) the developed case currents are 20% to 50% higher compared with the existing case.

Table 7.3: Depth-Averaged Current Statistics (analysis from 1 month of Modelled Data, Dec 2018 – Jan 2019). Location C2, north of offshore breakwater.

	Depth-Averaged Current Speed (ms^{-1}) Percentile											Main Dir To
Location	Min	Max	Mean	99	95	90	80	50	20	10	5	
C2 Ext	0.01	0.78	0.19	0.73	0.59	0.46	0.30	0.13	0.06	0.04	0.03	SSW
C2 Dev	0.01	0.92	0.28	0.86	0.76	0.65	0.48	0.21	0.08	0.04	0.03	ESE

It is noted that the model is reporting depth-averaged currents and currents speeds at the surface could be higher than the depth-averaged values. Joint Frequency Tables for modelled current velocity and rose plots are presented in Appendix D.

7.2.3 Spatial Plots of Tidal Currents

Spatial plots of the modelled current velocity (depth averaged) around Entrance Point have been produced from hydrodynamic model simulations over a spring tide and neap tide period in January 2019. Modelled spatial current maps have been developed and are included in Appendix C for the existing case (no structures) and with the BBF structures in place.

An example of the spatial mapping is shown in Figure 7.4 for the existing case peak ebb tide condition and in Figure 7.5 for the peak flood tide case. Measured data from DoT’s BRO4 AWAC have been superimposed onto the modelled vectors, as well as plotted over the current magnitude time series, showing very accurate reproduction of the current magnitude experienced in this location.

Peak ebb and flood tide conditions with the BBF concept design structures in place are shown in Figure 7.6 and Figure 7.7 respectively, demonstrating the changes in currents induced by the structures.

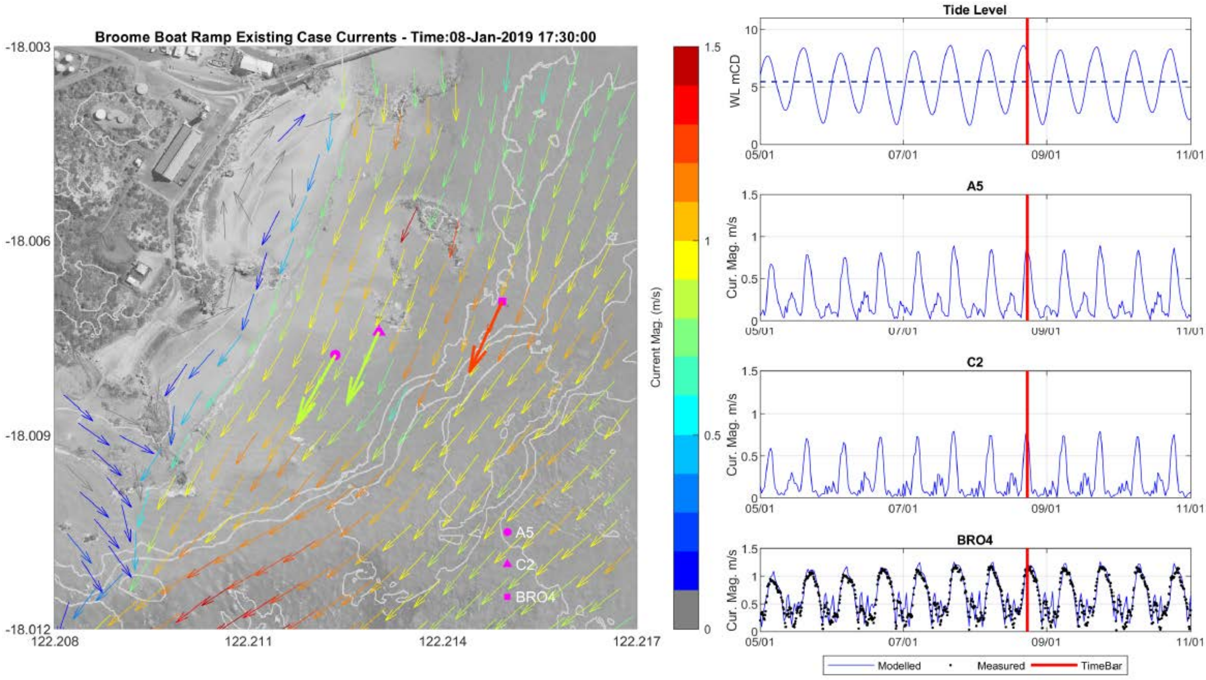


Figure 7.4: Modelled current velocity (depth averaged) for peak ebb tide case – Existing Bathymetry

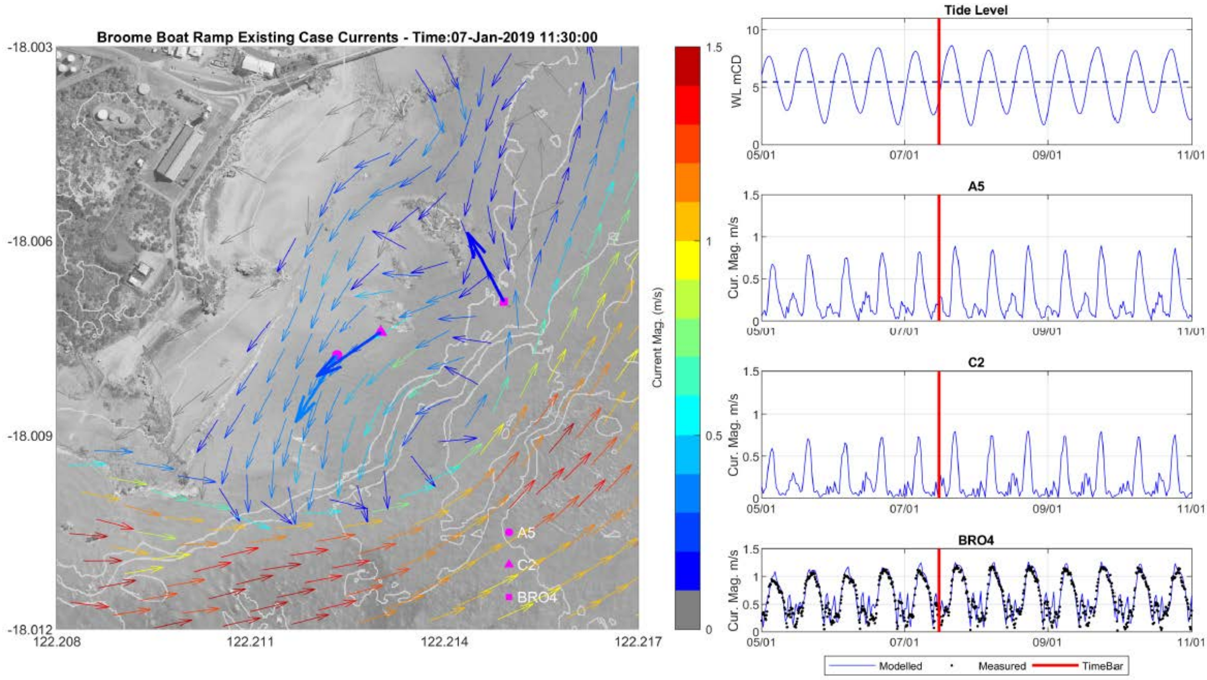


Figure 7.5: Modelled current velocity (depth averaged) for peak flood tide case – Existing Bathymetry

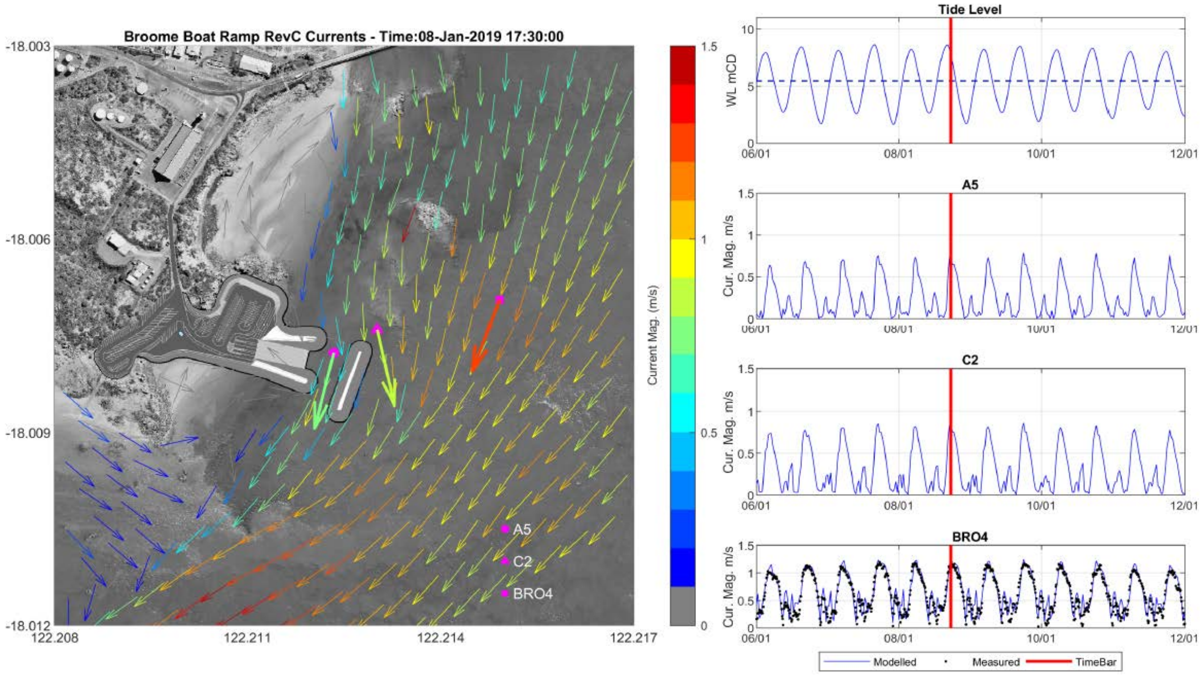


Figure 7.6: Modelled current velocity (depth averaged) for peak ebb tide case – BBF Structures

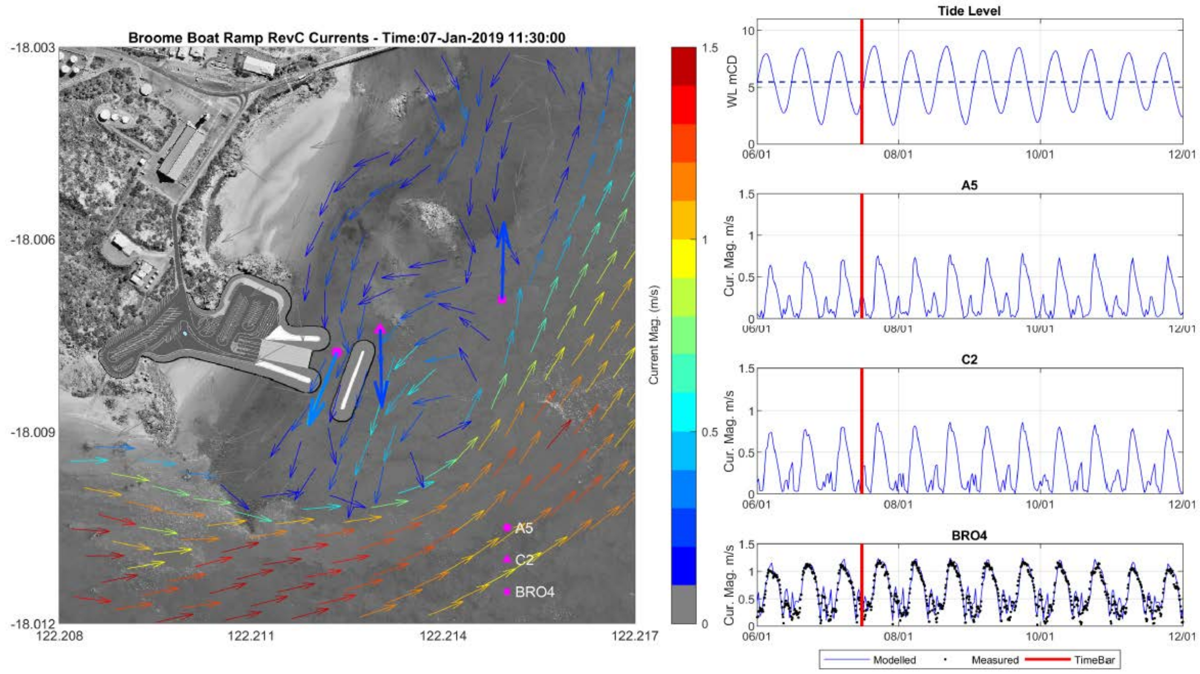


Figure 7.7: Modelled current velocity (depth averaged) for peak flood tide case – BBF Structures

7.2.4 Summary of ambient currents around the BBF

The peak current speeds around the BBF are high, due to the large tide range of Broome. The peak speed occurs at the turn of the tide at the start of the ebb tide, with spring tide current speed peak approaching 1ms^{-1} at location A5 and C2 in the modelled time series plots. The comparison of the magnitude of the currents at the A5 location between the existing and developed cases indicates the current velocity is marginally reduced with the inclusion of the BBF structures (Table 7.2), whilst at the C2 location the inclusion of the offshore breakwater increases current flow and magnitude is higher in the developed case (refer Table 7.3).

Detailed spatial current maps in Appendix C provide a useful reference for understanding conditions that may be experienced by vessels approaching the BBF. The intended approach route for vessels is to/from the North of the offshore breakwater, though users of the facility may also choose to travel from the southern side. The peak current velocity occurs at the turn of the tide from flood to ebb and peak conditions are relatively short (approximately 0.5-2 hours). Peak currents are always heading from north to south.

The offshore breakwater structure and landside structures will modify the current speed around the boat ramp. The analysis of the developed case in the model indicates:

- The design reduces current speed at the ramp to enable safe conditions for vessel launch and retrieval; and
- The modelled outcomes indicate that in the lee of the offshore breakwater (location A5) there is a reduction in the upper range current velocity (P80 and higher) of 10% to 20% against the existing case which is beneficial for navigation.

In the lee of the offshore breakwater the BBF design will need to strike a balance in achieving a current velocity that is safe for navigation but that also maintains the sediment transport mechanism currently in place at the location, so as not to become a sediment trap.

7.3 Operational Wave Conditions at the BBF

The operational wave conditions have been examined for the BBF developed case based on a one-year hindcast model of wave conditions, based on the measured data from BRO4 as outlined in Section 6.4.

The model hindcast conditions are updated hourly in the model for water level, wave conditions (Hs, Tp, wave direction) and wind speed and direction. The one-year hindcast has been developed from measured data from BRO4 (waves), water level (Broome tide gauge) and the BoM wind Data (Broome AWS and Airport data combined).

7.3.1 Operational Waves – Vessel Launch and Retrieval

The one-year hindcast provides time series modelled wave conditions over the 12-month duration at output locations on the boat ramp, which are assessed against thresholds for safe launching and retrieving of vessels.

The operational analysis is based on two requirements being met for ‘safe’ boat ramp usage:

1. Significant wave height < 0.2m (based on AS3962)
2. Depth at ramp toe of 1m or greater. The toe of the ramp is at approximately +0.5mCD.

The modelled timeseries data from the toe of the ramp (worst of BRT1/BRT2 location) was analysed through an algorithm conditioned to the 2 requirements above to examine how much downtime would occur over the 12-month hindcast period.

The analysis of downtime for the ramp is summarised in Table 7.4 over the one year of hindcast conditions, based on model outcomes at reporting locations at the base of the boat ramp. It is noted that the joint occurrence of water depth <1m and wave height >0.2m did not occur on the boat ramp toe in the dataset.

The results in Table 7.4 show:

- Depth limitation contributes to downtime at the boat ramp accounting for 179 hours over the year (2%) where there is less than 1m depth at the toe of the ramp (toe is assumed at +0.5m CD). The depth limitation would impact the ramp in the spring tide periods at the time of the largest tidal variation, for a short duration (1-2 hours);

- The annual downtime on the ramp due to wave conditions higher than the Hs=0.2m threshold represents 292 hours annually (3.3%). The total downtime due to wave conditions is weighted to the dry season months which incur 208 hours downtime (4.7%) vs the wet season figure of 84 hours (1.9%). The dry season wave conditions are significantly higher at the boat ramp location compared to wet season due to the easterly and south-easterly wave conditions resulting from the dry season wind regime, which drive wind sea across Roebuck Bay to the BBF; and
- The annual downtime at the ramp over the one-year hindcast period assuming the water level and wave height thresholds is 5.4%. By seasonal period, downtime over the dry season represents 7.1% of the time whilst for the wet season months the overall downtime is lower at 3.6%.

Table 7.4: Downtime Summary based on one year of hindcast conditions at Boat Ramp Toe (BRT1 / BRT2). The year selected is 1 Mar 2019 – 29 Feb 2020.

Options	Depth <1m At Toe Ramp		Hs>0.2m At Toe of Ramp		Combined Downtime Total Hours	
	Hours	% Time	Hours	% Time	Hours	% Time
Dry Season (May – October)	104	2.4%	208	4.7%	312	7.1%
Wet Season (November – April)	75	1.7%	84	1.9%	159	3.6%
Annual Total	179	2.0%	292	3.3%	471	5.4%

7.3.2 Operational Waves – Vessel Navigation

The hindcast wave conditions along the approach routes for the BBF developed case were assessed against a threshold value of H_s=0.5m for the one-year hindcast period. The 0.5m threshold was adopted as representative of conditions where vessel manoeuvrability for small craft would be impacted based on discussions with the project in earlier phases. The summary of the amount of time the modelled wave conditions exceed the threshold is presented in Table 7.5.

The data is presented as an annual figure as well as the Dry Season period (May – October) and Wet Season period (November – April). The results in Table 7.5 show:

- The number of times the threshold wave height is exceeded is weighted towards the dry season months. This is consistent with the dry season and wet season comparison of wave data measured at BRO4 presented in
- the wave conditions in the lee of the offshore breakwater (locations A3, A4, A5) rarely exceed the threshold Hs=0.5m wave condition shown as 0.2% to 1.4% of the time annually.
- At the exposed locations A1 and A2 south of the BBF the wave condition threshold is exceeded 6% and 9% of the time annually.
- At the northern corridor access locations (C1, C2, C3) the wave height threshold is exceeded 4%, 7% and 8% of the time respectively on an annual basis.

Table 7.5: Operational Waves for Navigation – Analysis of 1-year hindcast wave conditions on the approach to the Boat Ramp

Location	Dry Season (May – October)		Wet Season (November – April)		Annually	
	No. Hours	% Time	No. Hours	% Time	No. Hours	% Time
A1	533	12.1%	260	6.0%	793	9.0%
A2	320	7.2%	192	4.4%	512	5.8%
A3	91	2.1%	34	0.8%	125	1.4%
A4	23	0.5%	10	0.2%	33	0.4%
A5	7	0.2%	11	0.3%	18	0.2%
C1	239	5.4%	107	2.4%	346	3.9%
C2	464	10.5%	147	3.4%	611	7.0%
C3	551	12.5%	179	4.1%	730	8.3%

7.4 Cyclonic Wave Conditions

7.4.1 Overview of cyclone modelling approach

During recent studies undertaken in the Broome region of historical and synthetic storms, Baird has found that cyclones typically experienced in this region are comparatively fast moving, with a small Radius to Maximum Winds (RMW). On the lee side of Entrance Point where the BBF is sited, there is significant sheltering from the open coast extreme wave conditions during cyclone events.

Baird's investigation of these typical storms has been undertaken for the Kimberley Marine Support Base (KMSB) project using a Monte Carlo approach, to develop a realistic 500-year ARI storm, as well as estimates of both higher and lower ARI storms. The largest wave conditions are produced when winds are directed along the open fetch to the south-southeast of the BBF which is approximately 30km (refer Figure 3.6).

In modelled hindcast and synthetic cyclone scenarios completed by Baird, it is observed that for many cyclone events that track offshore of the BBF location, the sea conditions that are produced are not fully developed for their associated wind speed and direction. It was also observed that lower intensity and more frequent storms, for example a 20-year ARI event, the relative scale of these storms can be larger and are more likely to generate fully developed sea conditions, which typically require 2 to 3 hours of sustained winds from a south-east to south direction to generate fully developed at the BBF site. Cyclones that are more intense and lower frequency, typically have smaller RMW's and this results in sustained winds from a south-east to south fetch typically acting for a 1 to 2 hour period and not generating fully developed seas. A Monte Carlo approach can address those complexities; however, the result is that a larger confidence interval in the design criteria needs to be considered and a risk-based design methodology is required to ensure that coastal structures achieve the level of reliability that is required.

In light of the points discussed above, a conservative approach of using the stationary SWAN model results with fully developed seas has been adopted for defining design waves at the BBF resulting in a specific design wave condition for each recurrence interval (ARI).

The cyclonic design wave conditions have been determined for the BBF based on analysis of cyclonic wind conditions at the site from measured data sources and modelled cyclonic wind fields (refer Section 3.3). The design winds were applied in the wave model from key wind sectors over Roebuck Bay to determine the final cyclonic wave criteria. Wave modelling of extreme cyclonic wind conditions from the south, south east and east directions were completed at the 1yr ARI, 20yr ARI, 50yr ARI and 100yr ARI. The detailed outcomes from the 12 model cases are presented in full in Appendix E.

The wave conditions at the BBF structures have been determined based on analysis of results from the SWAN model. It is noted that the results are considered to be conservative, representing wave heights experienced at the structures under fully developed sea conditions. Joint occurrence of wind and water level is assumed in the model cases which is a conservative assumption that could be further refined in detailed design (eg the 50yr ARI wind is applied with the 50yr ARI water level).

7.4.2 Cyclonic Design Criteria for BBF Structures

The model results for the BBF layout were analysed in 7 sections as shown in Figure 7.8 to inform the engineering design. Design criteria for each respective return period were summarised based on the highest wave conditions (incident wave) from the model along the respective sections of the design:

- Section 1 – Southern Breakwater Landside Connection
- Section 2 – Southern Breakwater Head
- Section 3 – Boat Ramp
- Section 4 – Northern Breakwater Head
- Section 5 – Northern Breakwater Landside Connection
- Section 6 – Offshore Detached Breakwater Lee Side
- Section 7 – Offshore Detached Breakwater Exposed Side

Design criteria are presented for each of the return period cases summarising the wave parameters, wind and water level conditions at the 1yr ARI, 20yr ARI, 50yr ARI and the 100yr ARI return period in Table 7.6 to Table 7.9.

The detailed outcomes from the extreme model cases are presented in full in Appendix E.

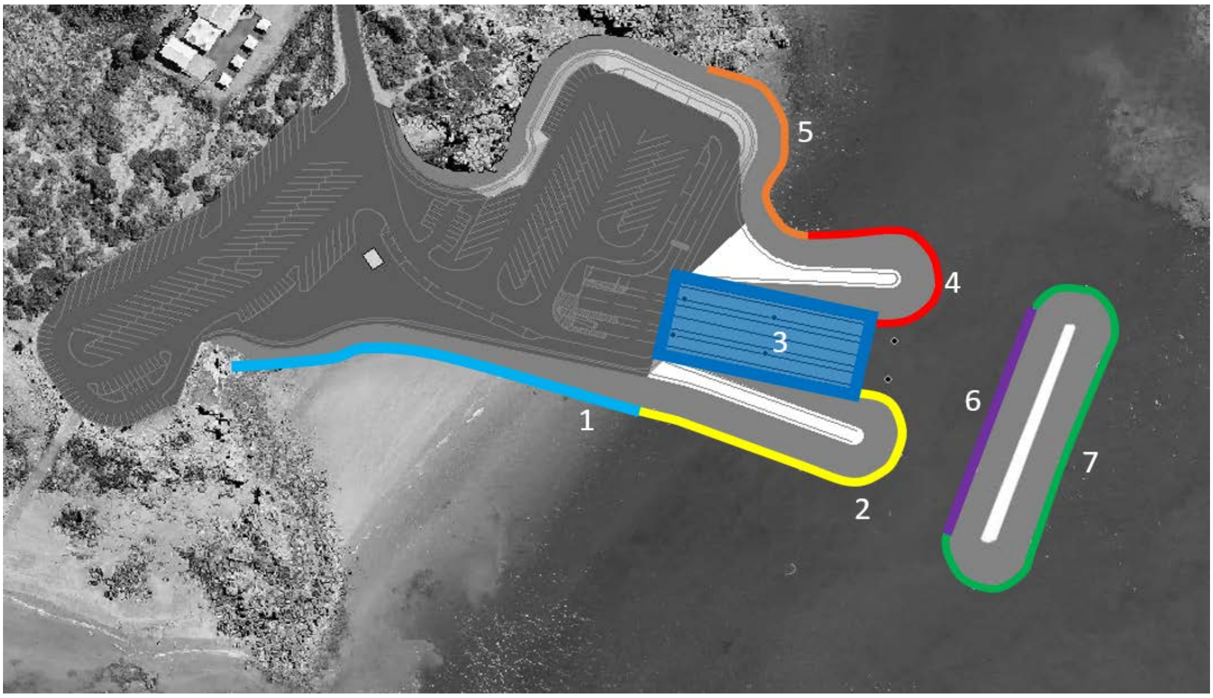


Figure 7.8: Cyclonic Design Criteria – Wave Conditions are reported in seven sections

Table 7.6: Cyclonic Design Criteria – 1yr ARI wave conditions

1yr ARI		1	2	3	4	5	6	7
Parameter	**Units**	**S BW**	**S Head**	**Ramp**	**N Head**	**N BW**	**Offshore Lee**	**Offshore**
Winds								
10-minute Mean Overwater Wind Speed at 10mAMSL	m/s	16.1	16.1	16.1	16.1	16.1	16.1	16.1
Water Levels								
Peak Total Still Water Level	mCD	10.4	10.4	10.4	10.4	10.4	10.4	10.4
Seastate								
Significant Wave Height (Hs)	m	1.4	1.5	0.6	1.0	1.1	0.9	1.5
Peak Wave Period (Tp)	s	4.6 - 4.9	4.9	3.9 - 4.9	4.3	4.5 - 5.0	4.9	4.5
Zero Crossing Wave Period (Tz)	s	3.8	2.1	2.8	3.2	3.4	3.6	3.7
98th percentile Wave Height (H2%)	m	1.9	2.1	0.8	1.4	1.6	1.3	2.1
Maximum Wave Height (Hmax)	m	2.5	2.9	1.1	1.8	2.1	1.7	2.8
Associated mean Wave Period for Hmax (T Hmax)	s	4.4	2.4	3.2	3.7	3.9	4.1	4.2

Table 7.7: Cyclonic Design Criteria – 20yr ARI wave conditions

20yr ARI		1	2	3	4	5	6	7
Parameter	**Units**	**S BW**	**S Head**	**Ramp**	**N Head**	**N BW**	**Offshore Lee**	**Offshore**
Winds								
10-minute Mean Overwater Wind Speed at 10mAMSL	m/s	27.8	27.8	27.8	27.8	27.8	27.8	27.8
Water Levels								
Peak Total Still Water Level	mCD	10.6	10.6	10.6	10.6	10.6	10.6	10.6
Seastate								
Significant Wave Height (Hs)	m	2.5	2.8	1.0	1.4	1.4	1.5	2.9
Peak Wave Period (Tp)	s	5.8	5.8 - 6.2	5.6 - 6.3	5.0 - 6.3	4.5 - 5.0	5.7	5.6 - 5.8
Zero Crossing Wave Period (Tz)	s	4.7	3.9	4.3	4.3	3.6	4.0	4.6
98th percentile Wave Height (H2%)	m	3.6	3.9	1.4	2.0	2.0	2.1	4.0
Maximum Wave Height (Hmax)	m	4.6	5.2	1.9	2.6	2.6	2.7	5.2
Associated mean Wave Period for Hmax (T Hmax)	s	5.4	4.5	5.0	4.9	4.2	4.6	5.3

Table 7.8: Cyclonic Design Criteria – 50yr ARI wave conditions

50yr ARI		1	2	3	4	5	6	7
Parameter	**Units**	**S BW**	**S Head**	**Ramp**	**N Head**	**N BW**	**Offshore Lee**	**Offshore**
Winds								
10-minute Mean Overwater Wind Speed at 10mAMSL	m/s	31.6	31.6	31.6	31.6	31.6	31.6	31.6
Water Levels								
Peak Total Still Water Level	mCD	10.7	10.7	10.7	10.7	10.7	10.7	10.7
Seastate								
Significant Wave Height (Hs)	m	2.9	3.3	1.2	2.0	2.3	1.7	3.4
Peak Wave Period (Tp)	s	6.3 - 6.5	6.4 - 6.5	5.6 - 6.6	5.6	5.6 - 5.7	6.3	5.7 - 6.4
Zero Crossing Wave Period (Tz)	s	5.0	4.6	4.6	4.0	4.3	4.2	4.9
98th percentile Wave Height (H2%)	m	4.1	4.6	1.7	2.7	3.2	2.4	4.7
Maximum Wave Height (Hmax)	m	5.3	6.0	2.2	3.6	4.1	3.1	6.1
Associated mean Wave Period for Hmax (T Hmax)	s	5.8	5.3	5.3	4.6	4.9	4.8	5.7

Table 7.9: Cyclonic Design Criteria – 100yr ARI wave conditions

100yr ARI		1	2	3	4	5	6	7
Parameter	**Units**	**S BW**	**S Head**	**Ramp**	**N Head**	**N BW**	**Offshore Lee**	**Offshore**
Winds								
10-minute Mean Overwater Wind Speed at 10mAMSL	m/s	34.6	34.6	34.6	34.6	34.6	34.6	34.6
Water Levels								
Peak Total Still Water Level	mCD	10.9	10.9	10.9	10.9	10.9	10.9	10.9
Seastate								
Significant Wave Height (Hs)	m	3.1	3.6	1.4	2.2	2.6	1.8	3.7
Peak Wave Period (Tp)	s	6.5 - 6.6	6.5 - 6.6	5.7 - 7.1	6.2	6.2	6.4	6.2 - 6.5
Zero Crossing Wave Period (Tz)	s	5.2	5.0	4.7	4.2	4.5	4.3	5.2
98th percentile Wave Height (H2%)	m	4.4	5.0	1.9	3.1	3.6	2.5	5.1
Maximum Wave Height (Hmax)	m	5.6	6.5	2.5	4.0	4.7	3.3	6.6
Associated mean Wave Period for Hmax (T Hmax)	s	6.0	5.8	5.4	4.8	5.2	4.9	5.9

8. Sediment Transport Processes

The construction of the BBF breakwater structures on the landside and offshore will modify the sediment transport processes on the beaches either side of the development on the east of Entrance Point. In this section a summary of the understanding of sediment transport processes currently acting around Entrance Point is presented. In Section 9 the prediction of how the shoreline processes are projected to change with the BBF structures is presented.

8.1 Coastal Processes Driving Sediment Transport

The key coastal processes that are responsible for sediment movement around the shorelines of Entrance Point are the strong tidal currents and seasonally varying wave conditions. Their influence on sediment transport is controlled by the extreme tide range, the sediment availability and size of sediments on the seabed around Entrance Point.

8.1.1 Sediment Transport – Influence of Tidal Currents

The Entrance Point shoreline around the BBF site is shown in Figure 8.1 in an oblique image taken at a very low tide on 12th March 2020 at 6.30 am, with a water level of approximately +0.5m CD. The low tide image provides a very good overview of the influence of tidal currents on sediment transport processes at the site of the BBF.

Figure 8.1: Oblique image showing Entrance Point with BBF site indicated. (DoT, image date Thursday 12th March 2020 at 6.30 am, water level at approximately 0.5m CD)

Notable in Figure 8.1 are the two beach compartments on the east side of Entrance Point. On the left in Figure 8.1 is the southern compartment where the BBF is to be located and on the right side of the natural headland feature is the northern beach compartment. The upper shoreline areas in each of the compartments are overlain with sand, with a clear line halfway down the exposed beach where the sand gives way to exposed reef overlain by a thin layer of sediment.

The sediment composition of the cross-shore area in front of the BBF is described in Figure 8.2 with a comparison to the elevation contours through the shoreline showing:

- the upper shoreline where sand is prevalent is in the range of -2m MSL to +1m MSL.
- at an elevation below -2m MSL the reef features and rock are exposed with a thin layer of sediment overlain.

The transition from sediment on the shore to exposed rock and reef is at approximately the -4mMSL contour. This correlates with the area at which the current speeds increase in the nearshore region as shown in Figure 7.4. The current speed approaches 1ms^{-1} in this area offshore in spring tides, which would mobilise sediment on the seabed overlying the rock features. This is the reason why there is only a thin overlay of sediment over the exposed rock in the nearshore of Figure 8.1 and Figure 8.2. Current speeds reduce markedly through the upper shoreline (elevation >-2m MSL) where sediment is observed on the beach in Figure 8.1 and Figure 8.2.

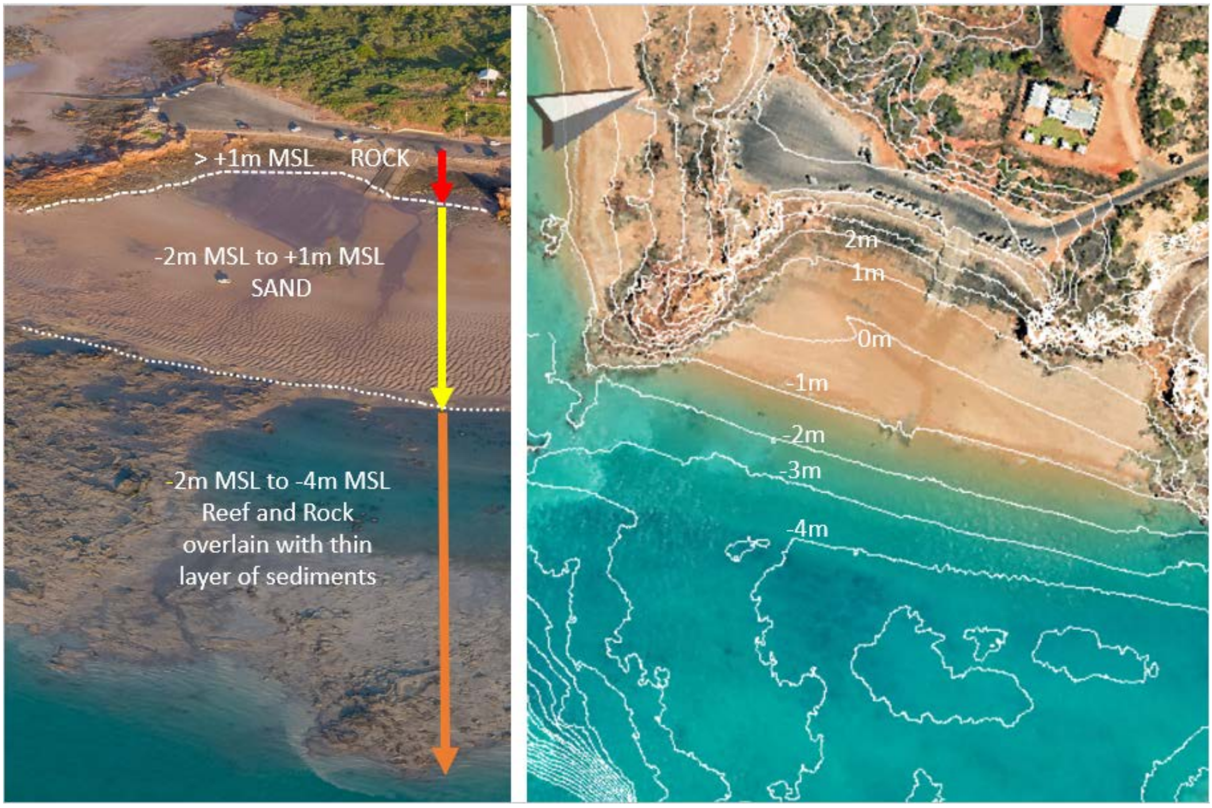


Figure 8.2: Shoreline sediment description at the BBF beach compartment

8.1.2 Sediment Transport - Sediment Size Around Entrance Point

The influence of the strong tidal currents is evident when looking at the sediment size on the seabed areas around Entrance Point.

Sediment sampling from around the site over numerous campaigns has been compiled to provide a description of the beaches and nearshore around Entrance Point as shown in Figure 8.3. The sediment results are summarised in Figure 8.3 based on the median sediment size (D_{50}) of the sample sources. It can be seen in Figure 8.3:

- On the upper shoreline of the BBF beach compartment the sediment is composed generally of coarse sand in the range of 0.24mm to 0.32mm. In the beach compartment to the north the sediments are similarly sized in the range 0.23mm to 0.41mm.
- Offshore where strong tidal currents dominate (refer Figure 7.4), the sediment samples show a median sediment size of 1.7 to 3.5mm, consistent with very coarse sand and gravel. In these samples a small proportion (5% of sample) of silts and clay was recorded.
- The onshore sediment sample taken near the top of the beach in the beach compartment north of the BBF showed a high proportion of gravel (D_{50} of 2.36mm);
- On the southwestern side of Entrance Point on the beach west of the existing boat ramp, the sediment samples are medium sand with a median sediment size of 0.18mm to 0.20mm; and

- North of the Broome Wharf in Roebuck Bay, the sediment is much finer and fine sediment (silt and clay) is evident in the samples. Sediment sample median sizes range from 0.04mm to 0.15mm. Additional sediment sampling through Roebuck Bay north of the Broome Wharf reports the composition of the seabed as very fine sand and silt (Appendix A).

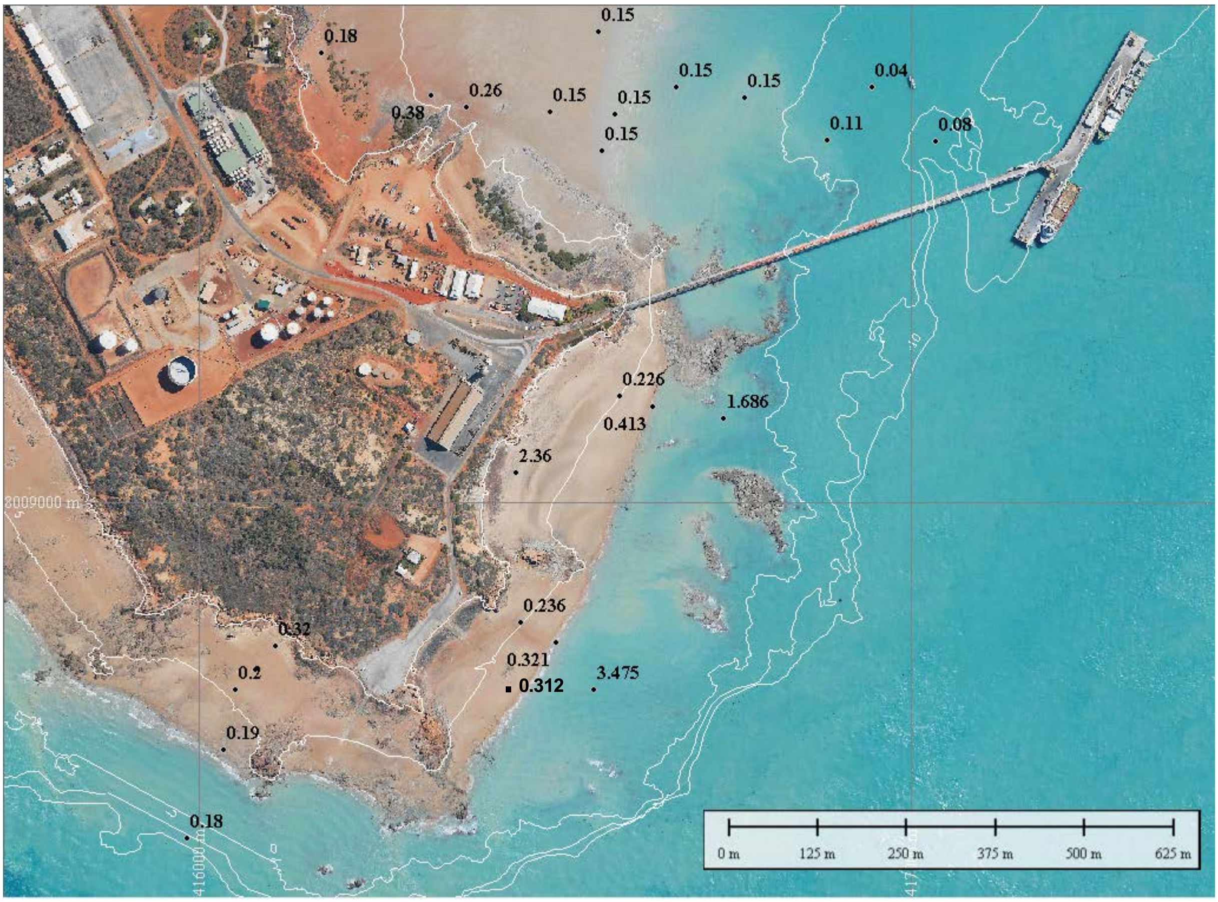


Figure 8.3: Summary of sediment size at the seabed in the nearshore region around Entrance Point. Median sediment size (D_{50} in mm) is shown at the locations where surface samples have been reported from various collection campaigns.

In general, sediment size around Entrance Point is influenced by the magnitude of current velocity:

1. For the Roebuck Bay area north of the Broome Wharf the seabed layer shows fine sands and silts dominate. In this region the tidal currents are low, fine sediments are deposited on the shoreline with a wide tidal flat area that has developed.
2. For the beach compartment of the BBF and the one to the north, the tidal currents are stronger and persistent. Mobilisation of the fine sediments (clays, silts) occurs, however the medium grained sands remain on the beach, too large to be mobilised from the bed and removed on the tidal-dominated current flows.
3. For the offshore section of the beaches on the east side of Entrance Point the sediment size increases to be consistent with coarse sand and gravel. The absence of smaller-grained sediment size on the seabed is the result of the high current velocities noted through this section of the coast mobilising finer sediments which are carried in suspension offshore.

8.1.3 Sediment Transport – Influence of Waves

Analysis of the historical aerial imagery from the Landgate aerial dataset and Google Earth around Entrance Point was undertaken to examine suspended sediment in the nearshore areas and the influence of waves and currents. In general, it was found that suspended sediment was most noticeable in images that were taken in the dry season months. A selection of the images is presented in Figure 8.4.

Figure 8.4: Selection of photos from Dry Season Months showing suspended sediment in the water column moving around Entrance Point (Google Earth)

The driving mechanism for the active sediment plumes seen in the examples in Figure 8.4, is understood to be the typical Dry Season easterly and south easterly winds acting over Roebuck Bay which create waves in the shoreline areas that break on the western side of Roebuck Bay. The wave action mobilises fine sediments in the nearshore north of the Broome jetty in Roebuck Bay, with the suspended sediment then driven southward on the strong ebb tide flow that runs along the western shoreline of Roebuck Bay past Entrance Point and offshore. Some of the fine sediments may settle on the beach compartments on the east side of Entrance Point – as indicated in the upper left panel of Figure 8.4.

An aerial image shown in Figure 8.5 supplied by the DoT from June 2011 (Source Landgate) shows the south easterly waves on the shore of the Entrance Point project site (inset). In the image the suspended sediment is evident throughout Roebuck Bay with increasing concentration toward the western shore.

Figure 8.5: Dry Season Aerial Image June 2011 (Source DoT, Landgate) showing suspended sediment throughout Roebuck Bay concentrated along the western shoreline and easterly wind waves along the Entrance Point shoreline (inset image).

Conversely, in wet season the wind direction is dominated by westerlies. Wave directions in the wet season are dominant from the South, South-Southwest and Southwest directions (Figure 6.6). In Figure 8.6 a wet season scenario is shown from 22 Jan 2015 with the aerial image showing waves on the southwest-facing shore of Reddell Beach, and calm conditions on the shoreline of Roebuck Bay north of the wharf. In Figure 8.6 there is suspended sediment in the nearshore along Reddell Beach as a result of longshore sediment transport. The longshore transport process moves sediment around the southern tip of Entrance Point to the beach compartments where the BBF will be sited.

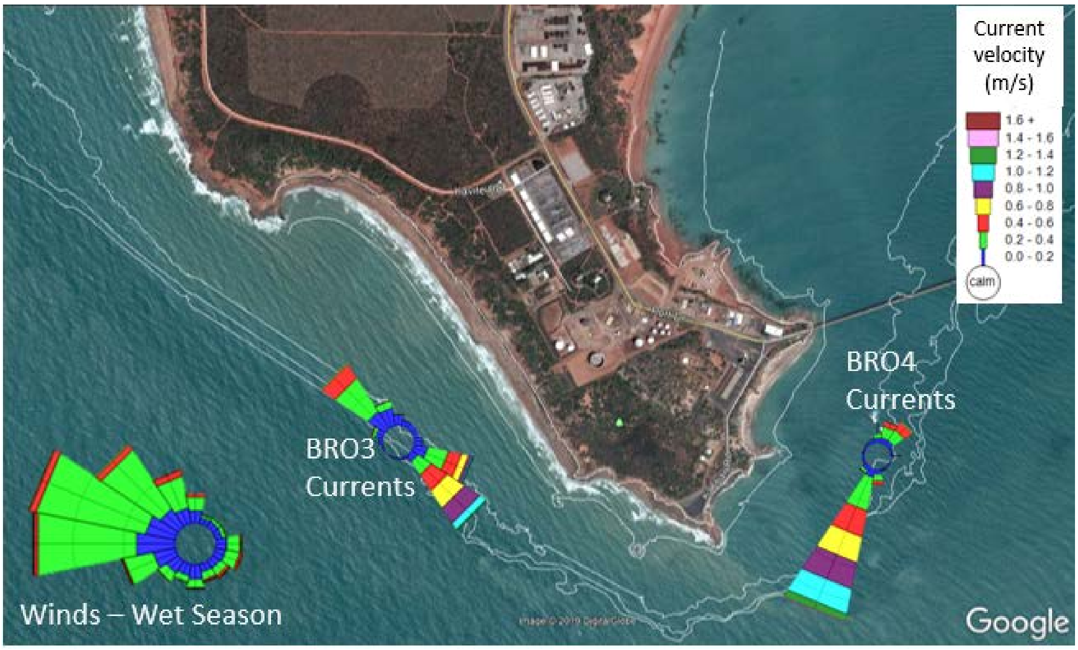


Figure 8.6: Wet Season Aerial Image 22 January 2015 (Google Earth) showing calm conditions in Roebuck Bay and westerly waves on the open coast of Reddell Beach created by the dominant westerly winds of the wet season.

8.1.4 Shoreline Stability – Analysis of Aerial Imagery

The shoreline around Entrance Point was analysed in the Broome Coastal Vulnerability Study (CVS, Cardno 2013). The CVS assessed the shoreline stability using the available historical aerial images dating back to 1965. The shoreline movement analysis around Entrance Point is shown in Figure 8.7 from the CVS report, with the BBF site located between transect 352 and 354 (indicated by red circle). Based on the analysis in the CVS, the shoreline of Entrance Point, where the proposed BBF would be sited, has remained very stable over the approximate 50-year period since 1965 with negligible shoreline movement. For the beach compartment on the north of the BBF between transect 355 and 360, a small degree of erosion is noted over the 50-year period of between 0.1m to 0.3m.

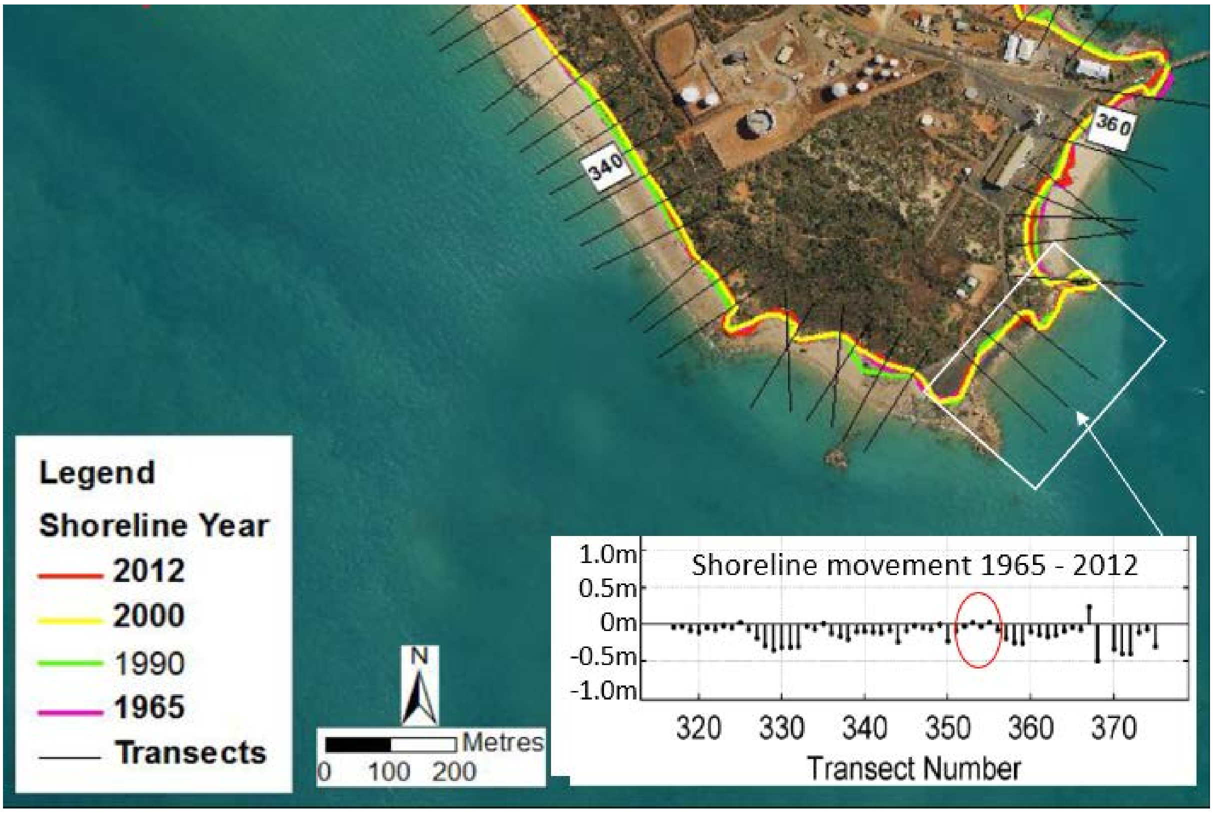


Figure 8.7: Shoreline Movement for the Entrance Point shoreline, calculated from historical aerial imagery. Extract from the Broome Coastal Vulnerability Study (Cardno 2013)

In Figure 8.8 a comparison of a recent drone photo taken at Entrance Point on the northern beach compartment from 2019 with a historical photo of the location from 1963 prior to the wharf and port establishment show the nearshore features to be very consistent over the approximately 50-year period. One notable difference in the 1963 image is the abundance of sand at the back of the beach overlaying the pindan which extends back over Entrance Point. This section is today covered by the Broome Port infrastructure with extensive vegetation. It is likely the sand over Entrance Point in the 1963 image was a source and sink for sediment moving on and off the beach system under the seasonal wind regime (aeolian). There is noted sediment build-up on the south side of the natural headland feature on the left of the 1963 image and at the back of the beach compared with the more recent image.

In Figure 8.9 an oblique photo of the Broome shoreline taken from Roebuck Bay and looking south over Entrance Point shows the distinctive changes in sediment in the shoreline areas. The foreground of the image shows the tidal flats where fine grained sediments are present on the shore of Roebuck Bay mixed with the red colour of the Pindan. Over the Entrance Point Beach compartments and the open coast of Reddell Beach the sediment changes to a sandy composition.

Figure 8.8: Entrance Point comparison of oblique photos - Upper 1963, Lower 2019 (Source DoT).

Figure 8.9: Entrance Point Oblique photo – 21 July 1985 looking from Roebuck Bay

8.1.5 Shoreline Monitoring - Site Photos

Site photos taken from the beach compartment north of the BBF in two visits over the wet season 2018/2019 are compared in Figure 8.10 which show a distinct increase in sand on the beach over the period from early November to late March (wet season). It is clear that an influx of sand has occurred through the Wet Season months.

Figure 8.10: Comparison of site photos taken from the Entrance Point beach. The photos on the left are taken on 11 November 2018 (Source DoT) and the photos on the right are from 27 March 2018 (Source WGA). There is a noticeable increase in the sediment in the nearshore areas between November and March.

It is noted that there were two tropical cyclones over the 2018/19 wet season that passed by Broome between the time of the photos presented in Figure 8.10 (TC Riley Jan 2019, TC Veronica Mar 2019). Site photos collected from the same beach compartment as part of the Broome Townsite Shoreline Monitoring project between December 2018 and April 2020 (Baird 2020c report, prepared for Shire of Broome) support that sediment changes on the upper beach are driven by ambient processes with rocks in the upper shoreline uncovered over dry season, and sediment gradually returning over the wet season.

Analysis of oblique photos collected by the DoT over the period provide further support to the wet season months providing opportunity for sediment to return to the northern beach compartment. In Figure 8.11, the drone image taken mid-dry season on 19 July 2019 shows exposed rock areas at the upper beach. A similar image taken of the beach compartment on 12 February 2020 in mid wet season in Figure 8.11 shows the same areas of the upper beach overlain with sediments. The natural headland feature in the foreground that divides the north and south beach compartments shows a continuous sand ‘bridge’ at the upper shoreline on 12 February 2020 which is similar to the top right image in Figure 8.10 from Wet Season 2019. The same area is exposed rock in the dry season image in the upper plot of Figure 8.11 and the upper left image in Figure 8.10.

Figure 8.11: Comparison of drone images north beach compartment – Upper Photo 19 July 2019 (mid Dry Season), Lower photo 12 Feb 2020 (mid-Wet Season). In dry season the upper beach is exposed rock (July 2019). The rock is then overlain with sediment by late wet season (Feb 2020).

For the beach compartment of the intended BBF location (south compartment), the photo monitoring data is still being collected and at present does not provide notable differences in sand cover on the beach seasonally. In Figure 8.12, site photos looking south over the existing boat ramp captured in December 2018 and March 2019 show consistent shoreline features over the three month period (Baird 2020c). An oblique image looking north over the BBF site in Figure 8.13 shows the sediment on the shoreline in the compartment to the SW of the BBF.

Figure 8.12: Photo sequence taken from Broome Shoreline Monitoring project from the site of the BBF (EP3-South). Photo dates - 5 Dec 2018 (left), 1 Mar 2019 (right) looking south over existing boat ramp.

Figure 8.13: Oblique image captured 12 February 2020 (mid-wet season) looking northward over the BBF site.

As part of the Broome Monitoring Program (Baird, 2020c), local scale beach survey at Entrance Point at the beach compartment of the BBF was collected using Unmanned Aerial Vehicle (UAV). The shoreline elevation was collected on 13th February 2020 and again on 25th June 2020. A difference plot showing the changes in elevation in the shoreline is presented in Figure 8.14 (based on Elevation June 2020 – Elevation Feb 2020).

The difference plot shows that between surveys the beach compartment of the BBF showed a general accretion trend with changes on the shoreline in the region of +0.25m. For the beach compartment on the west side of the BBF, erosion of a similar level was noted (~0.25m) on either side of the boat ramp. On the beach compartment north of the BBF, a mixture of erosion and deposition was noted in the region of +/- 0.25m.

It is noted that the comparison is made for one distinct Wet Season to Dry Season period in 2020, however the noted changes on the shoreline indicate the following:-

- Erosion from the open beaches on the west side of Entrance Point;
- Accretion on the beach compartment of the BBF; and
- A mixture of accretion and erosion on the northern beach compartment.

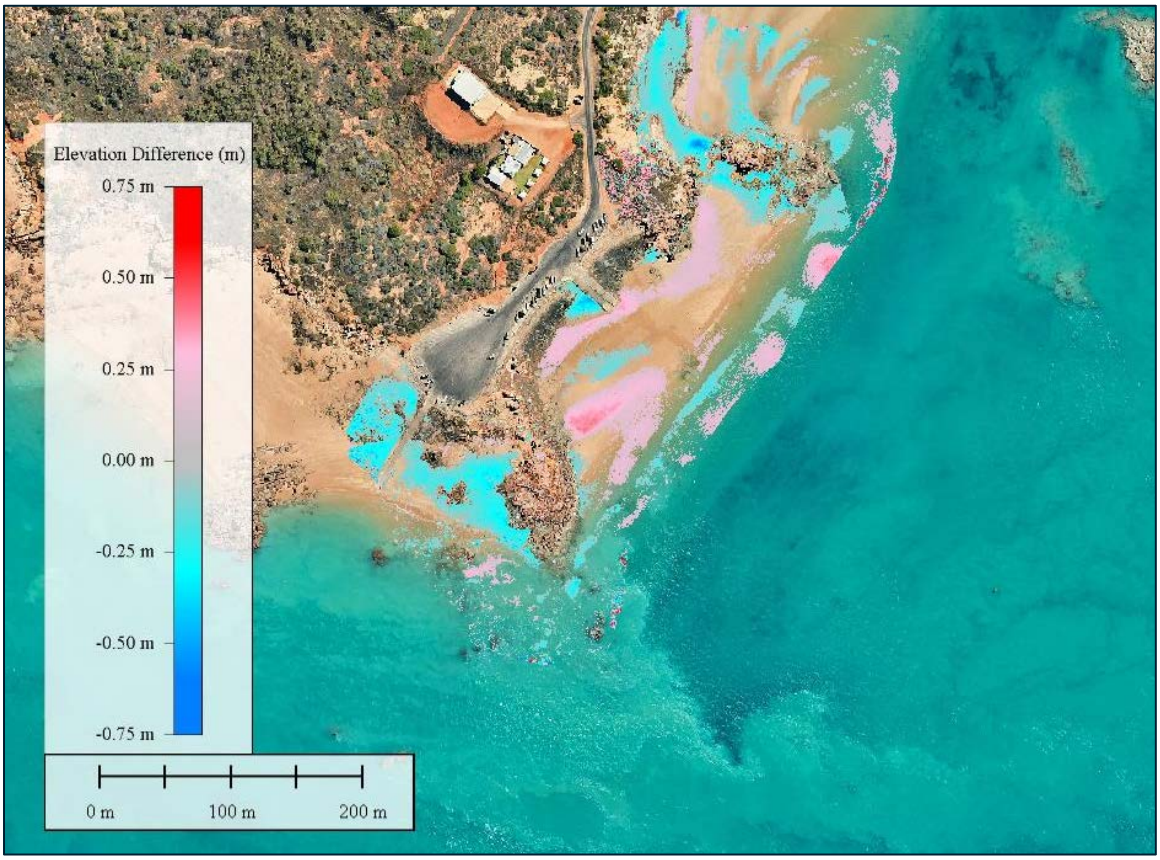


Figure 8.14: Elevation Difference Map showing the difference between the February 2020 UAV elevation data (13th February 2020) and the June 2020 UAV elevation data (25th June 2020) at Entrance Point

8.2 Sediment Transport Pathways - Summary

The understanding of the coastal processes in the beach compartments of the eastern side of Entrance Point has been developed from the assessment of historical imagery, analysis of measured data and the interpretation of site-based information outlined in the previous section.

An overview of the sediment transport pathways is shown in Figure 8.15 for dry season and Figure 8.16 for the wet season.

8.2.1 Dry Season – Sediment Transport Pathways

- Sediment transport processes in Roebuck Bay are most active in the dry season months, as the dominant easterly and south easterly winds create waves in the shoreline areas on the western side of Roebuck Bay.
- The waves mobilise sediments in the nearshore of Roebuck Bay and fine sediment is then carried in suspension and driven southward on the strong ebb tide flow that runs along the western shoreline of Roebuck Bay past Entrance Point and offshore (Figure 8.5).
- The strong south easterlies in late dry season results in the largest wave conditions that remove the sediment from the upper beach of the beach compartment to the north of the BBF exposing shallow rock (Figure 8.10).
- Waves on the BBF beach compartment can arrive from directions S, SSE, SE, ESE, E and ENE. There is sediment redistribution cross-shore and alongshore in the beach compartment.

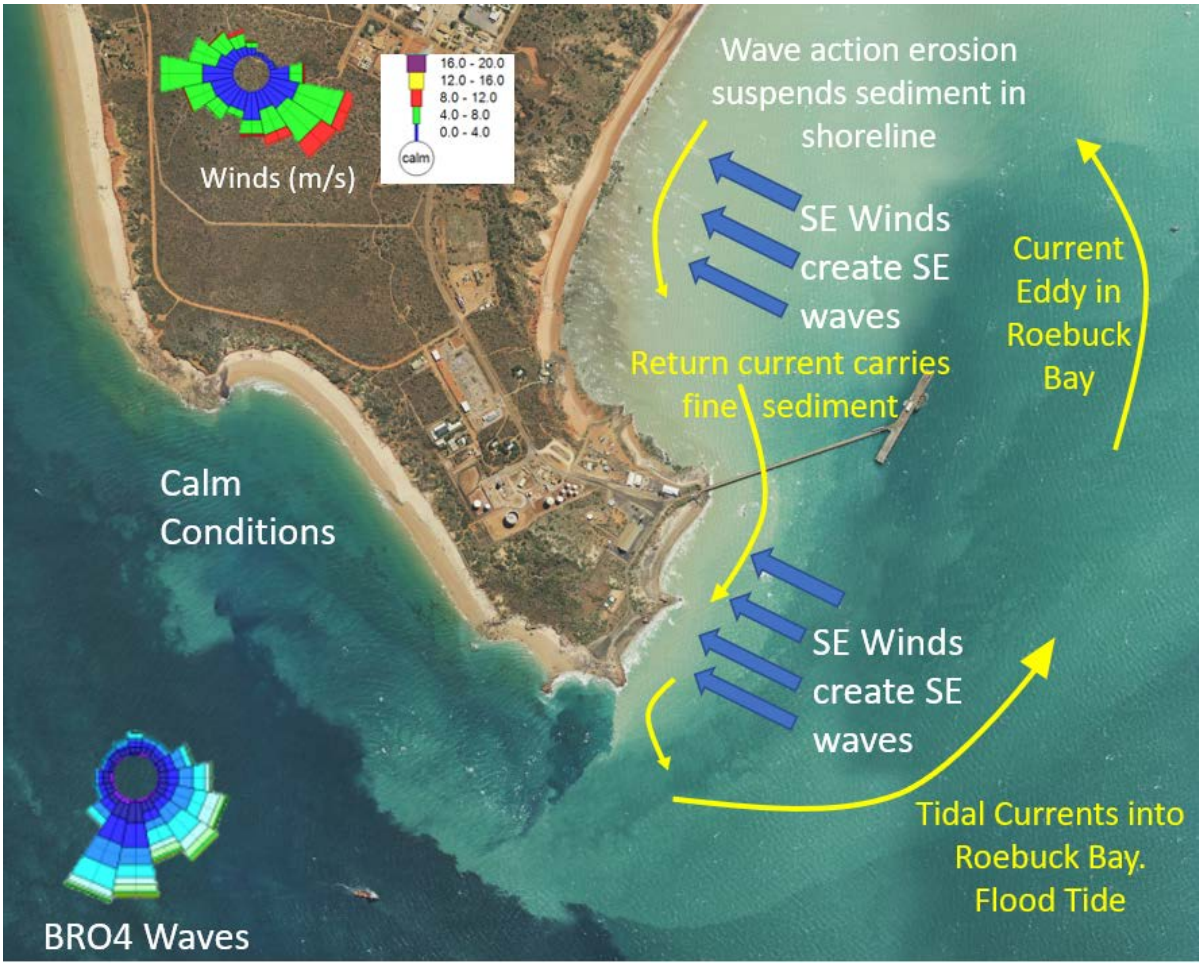


Figure 8.15: Sediment Transport Pathways – Typical Dry Season winds from the Southeast (Google Earth Image June 2011)

8.2.2 Wet Season – Sediment Transport Pathways

- The westerly-dominated wind regime of the wet season leads to milder conditions on the shoreline of Roebuck Bay and along the eastern shore of Entrance Point where the BBF is located.
- Under westerly wave action, longshore transport along the southwestern side of Entrance Point (Reddell Beach) shoreline directs sediment around Entrance Point to the beach compartment of the BBF (Figure 8.16).
- Wave conditions on the beach compartment of the BBF and the compartment on the north side are predominantly small, southerly-driven waves around Entrance Point which bring sediments onto the beach compartments through the longshore transport process.
- Fine sediments suspended in large spring tides in Roebuck Bay are transported to the beach compartments of Entrance Point where sediment will fall out of suspension.
- The comparatively milder wave conditions on the lee side of Entrance Point (east side) in Wet Season allow the beach compartments to accrete over the course of the Wet Season with sediment arriving via longshore transport from the south and suspended sediments carried in the tidal currents.

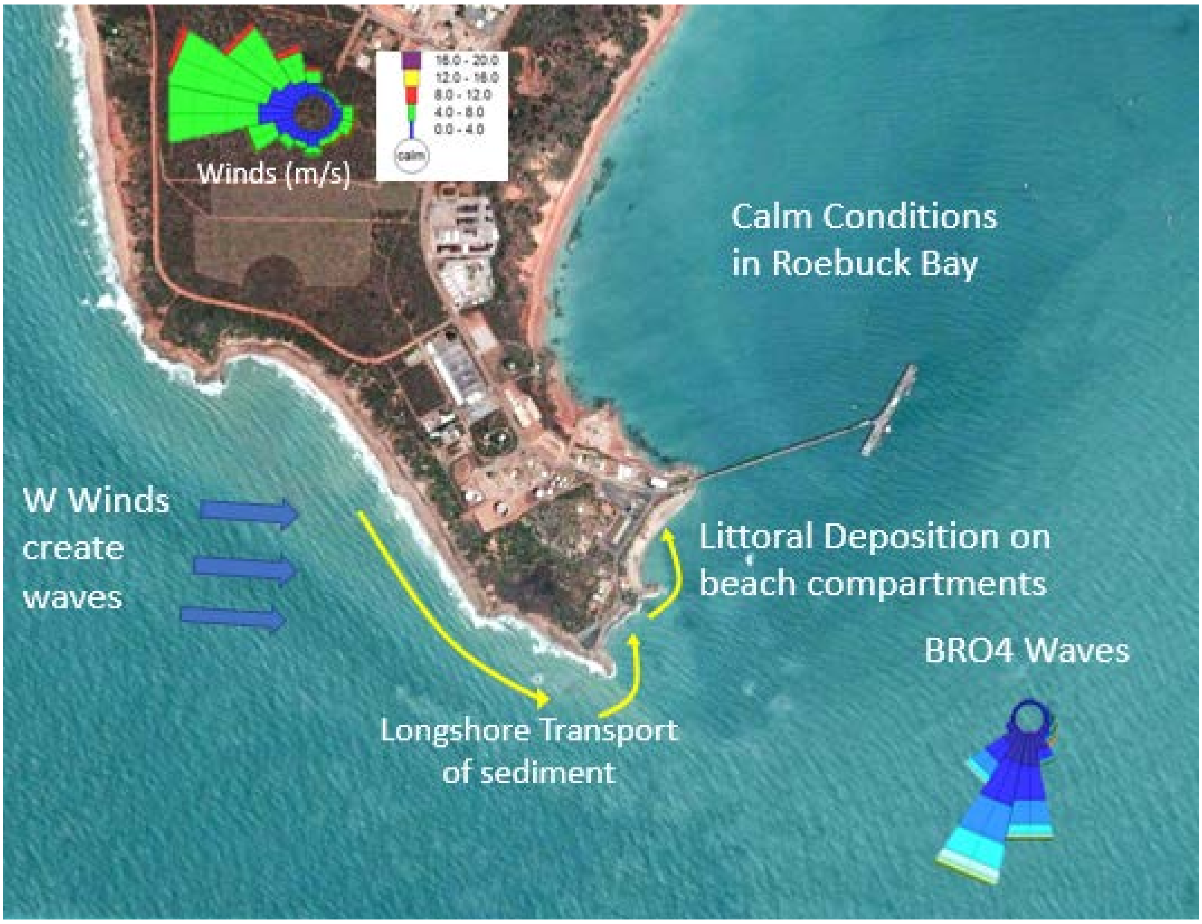


Figure 8.16: Sediment Transport Pathways – Typical Wet Season condition with westerly winds (Google Earth Image Jan 2015)

9. Sediment Transport Modelling

9.1 Overview of Model Approach

Sediment transport modelling has been completed using two numerical model systems. The first numerical modelling approach was to activate the *Online Sediment* module in Delft3D for the model system specified in Section 5.3. The Dellft3D model system is able to model the mobilisation and settlement of sand and fine sediments from combined current and wave forcing and can resolve many sediment transport processes including the generation and propagation of large bed forms. However, Delft3D *Online Sediment* does not accurately resolve longshore and cross-shore sediment transport within the surf zone. To assess the potential impact of coastal structures on the longshore transport processes near the BBF, the DHI Litpack module *Litprof* has been adopted to model longshore transport rates under normal seasonal conditions.

The sediment transport processes that have been focused on for this assessment are:

- Morphological impacts surrounding the BBF structures as a result of altering the hydrodynamic and wave climate over the predominantly sandy seabed. The seabed near the proposed BBF entrance structures is dominated by medium grain size sand, in the range of 0.2mm to 0.4mm. Further offshore in the approach channel and around the offshore breakwater, the seabed has exposed rock sections and sections of coarser sand between 1mm and 3mm. These processes are the result of the seabed sediment composition, hydrodynamic and wave climate near the BBF.
- Sedimentation of fine sands, silts and clay fractions in the sheltered areas that result from the BBF structures. The source of the fine sediments which can settle in the low energy areas is the wider environment, including the shallower areas of Roebuck Bay where tidal currents and waves can resuspend fine sediments.

The sediment transport modelling process and the detailed results are presented in full in Appendix F. The outcomes are summarised in this section based on interpretation of the modelling outcomes noting the model outcomes are intended to be semi-quantitative to inform the understanding of changes resulting to the system with the inclusion of the BBF against the base case of the existing condition. The uncertainty in sediment transport rates is at best +/- 50% for the values presented in this report, and likely to be in the order of +/- 100%. Sediment transport modelling and the understanding of key drivers of sediment transport processes (Section 8.2) are based on the existing conditions around Entrance Point which are highly complex. A dedicated monitoring program to assess the changes in sediment within the beach compartments either side of the BBF will be essential post-construction to fully inform management of the coastal process impacts.

9.2 Summary of Sediment Transport Modelling Outcomes

Based on the model outcomes presented in Appendix F and the understanding of coastal processes around Entrance Point presented in Section 8, the projected impacts for sediment transport with the construction of the BBF are summarised for the southern beach compartment, northern beach compartment and boat ramp area in Figure 9.1 and Table 9.1. The projected influence on the beach compartments beyond those immediately north and south is also summarised.

9.2.1 Southern Beach Compartment - South side of the BBF

Based on the model outcomes and the understanding of coastal processes around Entrance Point, it is predicted that the beach compartment on the south side of the BBF will be supplied sediment mainly through littoral drift, but also through fine sediments settling in the lee of the BBF. Based on the model results the compartment will have positive sediment supply, with sediment reworked in the compartment under ambient wave conditions. Over the long-term the shoreline would be expected to prograde along the southern landside breakwater from littoral drift. The south beach compartment would fill out from the existing shoreline, with a clockwise realignment of the shoreline predicted as shown in Figure 9.1 over time.

It is noted that a new sediment transport equilibrium may be reached under the future realignment of the shoreline, whereby the net positive northward littoral drift rate predicted with the BBF structures in place is reduced in future years. The passing of sediments around the end of the southern breakwater into the boat ramp is not expected to occur until such time as the compartment is filled. At this time sediment bypassing may be required (to north of the BBF), to prevent sedimentation on the boat ramp and in the lee of the structures.

Based on the model predictions, including both littoral processes and suspended sediments, the southern compartment is projected to accrete at a rate of 3,000m^3 annually (factored rate which includes sand and fine sediments). Under this assumption, it is predicted the southern compartment could accommodate sedimentation over a period of at least 3 years before bypassing is required.

9.2.2 Northern Beach Compartment - North side of the BBF

For the northern compartment, the construction of the BBF structures will result in the littoral supply of sediment from the south being cut-off completely by the landside breakwaters. This rate of supply is generally thought to be most active in the wet season months with projected annual volume in the range of 2,500m^3 based on sediment availability. Whilst this is a net deficit for sediment supply, the modelling of suspended sediments with the structures in place indicates there would be a higher volume of sediment deposited on the beach post-development due to the calmer conditions in the northern compartment as a result of the BBF structures. This increase in sediment supply is weighted towards the wet season.

Additionally, the northern compartment has been shown to experience erosion in the Dry Season months due to the Easterly and South Easterly wave conditions. With the BBF structures in place the wave conditions are shown to be reduced in the northern compartment, which could lead to a reduction in erosion potential for the shoreline in Dry Season months.

In summary, the northern compartment is expected to lose sediment supply from littoral processes but gain sediment from increased volume of fine sediments in suspension coupled with reduced erosion pressure in dry season by lower wave conditions. The overall net balance of sediment would need to be closely monitored in the northern compartment, with particular attention to the change of sediment size on the shoreline to confirm that the beach composition is not becoming more fines dominated (silts / clays). If there was an increase in fine sediment in the northern beach compartment over time, this has the potential to alter the characteristics of the seabed for the beach compartment which could impact benthic habitat and increase nearshore turbidity. The movement of the sand from the south compartment to the north under a sand bypassing program could provide the required mitigation.

9.2.3 Navigation Area Enclosed by BBF Structures

Sedimentation at the boat ramp and in the lee of the offshore breakwater is projected to be minimal with a volume of 100m^3 projected annually. This is fine sediments carried in suspension that settle out in the calm areas on the boat ramp. It is expected it would be possible to perform maintenance dredging using land-based plant under suitable tide conditions from the ramp to remove this sediment.

The BBF structures would interrupt the littoral transport of sediments to the boat ramp area, and in the immediate years after construction the process is not expected to contribute to sedimentation impacts at the boat ramp. Over time, under the general littoral transport process the southern beach compartment is projected to fill out and the shoreline realign such that littoral transport could result in sediments being transported around the edge of the southern breakwater head to the boat ramp. At this point, the sediment could be removed from the southern compartment adjacent the breakwater head and bypassed to the northern beach compartment under a general maintenance strategy.

Table 9.1: Summary of Sediment Transport Outcomes post Development

Location	Change in Annual Sediment	Comments
Beach Compartment South of BBF	+ 3,000 m^3	Sediment supply chiefly from littoral transport around Entrance Point (medium size sand) with contribution partly from fine sediments that settle out of suspension. Beach compartment expected to prograde and shoreline to rotate clockwise as sediment fills in compartment along edge of Southern Breakwater.
Boat Ramp	+ 100 m^3	The sedimentation is due to fine sediments that settle out of suspension in the calm area of the boat ramp.
Beach Compartment North of BBF	- 1,500 m^3	Supply of larger sediments (medium sand) reduced due to interruption of littoral transport. Increase in supply of fine sediments from calmer conditions post-construction. Potential for sediment composition on the beach to become finer (clays / silts). Net change to be confirmed by monitoring as the BBF structures reduce erosion pressure (waves conditions) in the compartment.

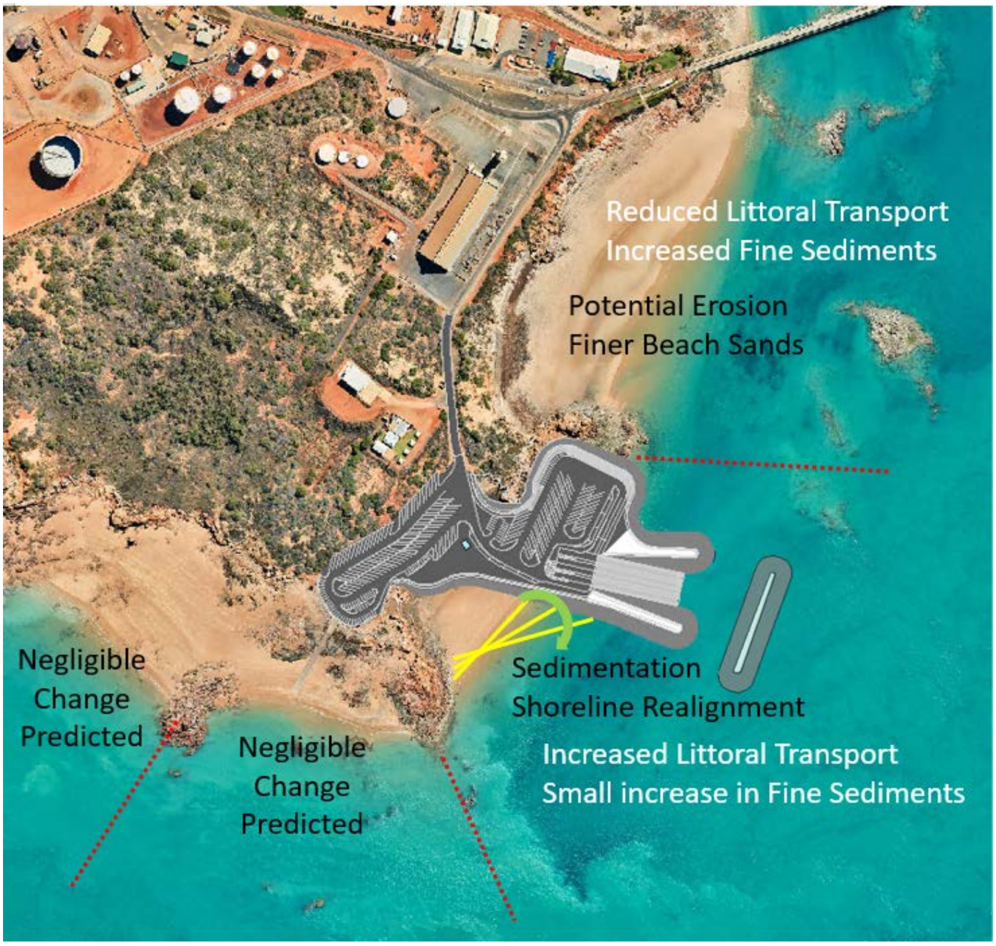


Figure 9.1: Overview of beach compartments around Entrance Point and shoreline impacts post development.

9.2.4 Adjacent beach compartments around Entrance Point

Based on a review of the model outcomes and the understanding of coastal processes around Entrance Point, the impact to coastal processes post-construction is expected to be most pronounced in the beach compartments immediately to the north and south of the BBF. The projected influence on the beach compartments beyond those immediately north and south is anticipated to be minor:

- For the beach compartments further west of the BBF around Entrance Point, the influence of the BBF structures on existing coastal processes is expected to be minimal. The beaches on the west of Entrance Point are considered a sediment source when westerly wave conditions create conditions for littoral transport which bring sediments around Entrance Point to the BBF location. This process would not be impacted by the BBF structures.
- Similarly, on the north side of the Broome Jetty, the beach in Roebuck Bay is not expected to experience changes to its existing coastal processes with the BBF structures in place. The beaches are already significantly sheltered from wave approach from the south by the headland on which the Broome Wharf connects to the land. The tidal currents that flow south out of Roebuck Bay are very strong close to the shore around the connection point to the Broome Jetty and these are unaffected by the BBF structures and will continue to direct fine sediments to the northern and southern compartment beaches as suspended load.
- For the wider Broome area including Cable Beach to the north and Town Beach in Roebuck Bay to the west, the impact to coastal processes as a result of the BBF is expected to be negligible.

9.2.5 Monitoring

Monitoring of the beach compartment post-development would be essential to understand the rate of sedimentation on the south of the BBF. Maintenance dredging to remove the sediment from the south compartment and transfer it to the north compartment may be required which could serve two purposes - firstly to control sediment reaching the boat ramp from the south and secondly to maintain the natural sediment balance in the northern beach compartment (north of the BBF) and provide a source of larger grained sediment (0.2mm to 0.3mm).

Rigorous post-development monitoring of the beach compartments on the north side and south side of the BBF over the wet season and dry season would be required to further develop understanding of the sediment transport processes. This would inform the long-term planning for maintenance of the beach compartments either side of the development.

10. Conclusions

Baird Australia (Baird) have completed a coastal processes assessment for the proposed Broome Boating Facility (BBF) at Entrance Point on behalf of the Department of Transport (DoT). The preferred concept is located south of the existing Broome wharf overlaying the existing carpark and boat ramp structures on the Southeast-facing beach compartment of Entrance Point as shown in Figure 1.1.

The initial design options for the BBF were developed in 2019 (WGA 2019), with subsequent revision and optimisation of the design carried out by the DoT in 2020. The preferred layout determined by the DoT in mid-2020 has been adopted for detailed analysis in the current study.

A significant amount of historical information was available from the site including a range of measured data sources. The data was reviewed to develop a summary of the key metocean influences at the project location in wet season and dry season as well as distinguishing between the operational conditions (non-cyclonic) and extreme (cyclonic) conditions.

There is a distinct seasonality in the wind regime at the location, which directly influences wave conditions at the site:

- In the wet season the winds are dominated by winds from the west to north-northwest sector;
- In the dry season the winds are characterised by south easterly winds (SE and ESE) as well as winds from the west sector (northwest through south west); and
- Further analysis of the dry season wind regime indicates there is a distinct sea breeze effect. In the morning (before 12pm) the winds are generally from the southeast direction whilst in the afternoon (after 12pm) winds are dominated by the westerly direction.

The cyclonic wind design criteria were developed through analysis of the available measured wind data complemented by Baird's synthetic database for higher return periods. Baird has a database location at the Boat Ramp site which has time series of sustained wind speed and direction acting over-water for over 28,000 synthetic cyclone events. The Broome AWS data (measured at the Broome Wharf) has been used to define design winds for 1 to 5-years ARI. The Monte Carlo data set has been analysed to determine design wind conditions for the east to south quadrant and determine design wind speeds between 10 years and 500 years ARI. The calculated wind speeds from the East to South quadrant are summarised in Table 3.4.

The wave conditions around Broome are a mixture of short period wind-sea generated by the local winds and, for the more exposed sections of the Broome coast (e.g. Cable Beach), long period swell originating from the Southern Ocean that propagates across the north west shelf to the Broome shoreline. For the project site, the coast is south-east facing and Entrance Point provides an effective barrier to the long period swell coupled with the sharp offshore bathymetry gradients which reflect and refract swell waves into Roebuck Bay. Analysis of the measured data from the BRO4 AWAC instrument located directly offshore of the project site has informed the understanding of the wave conditions for the BBF. The measured data indicates there is negligible swell wave energy in the record, with conditions dominated by wind-sea (periods of less than 8s). The chief influence on the wave conditions at the project site is the local winds.

Broome's tides are semi-diurnal, with high tide occurring twice daily. The very large tide range is a major factor influencing the design of the proposed BBF. With a typical spring-tidal range of 8m and a typical neap tidal range of 2m the tides are a key influence on the wave and current conditions that impact the site. The incoming tidal flows into Roebuck Bay setup an eddy structure on the lee side of Entrance Point west of the Broome Wharf, with flow reversing back along the shoreline. The return current that is created along the shoreline and nearshore areas of Entrance Point means that for the majority of the flood tide cycle the flow direction in the nearshore is aligned in the direction of the ebb tide flow. This phenomenon plays a critical role in the very directional nature of the currents experienced at the planned BBF site where tidal current flows are almost exclusively directed in the SSW direction throughout the full tide cycle. At the

BRO4 location closest to the project site, measured tidal currents reach 1ms^{-1} (2 knots) and above during the spring tide. These high current speeds are a key influence on the sediment transport processes.

A validated numerical model system was established by Baird and applied in the study to analyse the hydrodynamic and wave conditions at the BBF location. For the BBF developed concept the validated model system was used to:

- Assess cyclonic design criteria for structural elements of the breakwaters;
- Complete hydrodynamic modelling of the layout to assess navigation and launch conditions around the boat ramp in typical spring and neap tides; and
- Investigate wave penetration around structures and wave conditions at the base of the boat ramp for the layout, simulating a full year of hindcast wind, water level and wave conditions.

A summary of the metocean analysis undertaken for the concept is as follows:

1. Design wave conditions for the extreme cyclonic design criteria are summarised in Section 7.4.2 for the 1yr ARI, 20yr ARI, 50yr ARI and 100yr ARI. The model results for the BBF layout were analysed in seven key sections of the layout as shown in Figure 7.8. Design criteria for each respective return period were summarised based on the highest wave conditions (incident wave) from the model along the respective sections. Joint occurrence of wind and water level is assumed in the model cases which is a conservative assumption that could be further refined in detailed design (eg the 50yr ARI wind is applied with the 50yr ARI water level).
2. The wave protection at the boat ramp under ambient conditions (non-cyclonic) was assessed based on a threshold wave condition of H_s=0.2m, set as a basis for safe vessel launch and retrieval based on AS3962. Operational analysis of conditions favourable to launching vessels based on analysis of modelled results at the base of the ramp under threshold wave height (<0.2m) and water level (>1m depth) for the one year hindcast conditions is summarised in Section 7.3. The results show:
   - Depth limitation is a minor contributor to downtime at the boat ramp accounting for approximately 15 hrs a month (2% of the time) where there is less than 1m depth at the toe of the ramp. It is noted this limitation occurs during the spring tides for a duration of 1-2 hours maximum;
   - The downtime resulting from wave height conditions exceeding 0.2m threshold on the ramp toe is modelled at 292 hours (3.3%) over the 12-month hindcast period. The outcomes are weighted toward the dry season - on average the wave height is exceeded 35 hours a month (4.7%) in dry season, and 14 hours a month (1.9%) in wet season. Wave heights rarely exceed 0.3m on the ramp over the 12-month hindcast period; and
   - The combined downtime from the depth and wave thresholds is calculated at 5.4% over the 12-month hindcast period, weighted toward the dry season (7.1% in dry season, 3.6% in wet season).
3. Analysis of the currents at the boat ramp in Section 7.2 showed that for all options assessed, the currents at the boat ramp in the lee of the landside breakwaters were significantly reduced and safe launch conditions were achieved. For general tidal current conditions around the boat ramp:
   - For the developed case, the gap between the landside breakwaters and the offshore breakwater provided an effective means of maintaining the current speeds through the nearshore area. The influence of the structures results in a reduction in the current speed of 10% to 20% compared to the existing case for current speeds higher than the 50th percentile (P80, P90, P95).
   - The modelled current speed has the potential to present navigation challenges at the peak of spring tides where currents approach 1ms^{-1} (2 knots).
   - The design aims to strike a balance in achieving a current speed that is low enough for safe navigation but high enough to prevent slack water which is considered valuable in preventing sedimentation. The arrangement in the adopted design appears to have met this objective. In detailed design this balance could be further investigated.

Sediment transport processes around Entrance Point are analysed in detail in Section 8 based on a review of the measured data, photos, aerial imagery and site investigations. The sediment transport processes around the BBF location are highly complex, influenced by the extreme tides, large currents and wave conditions which are seasonally variable. A summary of the coastal processes sediment transport pathways in the wet and dry seasons has been developed from the available information as summarised at the end of Section 8.

Sediment transport modelling of the BBF concept has been completed based on a model approach that examines morphological impacts to the coastal areas surrounding the BBF structures as a result of altering the hydrodynamic and wave climate. The model system and the model outcomes are presented in detail in Appendix F with a summary of the sediment transport impacts and projected shoreline changes in Section 9.

Based on a review of the model outcomes and the understanding of coastal processes around Entrance Point, the impact to coastal processes post-construction is expected to be most pronounced to the beach compartments immediately north and south of the BBF. The projected influence on the beach compartments beyond those immediately north and south is anticipated to be minor and for the wider Broome region including Cable Beach and Town Beach impacts are expected to be negligible.

The overall projections for sediment transport changes post-construction are summarised in Table 10.1 for the beach compartments to the north and south of the BBF, along with a summary of the boat ramp area. The outcomes are intended to be semi-quantitative to inform the understanding of changes resulting to the system with the inclusion of the BBF against the base case of the existing condition. The uncertainty in sediment transport rates is at best +/- 50% for the values presented in this report, and likely to be in the order of +/- 100%.

Table 10.1: Summary of Sediment Transport Outcomes post Development

Location	Change in Annual Sediment (With BBF)	Comments
Beach Compartment South of BBF	+ 3,000 m^3	Sediment supply chiefly from littoral transport around Entrance Point (medium size sand) with contribution partly from fine sediments that settle out of suspension Beach compartment expected to prograde and shoreline to rotate clockwise as sediment fills in compartment along edge of Southern Breakwater
Boat Ramp	+ 100 m^3	The sedimentation is due to fine sediments that settle out of suspension on the calm area of the boat ramp
Beach Compartment North of BBF	- 1,500 m^3	Supply of larger sediments (medium sand) reduced due to interruption of littoral transport. Increase in supply of fine sediments from calmer conditions post-construction. Potential for sediment composition on the beach to become finer (clays / silts). Net change to be confirmed by monitoring as the BBF structures reduce erosion pressure (waves conditions) in the compartment

An overview of the projected outcomes within the compartments are noted as follows:

- Southern Beach Compartment - South side of the BBF
  - Based on the model outcomes and the understanding of coastal processes around Entrance Point, it is predicted that the beach compartment on the south side of the BBF will be supplied sediment mainly through littoral drift, but also through fine sediments settling in the lee of the BBF. Based on the model results the compartment will have positive sediment supply, with sediment reworked in the compartment under ambient wave conditions. Over the long-term the shoreline

would be expected to prograde along the southern landside breakwater from littoral drift. The south beach compartment would fill out from the existing shoreline, with a clockwise realignment of the shoreline predicted over time.
    - Based on the model predictions, including both littoral processes and suspended sediments, the southern compartment is projected to accrete at a rate of 3,000m^3 annually (factored rate which includes sand and fine sediments). Under this assumption, it is predicted the southern compartment could accommodate sedimentation over a period of at least 3 years before bypassing was required.
- Northern Beach Compartment - North side of the BBF
    - The northern compartment is expected to lose sediment supply from littoral processes but gain sediment from increased volume of fine sediments in suspension coupled with reduced erosion pressure in dry season by lower wave conditions. The overall net balance of sediment would need to be closely monitored in the northern compartment, with particular attention to the change of sediment size on the shoreline to confirm that the beach composition is not becoming more fines-dominated (silts / clays). If there was an increase in fine sediment in the northern beach compartment over time, this has the potential to alter the characteristics of the seabed for the beach compartment which could impact benthic habitat and increase nearshore turbidity. The movement of the sand from the south compartment to the north under a sand bypassing program could provide the required mitigation.
- Navigation Area Enclosed by BBF Structures
    - Sedimentation at the boat ramp and in the lee of the offshore breakwater is projected to be minimal with a volume of 100m^3 projected annually. This is fine sediments carried in suspension that settle out in the calm areas on the boat ramp. It is expected it would be possible to perform maintenance dredging using land-based plant under suitable tide conditions from the ramp to remove this sediment.
    - The BBF structures would interrupt the littoral transport of sediments to the boat ramp area, and in the immediate years after construction the process is not expected to contribute to sedimentation impacts at the boat ramp. Over time, under the general littoral transport process the southern beach compartment is projected to fill out and the shoreline realign such that littoral transport could result in sediments being transported around the edge of the southern breakwater head to the boat ramp. At this point, the sediment could be removed from the southern compartment adjacent the breakwater head and bypassed to the northern beach compartment under a general maintenance strategy.

Monitoring of the beach compartment to the north and south of the BBF will be essential to understand the changes post-construction. Sand bypassing to remove sediment from the south compartment and transfer it to the north compartment may be required which could serve two purposes - firstly to control sediment reaching the boat ramp from the south and secondly to maintain the natural sediment balance in the northern beach compartment (north of the BBF) and provide a source of larger grained sediment (0.2mm to 0.3mm). A rigorous post-development monitoring of the beach compartments on the north side and south side of the BBF over the wet season and dry season would be required to further develop understanding of the sediment transport processes. This would inform the long-term planning for maintenance of the beach compartments either side of the development.

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Dr Bruce Hegge
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Dear Bruce,

Underwater Noise Review for Broome Boating Facility Development

1 Introduction

1.1 Background

The Department of Transport (DoT) is proposing to develop the Broome Boating Facility (BBF) development which will be located close to Broome's Fishing Club on Kabbarli Road, adjacent to the Kimberley Marine Offloading Facility (KMOF). The BBF development will include piling and rock dumping.

As the facility will be adjacent to KMOF it is anticipated that the underwater noise impacts will be very similar and, as a result, the KMOF assessment can be used to determine likely underwater noise impacts for the BBF development.

As a result, a technical review of the project and the KMOF underwater assessment has been undertaken to determine if it is reasonable to use the KMOF assessment to provide an understanding of the potential impacts and appropriate management actions for the BBF.

1.2 Aim

The aim of this scope is to determine if the noise management approach proposed in the KMOF underwater noise study [1] can be adopted by the BBF project to mitigate underwater noise impact risks.

1.3 Applicable Documents

[1] Kimberly Marine Offloading Facility Environmental Review Document (Appendix C)[1].

[2] 20210115 1881-11-01_0 General arrangement 002.

[1] https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Supporting%20Document_18.pdf

1.4 Scope

The scope of this briefing note includes a technical review comparing underwater noise impacts from the KMOF [1] development and comparing it to the BBF project, to determine the similarities and see if the underwater noise impacts will be comparable. The briefing note does not include modelling or comparison of underwater noise measurements.

2 Comparison of BBF and KMOF

2.1 BBF Project Overview

The BBF development will be adjacent to the KMOF as shown in Figure 2-2. The development will include a car park, pre-cast concrete boat ramp, fishing platform, finger jetties, rock groynes, a break water and mooring and navigation piles.

The major underwater noise activities for the development will be piling and rock dumping for the breakwater and groynes. Piling will include 14 piles for the boat ramp platforms, 5 mooring piles, one navigation pile and 6 piles for the fishing platform.

2.2 KMOF Overview

The KMOF project (Figure 2-1) includes a trestle jetty and floating pontoon wharf, mounted on 46 steel piles driven in using a combination of drilling and hydraulic impact hammering during the construction phase of the project. The KMOF does not include rock dumping.

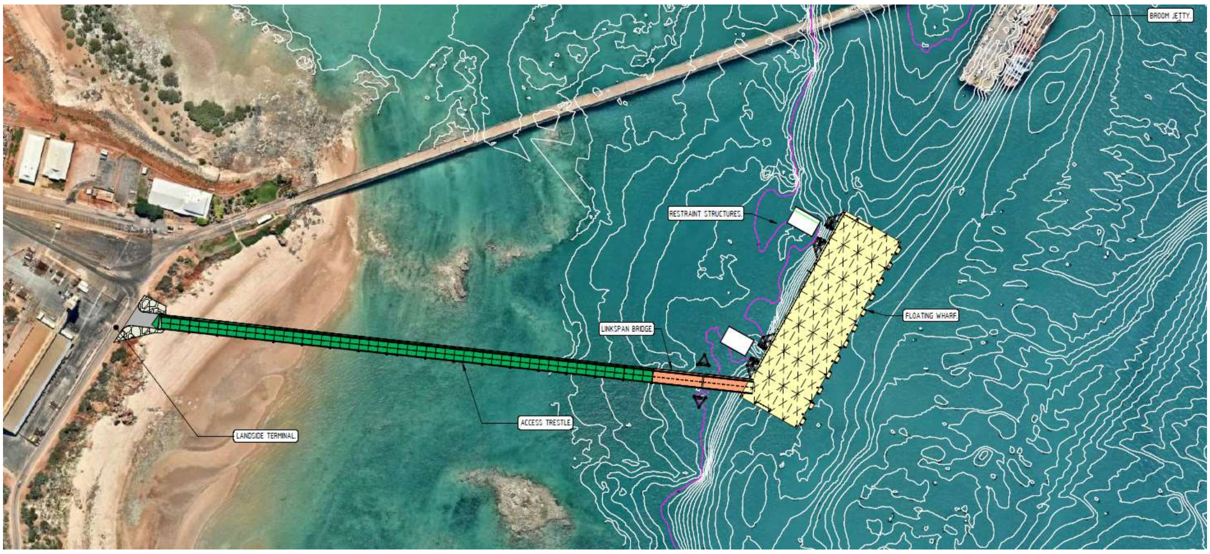

Figure 2-1: KMOF Jetty Design

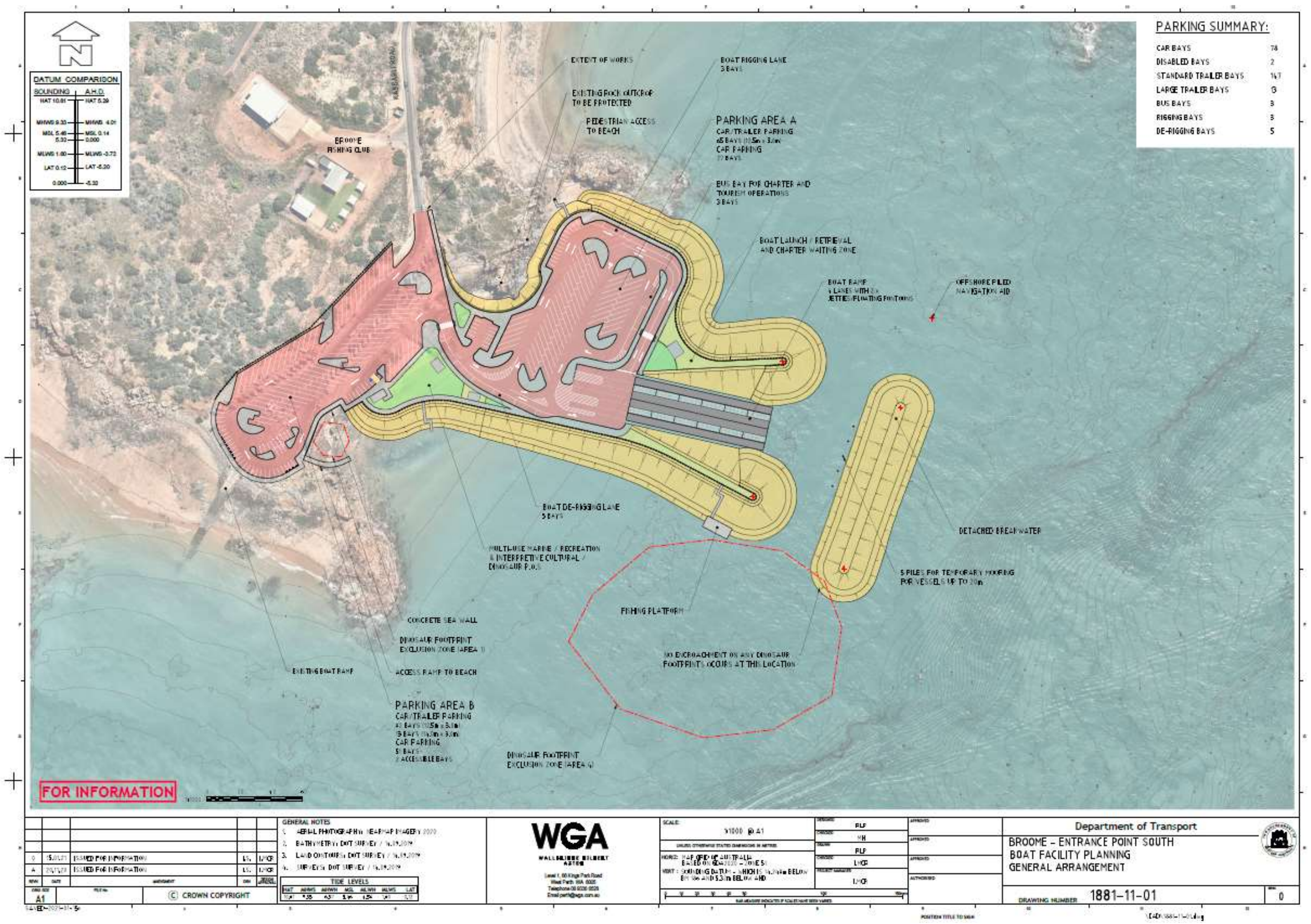

Figure 2-2 : BBF Proposed general layout drawing.

3 Marine Environment

The project area consists of shallow and deep water, as shown in Figure 3-1. The bathymetry in the area drops off steeply into a channel that has a maximum depth of approximately 110 m, known as Roebuck Deep. This natural channel to the west the BBF area is ~16 km long, starting North West of Gantheaume Point passing within 500 m of the shoreline, and extending South East for ~10 km past Entrance Point.

In comparison the shallow water area of the project, where all BBF construction activities occur, is between 0 and 10m. In these shallow water areas construction noise will attenuate quickly as the pressure wave frequently reflects off the surface and seabed. It is only when the noise progresses from shallow water into the deeper water of the channel that noise attenuates more slowly and becomes more conserved.

For the KMOF project it was found that the bathymetry affected the underwater noise propagation trajectories, resulting in sectorised Marine Mammal Observer (MMO) management zones. As the two projects are adjacent to each other, the noise transmission trajectories from construction activities for the BFF and therefore the sectorised management zones (see Figure 3-2 and Figure 3-3), will be similar to KMOF.

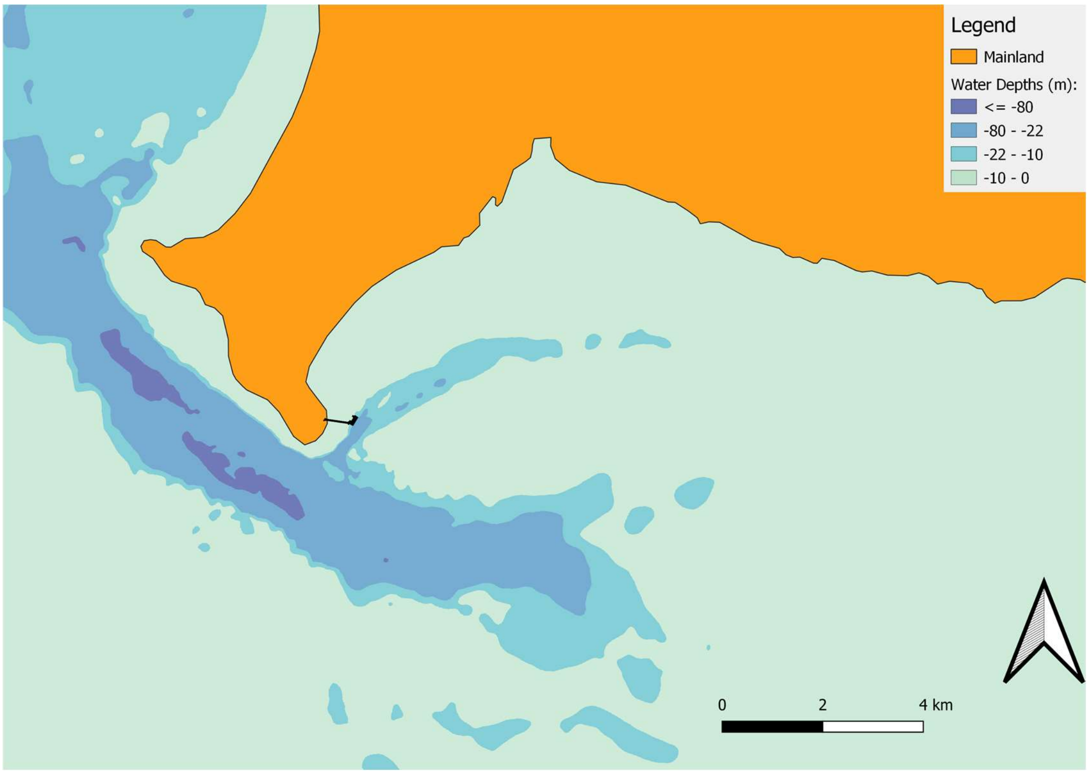

Figure 3-1 : Area overview showing the ~16 km channel.

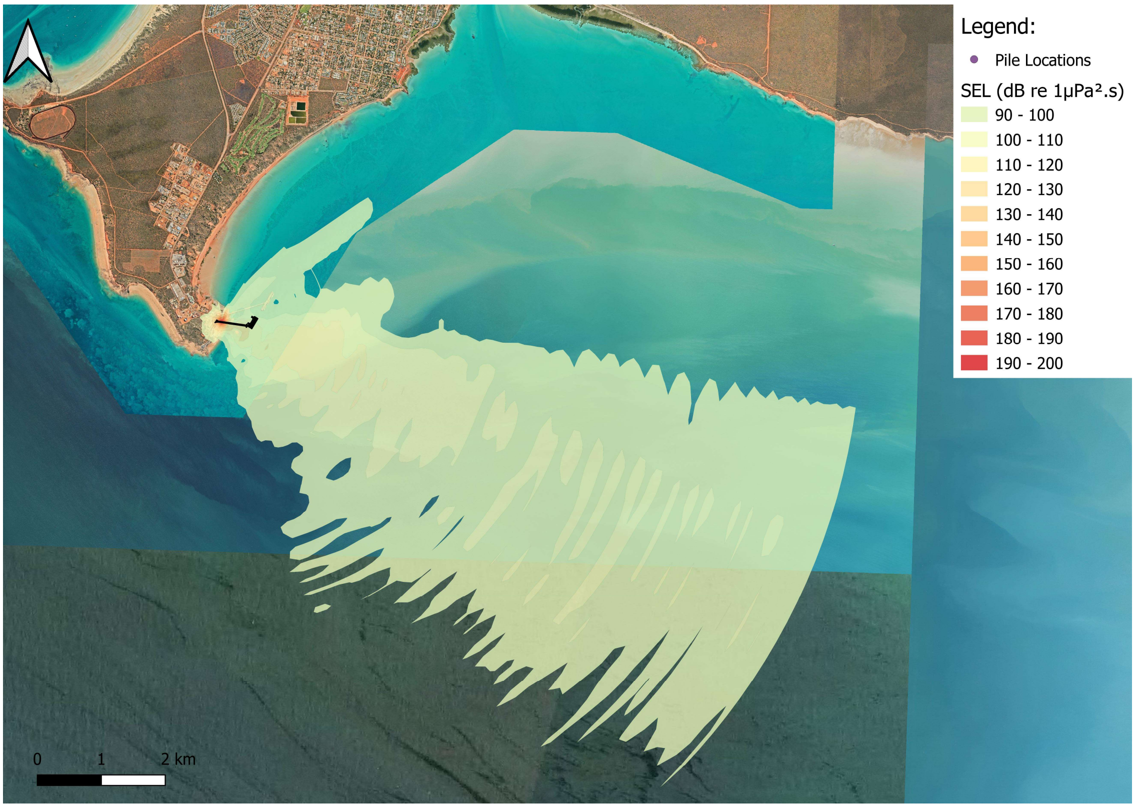

Figure 3-2 : Shallow water noise plot showing the effect of the channel, and management sector.

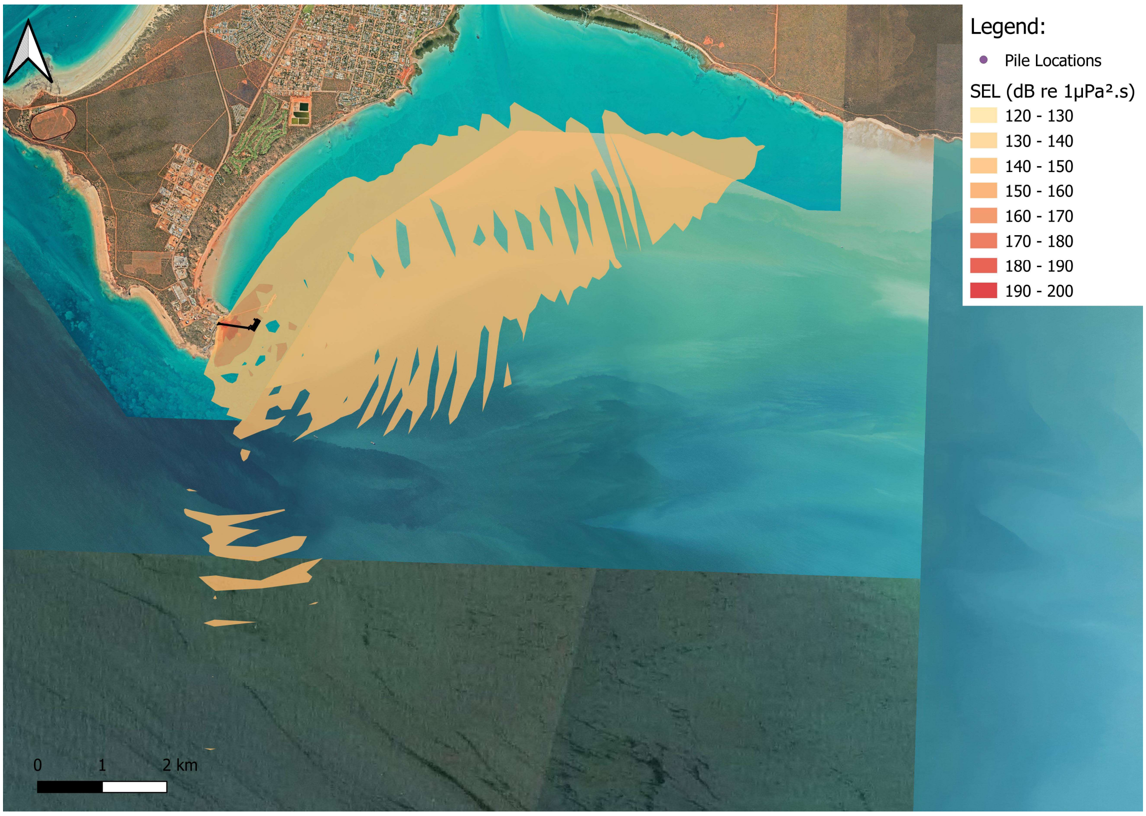

Figure 3-3 : Deep water noise plot showing the effect of the channel, and management sector.

4 Noise Sources

4.1 Piling

The KMOF underwater noise study considered tubular steel piles with a 1500 to 2000 mm diameter and a 500 kJ hydraulic hammer with a 30 bpm strike rate. As the BBF project will be hammering in mooring and navigation piles it is expected that the tubular piles will be 813 mm in diameter and a 250 kJ hammer with a 30 bpm strike rate will be used. It is therefore expected that the BBF piling source level will be lower than that of the KMOF piling, and as a result the impacts will be less.

Additionally, the KMOF project has a total of 46 piles while BBF will have approximately 26 smaller piles and as a result the total piling duration will be at least half that of the KMOF project.

4.2 Rock Dumping

Rock dumping was not required by the KMOF project and therefore no comparison can be made. However, in contrast to piling, rock dumping is a broadband noise source, that is created by rocks hitting each other and trapped air bubbles escaping as the rock is dumped. The source levels for rock dumping will be lower than piling and therefore the impacts will be less. As it is a broadband source the noise will blend in with other sources such as breaking waves and rocks moving back and forth with each wave action.

Additionally, depending on the sequencing of construction activities, the breakwater and groynes will provide shielding of the piling noise generated if the piles are inserted post breakwater and groyne development.

4.3 Noise Source Summary

As the BBF piles are lower energy, the TTS and PTS distances and management ranges proposed in the KMOF study could potentially be reduced. Additionally, the sequencing of the groynes and breakwater developments before pilling starts could provide significant shielding of the piling activities and as a result a significant reduction in noise management requirements for the project.

5 Conclusion

This review has determined that the KMOF study and BBF project are similar enough that the BBF project can mitigate their underwater noise impacts by adopting the underwater noise management approach detailed in the KMSB underwater noise assessment [1] (see Appendix A for a summary). It was also found that the BBF piling noise source levels will potentially be less than that of the KMOF levels, and therefore by adopting the KMOF management approach the BBF project will be conservative.

Additionally, the sequencing of the breakwater and groynes could provide considerable shielding to the BBF mooring and finger jetty piles which could significantly reduce underwater noise management requirements for the project.

6 Closing

If you have any queries, please do not hesitate to contact me.

Yours sincerely

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Noise

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DOCUMENT CONTROL					
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0	Draft internal review	13/08/21	RK	GB	
1	First issue for client review.	13/08/21	RK	BH/CD	GB
2	Second issue updated with clients' comments	20/08/21	GB		GB

APPENDIX A KMOF Management Range Summary

- Shallow water piling exceedances of TTS and behavioural disturbance levels only occur in proximity of the pile for Whales, Dugongs Dolphins and Sawfish. It is therefore possible to manage using Marine Mammal Observers (MMO's).
- Deep-water piling exceedances of TTS levels occur up to ranges of 500 m for turtles and sawfish and up to 1 km for Whales and Dugongs. It is therefore possible to manage using Marine Mammal Observers (MMO's).
- Deep-water piling behavioural exceedances range from 1.7 to greater than 10 km. These extended ranges are difficult to manage using MMO's, in particular the >10 km range for Whales. As a result, the following management or mitigation options should be considered:
    - There are only 10 deep water piles (assuming all other piling can be undertaken when water depths are < 5m). If each pile takes 1 hour to drive-in, this equates to a total 10 hours of disturbance, or maximum of 1 to 2 hours a day depending on whether 1 or 2 deep-water piles are driven in.
    - Blue and Bryde's whales are expected to occur outside Roebuck Bay in deeper water and will therefore not be affected by the piling.
    - Humpback whales occur in the vicinity of the Project area during their annual migration between July and September each year. Scheduling deep-water piling outside this time period will therefore mitigate the impacts.

OTS | Ornithological Technical Services

Broome Boating Facility Project: Migratory Shorebird Assessment

June 2020

Contents

Abstract

The Department of Transport is proposing to develop the Broome Boating Facility (BBF) upgrade at Entrance Point in the Port of Broome. Bird surveys were conducted for the Kimberley Marine Support Base (KMSB) project at Broome Port and Roebuck Bay from December 2019 to February 2020, which covered the area of interest for the BBF project. Data from the KMSB surveys are used in this report with permission from KMSB. The surveys were designed in accordance with EPBC Act Policy Statement 3.21, (Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species) and additionally collected data on species listed under the China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) and the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

Data from four field trips (each composed of at least six shorebird surveys) conducted during December 2019 to February 2020, confirmed the presence of 11 migratory shorebird species and five other EPBC Act listed species within the proposed BBF impact area. However, none of these species were detected in conservation significant numbers within the BBF impact area, nor did the site support a conservation significant total abundance or diversity of migratory shorebirds. Fieldwork conducted for KMSB (used with permission for this report) in the surrounding Yawuru Nagulagun / Roebuck Bay Marine Park and Roebuck Bay Ramsar wetlands found several sites supporting much greater, nationally significant, numbers of foraging and roosting migratory shorebirds.

Although the proposed BBF site did not support conservation significant numbers of migratory shorebirds, several mitigation procedures and recommendations have been proposed in this report to offset any potential negative impact on the low numbers of migratory shorebirds that were recorded in the proposed BBF impact area.

Introduction

Project Description

The Department of Transport (DoT) is proposing to develop the Broome Boating Facility (BBF) at Entrance Point, Broome. The proposed development will consist of an expanded carpark over the existing facility, four-lane boat ramp with finger jetties that extends out over the intertidal zone and an offshore breakwater (Fig. 1). The facility will serve as a recreational boat ramp of increased capacity to the current site facility.

Migratory Shorebirds

This report is focused on 37 migratory shorebird species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) which breed in the northern hemisphere and migrate to Australia along the East Asian-Australasian flyway during the northern hemisphere winter. Australia's coastal and freshwater wetlands provide vital habitat for these birds during their non-breeding season, where they must increase their body weight significantly to build sufficient energy reserves to travel the long distance back to their breeding grounds (Duijns *et al.* 2017). They rest during high-tide at suitable roosting sites, such as an ocean beach or in salt marshes bordering the coastal wetlands. Despite legislative protection and international bilateral conservation agreements, many of these shorebirds have suffered massive population declines in the last 30 years. This report includes additional observations of other migratory bird species (aside from migratory shorebirds) listed under the EPBC Act (see attached document EPBC Act Protected Matters Report BBF July 2020), and under bilateral migratory bird agreements between Australia and China (CAMBA), Japan (JAMBA), and Republic of Korea (ROKAMBA).

Scope of Work

Ornithological Technical Services (OTS) was engaged by Teal Solutions to provide a desktop assessment of migratory shorebirds in the BBF Project area and general region. Recent, targeted migratory shorebird surveys were conducted for the Kimberley Marine Support Base (KMSB) project, and these surveys also covered the area of interest for the proposed BBF Project. KMSB provided their data (data exchange facilitated by O2 Marine) which was used with permission of KMSB in this desktop assessment. The aim of this assessment is to complete a detailed assessment in accordance with EPBC Policy Statement 3.21 to evaluate the significance of the habitat and potential impacts on migratory birds from the proposed BBF. Specifically, the objectives of this investigation are to:

- Assess the abundance, diversity, behaviour and distribution of the 37 migratory shorebird species listed under the EPBC Act in both a local and regional context
- Present observations of other migratory bird species (excluding the 37 migratory shorebirds listed in the EPBC Act) listed under the China-Australia Migratory Bird Agreement (CAMBA), Japan-Australia Migratory Bird Agreement (JAMBA) and Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
- Identify internationally- and nationally-significant shorebird habitats within the BBF Project area and in the wider region
- Assess the potential impacts on EPBC Act listed migratory shorebirds from the BBF Project targeting sites that are identified as nationally significant for migratory shorebirds
- Consider the potential impacts of the Project at local and regional scales on EPBC Act listed migratory shorebirds

- Provide recommendations for mitigating potential significant impacts on EPBC Act listed migratory shorebirds

Figure 1. Proposed Broome Boating Facility design concept and infrastructure layout, located at Entrance Point, Broome, south of the Broome Jetty.

EPBC Act Policy Statement 3.21 Survey Requirements

The survey data discussed in this assessment were collected for the KMSB Project in accordance with the requirements of the EPBC Act Policy Statement 3.21 (Commonwealth of Australia 2017). This includes minimum requirements on survey coverage, timing, and effort, data requirements, definition of significant shorebird habitat, definition of significant impacts on migratory shorebirds, and mitigating impacts on migratory shorebirds.

Methods

This report was prepared in accordance with the requirements of the EPBC Act Policy Statement 3.21 guidelines. The observation data presented and discussed in the following sections were collected for KMSB (data collected for the KSMB project included the area of the proposed BBF). KMSB confirmed (via O2 Marine) that permission was granted for their data to be re-used in this report. The methods used to collect the data for KMSB are presented below for reference.

Survey Areas

The Broome Peninsula is located at the Northwest of Roebuck Bay, a large bay containing significant undisturbed areas of beaches, mangroves and mudflats (Fig 2). Covering most of the Bay are the Yawuru Nagulagun / Roebuck Bay Marine Park and the Roebuck Bay wetland of international importance (under the Ramsar Convention), which is one of the most important sites for migratory shorebird conservation in the World. The Port of Broome waters border the Yawuru Nagulagun / Roebuck Bay Marine Park. The Roebuck Bay RAMSAR Wetland is located ~30 km to the west and 15 km to the north of Entrance Point. The area also supports the Roebuck Bay Mudflats Threatened Ecological Community (listed as vulnerable under the WA Minister Environmentally Sensitive Areas list) and is an important area for the local community and Traditional Custodians/Owners. The Port of Broome waters do not overlap with any of these important areas.

Study Areas:

- Roebuck Bay study area (Fig. 2 inset A) consisted of 13 discreet sites covering approximately 2.3 km of surveyed coastline.
- Broome Peninsula study area (Fig. 2 inset B; Fig. 3) included the targeted survey sites A1-A4 along with two adjacent comparison sites, altogether covering approximately 3.4 km of coastline.

Project Area: The BBF project development envelope of approximately 4.85 ha.

Survey Coverage

Within the Roebuck Bay study area, 13 survey sites were chosen along the length of the reserve (Fig. 2 inset A) due to easy access from the road (reducing the time required for the survey). The sites cover approximately six kilometres of coastline between Crab Creek Road and Broome Bird Observatory. The habitat along this stretch of coastline consists of beaches, rocks, and extensive mudflats (at low tide), with some sparse patches of mangrove trees. This section of Roebuck Bay was surveyed to put the Broome Peninsula study area into regional context.

Beaches, rocks and mudflats comprise the habitat within the Broome Peninsula study area for shorebird surveys. This area was divided into six sites (A0 to A5), each separated by rocky headlands (Fig. 3). Site A2 is the location of the BBF Project (Fig. 3). The surrounding sites form the entire area of contiguous habitat that migratory shorebirds are likely to use. The extent of habitat available in these sites varies considerably with the tide (Fig. 3). At low tide, the area of beach and exposed rock is extensive with several rocky islets just offshore. At high tide, most of the rocky islets are submerged and there is little exposed beach habitat. Sites A0 to A3 are similar in habitat, with a mixture of beach and rock submerged at high tide, some exposed rocks at all tides, and rocky islets. The habitat in A4 is a mixture of beach and mudflats with scattered mangrove trees and some rocky areas that are not submerged at high tide. Site A5 consists of beaches, extensive mudflats (at low tide) and sparse patches of mangrove trees. These large mudflats are usually separated from the small mudflats in site A4, however on extremely low spring tides the two areas may connect.

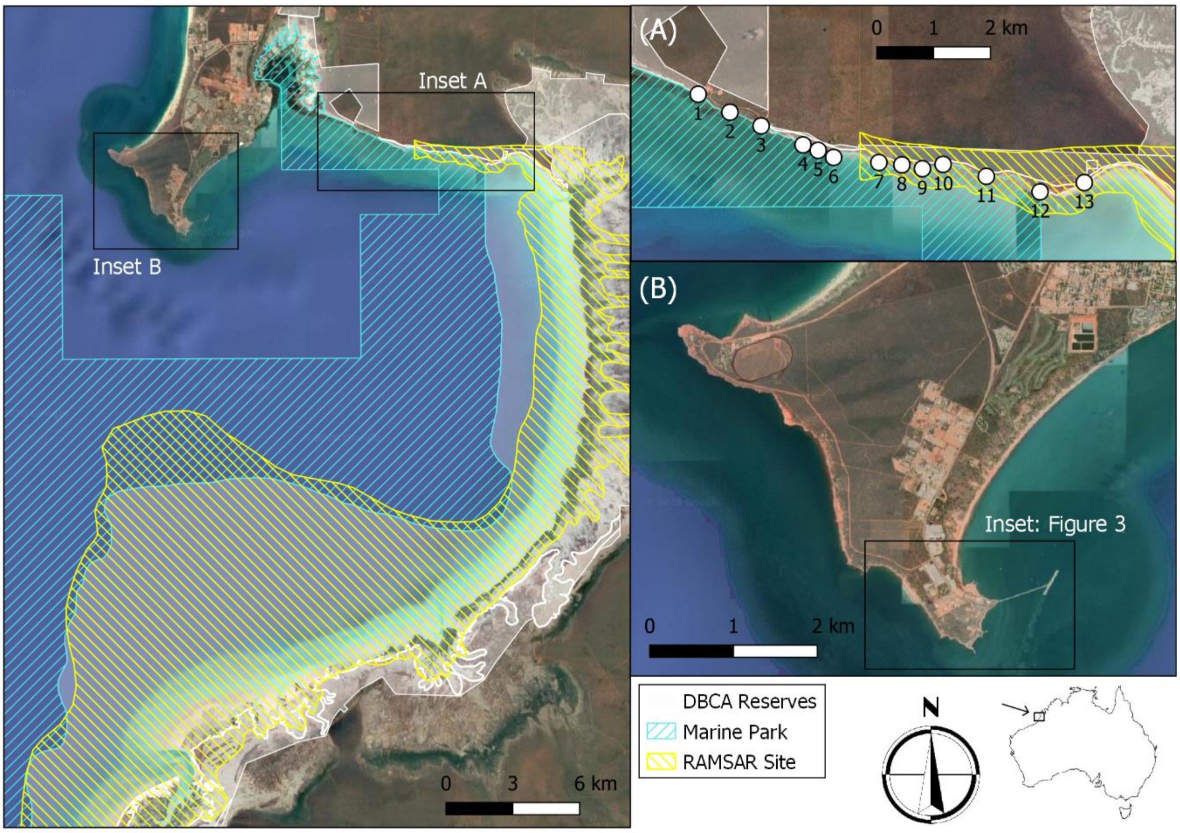

Figure 2. Satellite imagery of Roebuck Bay, northwest Australia, showing the location of the two survey areas: Roebuck Bay study area (inset A) and the Broome Peninsula study area south of the town (inset B). White circles in Inset A show the 13 survey sites of the Roebuck Bay study area. See Figure 3 for a detailed map of the Broome Peninsula study area. Protected areas are displayed: Yawuru Nagulagun / Roebuck Bay Marine Park (blue hashed area), DBCA Legislated Lands and Waters (translucent white areas), and Roebuck Bay RAMSAR Wetland of international importance (yellow hashed area).

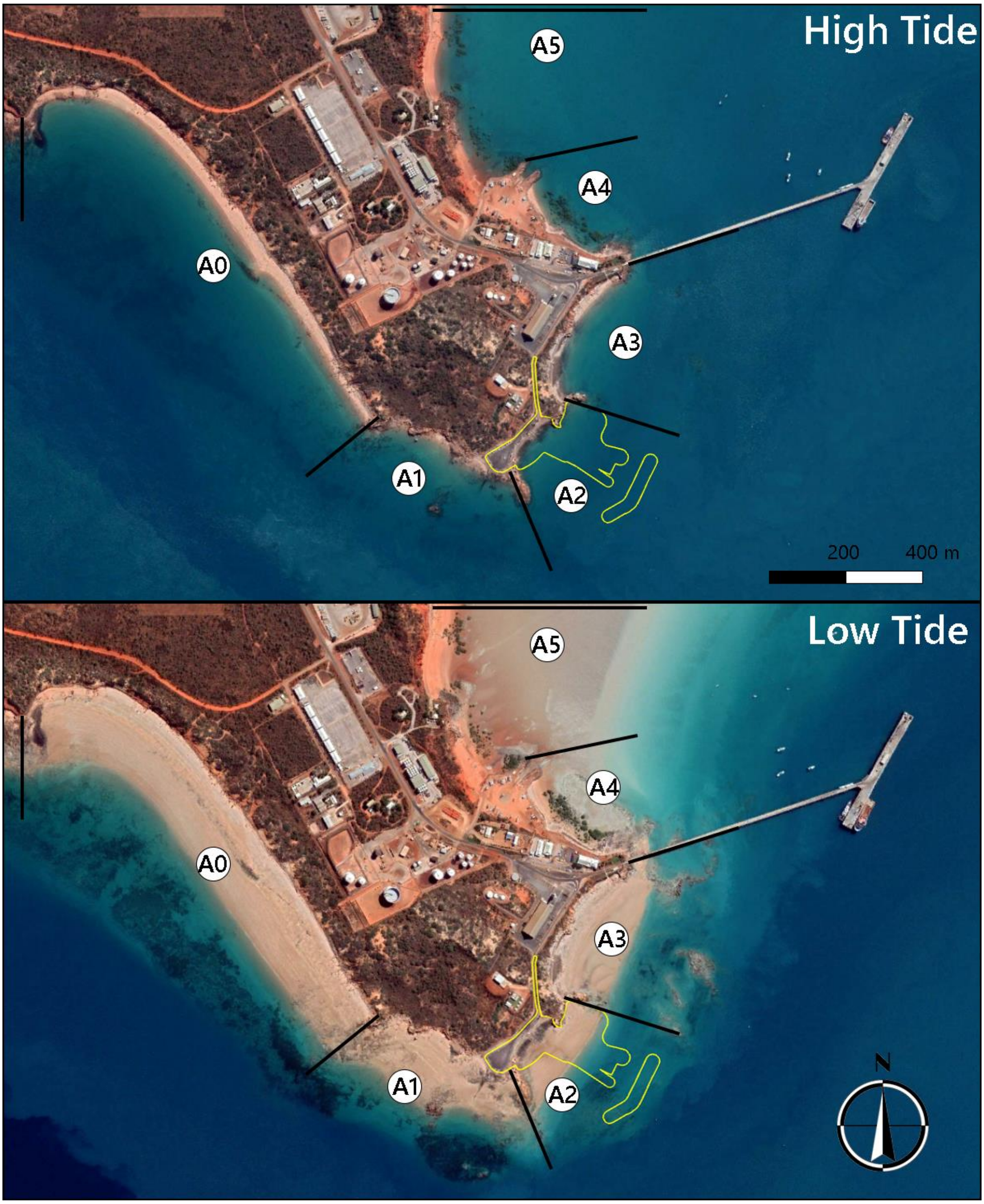

Figure 3. Satellite imagery of the Broome Peninsula study area where shorebird surveys were conducted in 2019 and 2020. High tide (top) and low tide (bottom) maps show the daily variation in habitat availability. The survey sites are labelled A0 to A5, with black lines showing their boundaries. The BBF Project area occurs within site A2 (yellow outline).

Survey Timing

Surveys of the Broome Peninsula study area were conducted over four separate trips during the period when most migratory shorebirds were in the region: one in December 2019, two in January 2020, and one in February 2020 (Table 1). One trip (January 2020) coincided with a neap tide, and the other trips coincided with spring tides.

A minimum two high tide (roosting) surveys and two low tide (foraging) surveys were conducted on each trip to assess the variability in shorebird numbers. Surveys for roosting shorebirds were conducted as close to high tide time as possible, and always within two hours either side of high tide. Surveys for foraging shorebirds were conducted as close to low tide as possible, and always within two hours either side of low tide.

Sites A1-A4 were targeted during each survey of the Broome Peninsula study area. When weather and time permitted, surveys were conducted at sites A0 and A5. The mudflats at A5 were vast at low tide, so time did not permit a survey along the whole length of this habitat; however, these two sites were surveyed at least once per trip.

Additional surveys of the Broome Peninsula study area were conducted during rising or falling tides (outside of the time period restrictions for low and high tides). During heavy rainfall or high winds surveys were delayed, if time permitted, or cancelled. Survey timing was also scheduled to avoid major disturbances such as dog walkers and fishermen where practicable. Details of tide times and surveys in the Broome Peninsula study area are shown in Table 1.

The Roebuck Bay study area was surveyed at least once per trip. These surveys were time-consuming, and priority was given to scheduling the Broome Peninsula study area surveys so that they occurred in accordance with EPBC Act Policy Statement 3.21 timing requirements. Therefore, surveys of the Roebuck Bay study area were undertaken during variable heights of the tidal range (i.e. high, ebb, low, and flood tides).

Survey Effort

Four separate field trips took place between December 2019 and February 2020. Each field trip consisted of multiple surveys in the Broome Peninsula study area (minimum two high-tide and two low-tide surveys per field trip). Each survey (e.g. survey S01: 13 Dec 2019 low tide at 17:30) covered all four targeted survey sites (A1-A4). Some surveys Roebuck Bay surveys covered all 13 sites within the study area.

Surveys at low tide were conducted by walking along the length of the sites close to the water's edge along beaches and onto rocky headlands, using a telescope to check for birds on rocky islets. High tide surveys were conducted in the same way, or with stationary counts from a high vantage point where the whole site could be seen. All bird species, their numbers and their behaviour were recorded, along with spatial data to identify preferred roosting and foraging locations by shorebirds.

Species abundance, maximum abundance, total abundance, species richness, total species richness and birds per km were calculated for the targeted study sites (A1-A4), each site individually (A0 to A5, RB1 to RB13), and for Roebuck Bay all sites combined.

- Species abundance is the number of individuals observed for each species per survey (e.g. Ruddy Turnstone abundance on survey S01 was 21 individuals).
- Maximum abundance is the highest species abundance recorded during any survey (e.g. the maximum abundance of Ruddy Turnstone in sites A1-A4 was 111 individuals on survey S08).

- Total abundance is the number of individuals observed for all migratory shorebird species per survey (e.g. migratory shorebird abundance on survey S01 was 416 individuals).
- Species richness is the number of migratory shorebird species observed per survey.
- Total species richness is the total number of migratory shorebird species observed over the four field trips (Dec 2019 to Feb 2020).
- Birds per km for each site/area is the maximum abundance per species divided by the length (in kilometres) of coastline surveyed (e.g. sites A1-A4 covered approximately 1.9 km and the maximum abundance of Ruddy Turnstone for these sites was 111, so 59.04 Ruddy Turnstones per km were seen in A1-A4.

Each field trip was conducted by one of three ornithologists who have extensive experience working as shorebird experts throughout Western Australia, including in the northwest coast and on RAMSAR wetlands of international importance.

Additional Data

Observations on shorebird disturbance were recorded at Broome Peninsula study area sites during shorebird surveys. Potential nocturnal roosts were identified in the Broome Peninsula study area, and one of these was surveyed during the night.

Table 1. Schedule of shorebird surveys at targeted sites from Broome Peninsula study area (sites A1-A4) from December 2019 to February 2020. The boxes in the 'Field Trip' column summarise the number of high, low, and falling/rising (mid) tides that were surveyed during each trip. All surveys were conducted within two hours either side of the respective low/high tide, except those noted as falling or rising tide surveys.

Field Trip	Unique Survey No.	Survey Date	Tide Height (m)		Tide Time	Notes
(1) December	S01	13 Dec 2019	1.41	Low	05:20	Survey rising tide 9:30
	S02		2.13	Low	17:30	
[2x high]	S03	14 Dec 2019	1.27	Low	05:55	
[4x low]	S04		8.92	High	11:53	
[2x mid]	S05		2.07	Low	18:07	
	S06	15 Dec 2019	1.34	Low	06:30	
	S07		8.88	High	12:28	
	S08		2.16	Low	18:42	Survey falling tide 17:00
(2) January	S09	02 Jan 2020	2.99	Low	08:33	
	S10		7.80	High	14:43	
[2x high]	S11	03 Jan 2020	3.49	Low	09:05	
[3x low]	S12		7.43	High	15:22	
[1x mid]	S13	04 Jan 2020	6.40	High	03:31	Survey falling tide 5:25
	S14		4.01	Low	09:45	
(3) January	S15	14 Jan 2020	1.24	Low	07:04	
	S16		9.20	High	13:00	
[3x high]	S17		1.86	Low	19:20	
[4x low]	S18	15 Jan 2020	1.45	Low	07:40	
[2x mid]	S19		9.13	High	13:38	
	S20		2.04	Low	19:58	Survey falling tide 18:30
	S21	16 Jan 2020	1.85	Low	08:17	
	S22		8.91	High	14:17	

	S23		2.39	Low	20:36	Survey falling tide 17:10
(4) February	S24	26 Feb 2020	9.39	High	12:26	
	S25		1.64	Low	18:48	Survey falling tide 15:05
[3x high] [2x low] [1x mid]	S26	27 Feb 2020	1.40	Low	06:59	
	S27		9.41	High	12:50	
	S28	28 Feb 2020	1.58	Low	07:21	
	S29		9.33	High	13:13	

Survey Results

A minimum of two high-tide and two low-tide surveys of targeted sites (A1-A4) within the Broome Peninsula study area were completed on all four trips (Table 1), despite occasional delays or abandoned surveys due to heavy rainfall. A total of 29 surveys were completed at these sites (10 high tide and 13 low tide). Adjacent sites A0 and A5 were surveyed at least once per trip, and Roebuck Bay study area sites were surveyed at least once per trip.

Broome Peninsula Study Area

Shorebird abundance and richness statistics for targeted sites of the Broome Peninsula study area (A1-A4) are summarised in Table 2, and a detailed breakdown is available in Appendix 1. The total species richness was 17 migratory shorebird species across the four sites. Site A3 had a total species richness of seven migratory shorebird species and highest total recorded abundance of 105 individuals. Site A4 supported 17 species and a highest total abundance of 388 individuals. Sites A1 and A2 were similar to each other with 12 and 11 species respectively, and maximum total abundance of 32 and 39 individuals, respectively.

Sites A1 and A2 (the BBF study area) were found to not support any species in numbers of national significance. Ruddy Turnstone was occasionally present in nationally significant numbers (at least 0.1% of the species' flyway population) at both high and low tides at site A3; however, this was infrequent (10% of surveys). Four species were present in nationally significant numbers at site A4. Grey-tailed Tattler was nationally significant at both high and low tides on 34% of surveys. Ruddy Turnstone, Sanderling and Terek Sandpiper were infrequently observed in nationally significant numbers and only at either high or low tide: Ruddy Turnstone at high tide (3% of surveys), Sanderling at high tide (3%), and Terek Sandpiper at low tide (3%).

Targeted sites of the Broome Peninsula study area (A1-A4) do not meet the EPBC Act Policy Statement 3.21 criteria for an area supporting internationally significant migratory shorebirds. However, site A4 supports more than 15 species of migratory shorebirds, and both A3 and A4 support at least one species of migratory shorebird in numbers greater than 0.1% of their respective flyway populations. In accordance with the EPBC Act Policy Statement 3.21 criteria, sites A4 and A3 should both be regarded as nationally significant areas for migratory shorebirds.

Table 2. Maximum abundance of the 17 migratory shorebird species that were recorded at the Broome Peninsula main study areas (sites A1 to A4) from December 2019 to February 2020. The main impact site (A2) is shaded in grey. Pink cells indicate statistics that cross the national significance threshold.
*National significance thresholds as defined in EPBC Act Policy Statement 3.21.

†Flyway population estimates sourced from Hansen *et al.* (2016).

Species	National significance threshold* (0.1% flyway population†)	Maximum abundance A1	A2	A3	A4
Bar-tailed Godwit	325	0	0	0	96
Common Greenshank	110	0	0	0	10
Common Sandpiper	190	12	4	3	5
Curlew Sandpiper	90	1	7	0	42
Great Knot	425	0	0	0	112
Greater Sand Plover	200	15	10	40	150
Grey Plover	80	1	2	0	30
Grey-tailed Tattler	70	6	10	38	280
Lesser Sand Plover	180	5	2	0	14
Pacific Golden Plover	120	5	4	6	20
Red Knot	110	1	0	0	40
Red-necked Stint	475	1	2	0	60
Ruddy Turnstone	30	25	15	40	70
Sanderling	30	4	17	0	40
Sharp-tailed Sandpiper	85	0	0	0	2
Terek Sandpiper	50	0	0	15	80
Whimbrel	65	1	1	4	12
	National significance threshold*	**A1**	**A2**	**A3**	**A4**
Total abundance	2,000 migratory shorebirds	32	39	105	388
Total species richness	15 migratory shorebird species	12	11	7	17

The distribution of shorebird sightings from the Broome Peninsula study area during all high and low tides are presented in Figure 4. The mudflat of site A4 and nearby similar habitat to the north is the most important foraging location in the Broome Peninsula study area. In contrast, some species such as the Ruddy Turnstone were not well represented on the mudflats, and their main foraging areas were on the beaches at sites A3 and A1 (Fig. 5). Major shorebird roosting locations were at sites A4 and A5 (Fig. 5). These were rocky areas near the mudflats and supported large flocks of roosting shorebirds (e.g. 280 Grey-tailed Tattler on one occasion). Smaller groups of shorebirds were seen roosting on rocky islets from A1 to A3. Most of these islets are submerged during high tides, except one islet at A1 which was more frequently observed to be used as a roosting location (Fig. 5).

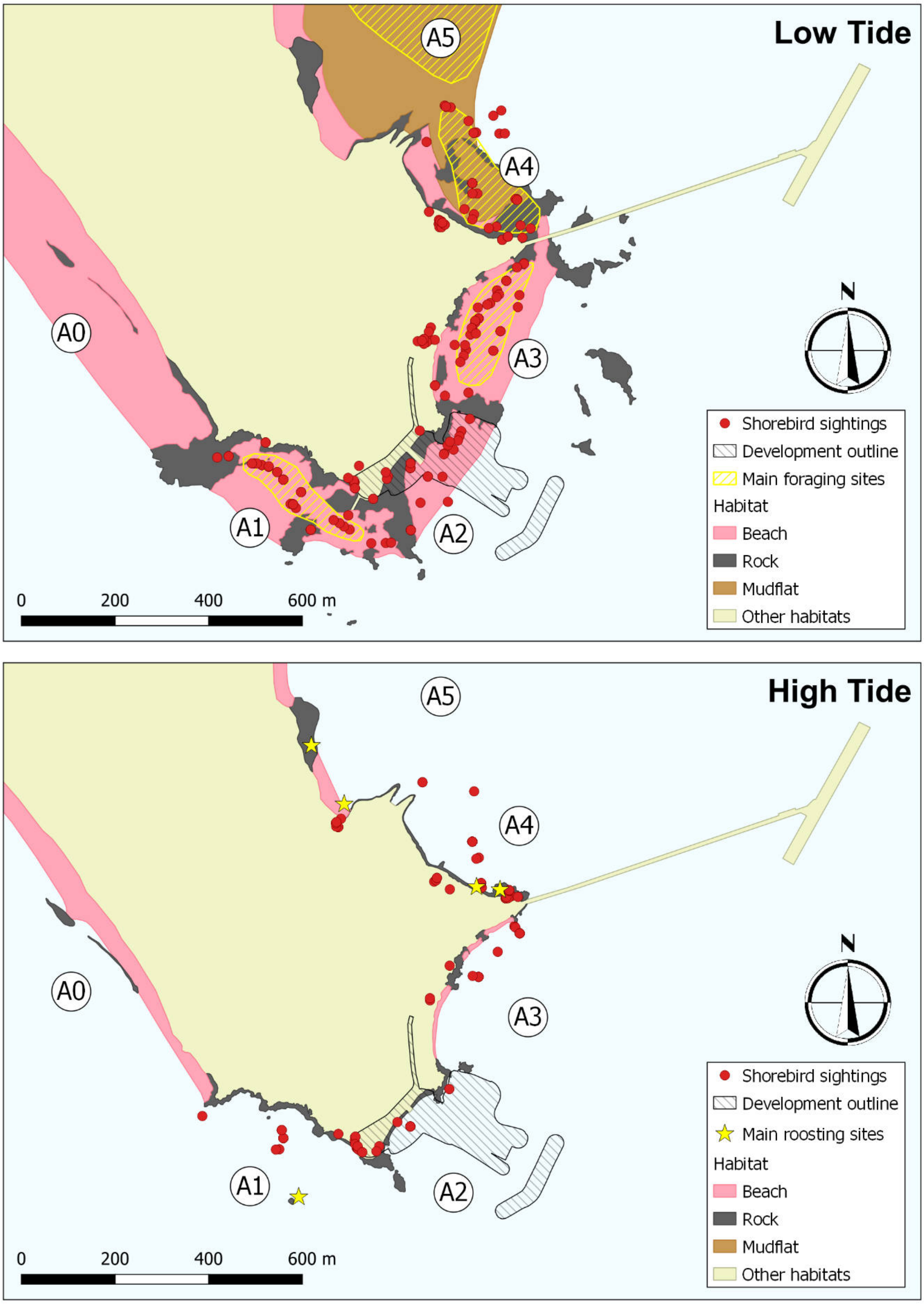

Figure 5. Major shorebird habitats within the Broome Peninsula study area (A0-A5). The low tide map shows GPS locations of all low tide migratory shorebird sightings in sites A1-A4, as well as the main foraging areas for shorebirds. The high tide map shows GPS locations of all high tide migratory shorebird sightings in sites A1-A4, as well as the main roosting locations for shorebirds. Note that GPS points were recorded from the observer's

location in many cases (especially when recording roosting birds), so clusters of points do not always align with main feeding/roosting areas.

Levels and sources of disturbance to shorebirds varied between sites. Site A4 was the least disturbed. Here disturbances include crabbers walking on the mudflats, fishermen on the rocks underneath the Broome Jetty, and potentially commercial vessels launched from the Port of Broome Slipway (not observed). Disturbances at site A3 included recreational activities on the beach (walking, swimming, dog walking, etc.), and fishermen on the rocks and beach. These disturbances were frequent during low tide, and infrequent during high tide. Similar disturbances were observed at sites A1 and A2, as well as the presence and noise from vehicles and boats, as a public boat ramp is located within both areas. The frequency of disturbance at sites A1 and A2 (the BBF study area) was extremely high due to the ease of access from the adjacent car park. Only the islets remained undisturbed at these two sites.

Site A4 and the extensive habitat nearby at A5 are the most likely refuge areas for shorebirds to move to after disturbance from the beaches at A1-A3, both at high and low tides (although birds that prefer beach habitat may move west around the peninsula at low tide instead). The high tide roosts in and near site A4 also present the most likely candidates for nocturnal roost sites, due to their relatively low levels of disturbance and the high numbers of roosting birds noted during the day.

The results for the other migratory bird species listed under the CAMBA, JAMBA or ROKAMBA (referenced in text below as CJR), excluding shorebirds, which were observed in the Broome Peninsula study area are presented in Table 3. A total of eight species were observed within the Broome Peninsula study area. None of these species were observed in numbers greater than 0.1% of their respective global populations. The nearest was Little Tern (0.09% of global population).

Table 3. Bird survey results at the Broome Peninsula study area (A0-A5) from December 2019 to February 2020. Species included here are those listed under the CAMBA, JAMBA or ROKAMBA, excluding the migratory shorebird species already presented above. Statistics represent the maximum abundance at each site during any survey, per species. The proposed BBF site (A2) is shaded in grey.

Species	Maximum abundance					
	A0	A1	A2	A3	A4	A5
Brown Booby	0	18	50	12	0	0
Lesser Frigatebird	0	0	0	1	0	0
Caspian Tern	0	0	0	0	0	0
Common Tern	2	30	10	13	60	211
Little Tern	8	46	11	8	109	15
Gull-billed Tern	1	18	0	0	20	2
Greater Crested Tern	0	35	37	110	50	12
White-winged Tern	0	3	0	0	1	0
Barn Swallow	0	2	36	0	0	0

Broome Port Peninsula Study Area: Supplementary Sites

Shorebird statistics from the supplementary sites A0 and A5 are compared to the targeted sites of the Broome Peninsula study area in Table 4. The beach habitat at site A0 supports less shorebirds than any site within A1-A4. The total species richness was nine migratory shorebird species, with a maximum total abundance of 38. No species was seen in numbers exceeding 0.1% of their flyway populations. Conversely, the mudflat and rock habitat at site A5 supported a higher abundance of shorebirds at both high and low tides. The total species richness was only 13 species, but the total abundance was much higher at 1,416 migratory shorebirds, although still below the national significance threshold of 2,000. Five species were present in nationally significant numbers. Grey-tailed Tattler and Terek Sandpiper were nationally significant in A5 (and A4), while Curlew Sandpiper, Great Knot and Greater Sand Plover were also nationally significant but only in A5. Within site A5 shorebirds were widely spread foraging across the expansive mudflats at low tide, and at high tide shorebirds roosted in large flocks on rocky areas (Fig. 5).

Table 4. Maximum abundance of the 17 migratory shorebird species that were recorded in the proposed BBF site (A2), and supplementary sites (A0 and A5) which were adjacent to the targeted study area (A1-A4), from December 2019 to February 2020. The main impact site is shaded in grey. Pink cells indicate statistics that exceed the national significance threshold.

*National significance thresholds as defined in EPBC Act Policy Statement 3.21.

†Flyway population estimates sourced from Hansen *et al.* (2016).

Species	National significance threshold* (0.1% flyway population†)	Maximum abundance		
		A0	A2	A5
Bar-tailed Godwit	325	0	0	24
Common Greenshank	110	0	0	56
Common Sandpiper	190	3	4	11
Curlew Sandpiper	90	0	7	260
Great Knot	425	0	0	460
Greater Sand Plover	200	6	10	270
Grey Plover	80	2	2	0
Grey-tailed Tattler	70	0	10	173
Lesser Sand Plover	180	1	2	40
Pacific Golden Plover	120	2	4	1
Red Knot	110	0	0	0
Red-necked Stint	475	2	2	40
Ruddy Turnstone	30	7	15	16
Sanderling	30	14	17	0
Sharp-tailed Sandpiper	85	0	0	0
Terek Sandpiper	50	0	0	110
Whimbrel	65	1	1	17
	National significance threshold*	**A0**	**A2**	**A5**
Total abundance	2000 migratory shorebirds	38	39	1,416
Total species richness	15 migratory shorebird species	9	11	13

Disturbance at sites A0 and A5 was relatively low compared to the targeted sites (A1–A4). Disturbance-causing activities at A5 were similar to those at A4, and activities at A0 were similar to those at A3. The frequency of disturbance in both cases was lower than in the targeted sites A1-A4, possibly because A0 and A5 are located further from parking areas.

Sites A0 and A5 support fewer CJR listed migratory species than the main study area (Table 3). At site A0, only three species were observed, all in low numbers. Site A5 also supported few CJR species, but Common Tern was seen in higher numbers here than anywhere else. These Terns were seen roosting on the mudflats and feeding nearby along with three other tern species. As with the targeted sites, CJR species were not observed in numbers greater than 0.1% of the global population at either site.

Roebuck Bay Study Area

Shorebird statistics from Roebuck Bay study area are compared to the BBF Project site (A2) in the Broome Peninsula study area in Table 5. The entire length of the Roebuck Bay study area was utilised for foraging, with extensive mudflats exposed at low tide along the coastline. Roosting locations were observed at every site and some held particularly high numbers of roosting shorebirds (e.g. sites 3 and 12). Migratory shorebird numbers in several Roebuck Bay sites were higher than any site in the Broome Peninsula study area. A detailed breakdown of shorebird abundance for each site in Roebuck Bay is shown in Appendix 2. Over the entire Roebuck Bay study area, the highest total abundance was 11,177 migratory shorebirds of 22 species, both well above the criteria threshold for nationally important wetlands. Of the 22 species recorded, 16 were observed in numbers greater than 0.1% of their respective flyway populations (note that when considering individual sites, only 13 species were recorded in significant numbers (e.g. Table 5) – this becomes 16 species when totals across all Roebuck Bay sites are considered). Only four of these 22 species were recorded in nationally significant numbers in the Broome Peninsula study area, and just one species, Terek Sandpiper, was more abundant in the Broome Peninsula than in the Roebuck Bay study area (however Terek Sandpiper was not recorded from site A2).

The Roebuck Bay study area covers a broader spatial range than the Broome Peninsula study area, so it is not surprising that a higher total abundance of shorebirds was recorded. Single sites from Roebuck Bay study area supported far more shorebirds than single sites in the Broome Peninsula study area. Roebuck Bay study area also supported more shorebirds per kilometre of surveyed coastline than the Broome Peninsula study area for most species (Appendix 3), especially when comparing site A2 to Roebuck Bay (Table 5). Several species seen in site A2 were at least 10 times more abundant, per kilometre, in Roebuck Bay. Pacific Golden Plover abundance was similar in Roebuck Bay and site A2, and the only species that was significantly more abundant in site A2 than Roebuck Bay was Common Sandpiper.

Table 5. Shorebird survey results at the proposed BBF Project site (A2) compared to 13 sites in Roebuck Bay study area from December 2019 to February 2020 for the 22 migratory shorebird species that were recorded in either area. Pink cells indicate statistics that exceed the national significance threshold.
*Maximum abundance statistics refer to the maximum abundance of shorebirds recorded during a single survey of site A2, or of any single site in Roebuck Bay. Birds per km statistics refer to the maximum recorded on a survey of site A2, or on an entire survey covering the length of Roebuck Bay (RB1-RB13).
*National significance thresholds as defined in EPBC Act Policy Statement 3.21.
†Flyway population estimates sourced from Hansen *et al.* (2016).

Species	**National significance threshold* (0.1% flyway population†)**	**Maximum abundance**		**Birds per km**	
		A2	**RB single site**	**A2**	**RB all sites**
Bar-tailed Godwit	325	0	2,000	0	1,029.4
Black-tailed Godwit	160	0	500	0	212.8
Broad-billed Sandpiper	30	0	30	0	12.8
Common Greenshank	110	0	60	0	59.6
Common Sandpiper	190	4	3	11.1	1.3
Curlew Sandpiper	90	7	1,200	19.4	511.1
Far Eastern Curlew	35	0	300	0	217.0

Great Knot	425	0	4,000	0	1,980.4
Greater Sand Plover	200	10	1,000	27.8	595.7
Grey Plover	80	2	40	5.6	37.9
Grey-tailed Tattler	70	10	410	27.8	174.5
Lesser Sand Plover	180	2	125	5.6	53.2
Oriental Plover	230	0	1	0	0.4
Oriental Pratincole	2,880	0	20	0	22.6
Pacific Golden Plover	120	4	20	11.1	13.2
Red Knot	110	0	100	0	97.0
Red-necked Stint	475	2	4,000	5.6	1,737.9
Ruddy Turnstone	30	15	200	41.7	85.1
Sanderling	30	17	200	47.2	170.2
Sharp-tailed Sandpiper	85	0	40	0	17.9
Terek Sandpiper	50	0	50	0	22.6
Whimbrel	65	1	100	2.8	76.6
	National significance threshold*	**A2**	**RB single site**	**A2**	**RB all sites**
Total abundance	2,000 migratory shorebirds	39	8,951	108.3	4,756.2
Total species richness	15 migratory shorebird species	11	17		

Disturbance at the Roebuck Bay sites was very low, and no cases of human or human-related disturbances to shorebirds were observed. There is very little infrastructure in the area that may lead to shorebird disturbance (e.g. jetties or boat ramps).

Roebuck Bay supported fewer CJR-listed migratory species than the main study area (Table 6). One species (Caspian Tern) was seen in Roebuck Bay and not in the Broome Peninsula study area sites. Roebuck Bay, with its extensive mudflats, is generally more suited to shorebirds than terns. As found for the Broome Peninsula study area, none of the CJR species were observed in numbers greater than 0.1% of the global population.

Table 6. Bird survey results at the proposed BBF Project site (A2) compared to 13 sites in Roebuck Bay study area from December 2019 to February 2020. Species included here are those listed in any one of the CAMBA, JAMBA or ROKAMBA, excluding the migratory shorebird species already presented above.
*Maximum abundance statistics refer to the maximum abundance of birds recorded on a survey of site A2, or of any single site in Roebuck Bay. Birds per km statistics refer to the maximum recorded on a survey of site A2, or on an entire survey covering the length of Roebuck Bay (RB1-RB13).

Species	**Maximum Abundance**		**Birds per km**	
	A2	**RB single site**	**A2**	**RB all sites**
Brown Booby	50	0	138.9	0
Lesser Frigatebird	0	0	0	0
Caspian Tern	0	40	0	17.0
Common Tern	10	80	27.8	34.0
Little Tern	11	80	30.6	34.0
Gull-billed Tern	0	17	0	10.6
Greater Crested Tern	37	80	102.8	34.0

White-winged Tern	0	0	0	0
Barn Swallow	36	0	100.0	0

Potential Significant Impacts on Migratory Shorebirds

In Australia, important migratory shorebird habitat is protected under the EPBC Act. Approval is required for any action that is likely to have a significant impact on migratory shorebirds and the habitats they use. As described in the EPBC Matters of National Significance (MNES) Significant Impact Guidelines 1.1 (the guidelines), an action is likely to have a significant impact on migratory shorebirds if there is a real possibility that it will:

- substantially modify, destroy, or isolate an area of important habitat; or
- result in an invasive species that is harmful to migratory shorebirds becoming established in an area of important habitat; or
- seriously disrupt the lifecycle of an ecologically significant proportion of a migratory shorebird species.

The MNES Guidelines state that an area of 'important habitat' for a migratory species is:

- habitat utilised by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- habitat that is of critical importance to the species at particular life-cycle stages, and/or
- habitat utilised by a migratory species which is at the limit of the species range, and/or
- habitat within an area where the species is declining.

During this study, the proposed BBF Project area (site A2) did not meet any criteria for identifying important habitat for migratory shorebirds. The site supported less than 2,000 individuals and less than 15 migratory shorebird species, and no species were present in nationally significant numbers (at least 0.1% of the species' flyway population).

The BBF project area does not qualify as important habitat for migratory shorebirds, and no species were present in nationally significant numbers, however the site is still of value to several species of shorebirds in low numbers. We have therefore included below advice regarding identifying and mitigating potential impacts to shorebirds resulting from the proposed BBF Project.

Identifying Potential Significant Impacts

Actions most likely to result in significant impacts to migratory shorebirds are those that lead to habitat loss, habitat degradation, increased disturbance to shorebirds, and/or direct mortality of shorebirds, leading to a substantial reduction in migratory shorebird numbers.

Habitat Loss

The area of habitat lost following completion of the BBF Project development will be confined to site A2. The area of shorebird habitat lost will be approximately 2.03 ha (61.4% of the total area of shorebird habitat in A2), which includes approximately 0.71 ha of beach (67.0% of the total beach area in A2). Habitat areas were calculated for low tide, when the largest proportion of habitat is exposed and available for use by shorebirds.

Habitat Degradation

The BBF Project may potentially reduce the quality of the remaining migratory shorebird habitat in site A2. Habitat degradation in relation to the BBF Project could result from actions either relating to the physical structure itself (sub-section 1 below), or to the operational activities of the facility (sub-sections 2-4).

1. Longshore Drift

The proposed BBF development will change the shape of the coastline which has the potential to affect the current movements and flow intensity in the study area. Sediment deposits may shift as a result, however this is not within the scope of the migratory shorebird assessment and will not be discussed further in this report. DoT have commissioned an assessment on coastal processes impacts.

2. Biosecurity and Invasive Species

Invasive marine species may be introduced or translocated on the hulls of vessels and vehicles, although the chance of this is low as all vessels accessing the facility will be via trailer. Some invasive species have the potential to negatively impact migratory shorebirds by modifying the habitat and/or the productivity of benthic communities on which shorebirds feed. Invasive weeds such as *Spartina* species are known to modify intertidal habitat and make it less suitable for foraging shorebirds (Commonwealth of Australia 2017).

3. Spills and Pollutants

Accidental spills of hydrocarbons, oil or other substances (including runoff of substances from the parking area into the water) may have toxic effects on the Benthic Communities and Habitats (BCH) in the vicinity of the development, with negative effects on migratory shorebirds which feed on BCH. The material used to seal the surface of the parking area may also have a negative effect on the BCH. For example, a tarmac surface may lead to hydrocarbon runoff into the water. Accidental spills also have the potential to directly impact shorebirds by increasing the chance of direct mortality.

4. Construction

Temporary degradation of part of the beach habitat is possible during the construction process, as vehicles and plant will need to drive onto the beach. The extent of this should be restricted to the construction footprint of the project (habitat which will be lost anyway), leaving the habitat outside the footprint unaffected. Any habitat degradation outside the construction footprint will be temporary, and the habitat will likely recover once construction is completed.

Disturbance

Actions that cause disturbance to shorebirds include visual disturbance from human activities (e.g. vehicles, walking dogs, lights, etc.), loud noises and/or vibrations (e.g. construction/demolition activities), and presence of other animals (e.g. feral predators). These actions may lead to significant impacts if they take place within an area of important habitat. Roosting and foraging birds are particularly sensitive to discrete, unpredictable disturbances such as sudden loud noises. The BBF Project development includes several actions which have the potential to disturb migratory shorebirds, which broadly fit into three categories: construction, operation, and recreation, which are addressed below.

1. Construction

Site staff, vehicles and plant involved in construction activities may cause disturbance to migratory shorebirds, however these activities should be restricted to the development footprint of the project leaving most of site A2 unaffected. Loud, unpredictable noises and strong vibrations will disturb shorebirds, potentially at a longer distance than visual disturbances such as moving vehicles. Nocturnal work activity utilizing bright artificial lighting may also disturb shorebirds in site A2. Finally, temporary and permanent artificial structures and food waste inside the construction site will attract non-native pest species such as Black Rat (*Rattus rattus*), which in turn is likely to attract feral predators such as feral cat (*Felis silvestris*) and Red Fox (*Vulpes vulpes*). These predators will disturb migratory shorebirds and lead to direct mortality of shorebirds.

2. Operation

As with the construction phase, sudden loud noises will lead to disturbance of shorebirds especially if irregular and unexpected. Nocturnal lighting from the usual operation of the facility may impact migratory shorebirds (Poot et al. 2008). Artificial structures may provide shelter for pest animals, possibly attracting feral predators as discussed in the construction phase above. Food waste, especially around fish cleaning stations, is likely to attract pest animals and feral predators to the area.

Beach-based recreational activities such as four-wheel-driving, dog walking, fishing, and boat launching from the beach all have the potential to disturb migratory shorebirds. All these activities already take place on the beach in site A2. The proposed development will provide pedestrian access to the remaining beach habitat, and we recommend that vehicle access to the beach is limited or prevented altogether. The provision of additional parking and improved pedestrian access to the beach may lead to an increase in disturbance for shorebirds using the site, particularly if dog walking continues to be permitted on the beach.

Direct Mortality to Shorebirds

Actions which increase the risk of mortality to shorebirds (e.g. collision, or predation) in important habitat may result in a significant impact. Two actions relating to the BBF development have the potential to increase the risk of mortality. These two actions are only mentioned here for completeness, as they have all been discussed in the habitat degradation or disturbance sections above. Spills of fuel or other substances associated with BBF operations will have toxic effects on shorebirds if they come into contact. Oily substances can also coat the birds' feathers and compromise their ability to fly and find food. Artificial structures and inadequate waste management may attract pests and predators, which may also predate directly on migratory shorebirds.

Off-lead dog walking is a significant cause of disturbance to migratory shorebirds and may result in direct mortality to shorebirds if dogs are not controlled. If the BBF Project directly or indirectly leads to increased use of the beach by dog walkers, this will lead to increased risk of direct mortality to shorebirds from uncontrolled dogs.

Mitigating Potential Significant Impacts

Some potential impacts on migratory shorebirds may be avoided altogether through careful planning, but some impacts cannot be avoided and instead should be minimised or mitigated as much as possible.

The proposed impact area lies within the Port of Broome waters (Kimberley Port Authority port waters), adjacent to but not within the Yawuru Nagulagun / Roebuck Bay Marine Park. The Yawuru Nagulagun / Roebuck Bay Marine Park management plan represents consensus around the Port of Broome annex as an area designated for future onshore/offshore industrial development (Department of Parks and Wildlife 2016). The annex was adopted to help facilitate the development and expansion of the Port of Broome, while recognising the much higher conservation significance of nearby Roebuck Bay protected areas.

Habitat Loss

Loss of shorebird habitat is unavoidable with the proposed development as the structure will remove foraging habitat. The project will include an offshore breakwater which has the potential to become an artificial roosting site for shorebirds. This structure, being separated from the mainland, would provide a predator-free alternative roosting habitat for birds and would be permanently available as a roosting site during high tides. Research has shown that the presence of offshore roost sites near feeding areas correlates to higher densities of foraging shorebirds including Ruddy Turnstones (Whittingham *et al.* 2020). The proposed offshore breakwater may provide an alternative roost site closer to the remaining foraging area in A2, thus requiring less energy on the part of shorebirds to maintain daily routines. This would potentially offset the loss and degradation of migratory shorebird foraging habitat within the A2 impact area. Every effort must therefore be made to help facilitate the offshore breakwater as a roost site if this mitigation is a preferred option. The major constraint on this feature being used as a roost site will be open access to the general public and therefore the structure will need to be signed as no-access to general public for it to function as a potential roost site for migratory shorebirds. There is no guarantee that migratory shorebirds would use an artificial roost site installed at the site of the BBF project, however many species of migratory shorebirds show willingness to use artificial roost sites even in the presence of boats (Peters & Otis 2007).

Habitat Degradation

The proposed BBF development will change the shape of the coastline which has the potential to affect the current movements and flow intensity in the study area. Sediment deposits may shift as a result, however this is not within the scope of the migratory shorebird assessment and will not be discussed further in this report. DoT have commissioned an assessment on coastal processes impacts.

3. Biosecurity and Invasive Species

We recommend the implementation of strict biosecurity protocols reflecting current best practice to mitigate the risk of invasive species becoming established in the area. This should include a pest management plan and waste management procedures.

4. Spills and Pollutants

We recommend strict Safe Work Methodology Statement reflecting current best-practice around managing and mitigating potential pollutants and the marine environment. We recommend the use of only biodegradable products for all maintenance and cleaning of the facilities wherever possible to mitigate the potential negative impact of non-biodegradable contaminants. We also recommend effective drainage / stormwater management to minimise runoff to the marine environment.

5. Construction

Potential spills of fuel and other substances should be strictly managed as discussed above (see Pollutants). Vehicles should stay within the construction footprint and will use regular access routes and movement paths to keep the impacted area to a minimal size.

Disturbance

1. Construction

The timing of the construction phase will be essential to mitigating shorebird disturbance. We recommend the construction phase being scheduled during the times of year when most shorebirds are not present in the area (May to August, during the Austral winter) while they are on their Arctic breeding grounds. This represents the most effective strategy for mitigating potential disturbance impacts to migratory shorebirds.

Construction work activities that cannot be completed during the Austral winter will take further steps to mitigate potential disturbance to shorebirds. Loud, unpredictable noise can be a significant disturbance to shorebirds (Commonwealth of Australia 2017) especially near roost sites, however generally birds will become habituated to loud noise if it is predictable and consistent (e.g. at airports).

Loud noise should be limited to certain periods during the day or night wherever possible and noise-generating work activities should be planned to coincide with each other. Noise-generating work should be planned to avoid high-tide times when shorebirds may be roosting nearby and, if possible, to avoid low-tide times when shorebirds may be foraging – mid-tide times are the preferred compromise. We recommend that all noise-generating activities have a maximum decibel level of 100 dB (A), based on shorebird responses to different perceived dB (A) measurements (actual volume of the noise stimulus attenuates over distance), and the size of the beach (Wright, Goodman & Cameron 2010). Sirens, ship horns, etc. should be started at low volume and gradually increased in volume over a few seconds.

Bright artificial light can disturb shorebirds at night (Commonwealth of Australia 2020) particularly if the light source is moving and/or flashing/flickering. Some research suggests that shorebirds can benefit from artificial illumination at foraging areas by allowing them to use visual foraging strategies and increase their foraging efficiency (Dwyer et al. 2013; Santos et al. 2010). It is unclear whether lighting from construction of the proposed development will impact migratory shorebirds, but steps should still be taken to mitigate potential impacts. Disturbance from bright artificial lighting during nocturnal works should be mitigated by ensuring that construction lights are aimed away from shorebird feeding and roosting areas wherever possible, and that lights are static and not flickering.

Visual disturbance from personnel and vehicles can be kept to a minimum by ensuring that all construction activities are kept within the construction footprint of the project, and by erecting barriers around the work site to hide activities from the view of nearby shorebirds.

We recommend a pest management plan as part of the biosecurity and invasive species mitigation procedures – this plan should include pest management during the construction phase with emphasis on controlling non-native mammalian predators.

2. Operation

Operational use of the facility cannot be limited to the Austral winter as with construction activities. Mitigation strategies for noise and lighting disturbance during the construction phase are also relevant during operational use (see Construction above). Permanent lighting for the facility should be as environmentally-friendly as possible while maintaining necessary operational standards, and not be directed toward shorebird feeding or roosting areas.

The development is likely to increase the amount of human disturbance in the area. To mitigate this increased disturbance, we suggest the creation and posting of clear signage outlining information about migratory shorebirds and the importance of Roebuck bay as a migration stop. It should highlight the damages disturbance can have on foraging and roosting shorebirds, with particular focus on the impact of dogs chasing shorebirds. Through improved awareness this measure can encourage cooperation by the public and reduce the impact of the disturbance. Training of the local ranger service in shorebird identification and biology is another step that could be taken to improve the public understanding and conduct around migratory shorebirds and will give them the understanding and awareness to help enforce correct conduct on the site.

The pest management plan recommended as part of the biosecurity and invasive species mitigation procedures will also mitigate potential disturbance from introduced pests, especially non-native mammalian predators.

Direct Mortality to Migratory Shorebirds

With increased usage by the public the likelihood of direct mortality to shorebirds by uncontrolled dogs is increased. Public information signage, as described under the Disturbance section above, will help reduce the risk of direct mortality to shorebirds by uncontrolled dogs. Signage at all access points will serve to remind and inform beach users about the importance of the habitat for migratory shorebirds, and about proper conduct and behaviour around shorebird areas with emphasis on not allowing dogs to chase shorebirds.

The previously recommended pest management plan as part of the biosecurity and invasive species will act as a mitigator, reducing the likelihood of direct mortality to shorebirds resulting from pests, especially non-native mammalian predators.

Spills of fuel and other substances should be managed to avoid potential habitat degradation as discussed in that section above, but proper management of pollutants will also help minimise the likelihood of direct mortality to shorebirds through ingestion of toxic substances or contact with oily substances. We recommend against the use of bird deterrent products (e.g. alpha-chloralose), especially products with bioaccumulation effects.

Conclusion and Recommendations

Results from the survey data presented in this report demonstrate that the impact area of the proposed BBF project (site A2) does not support any shorebird species in numbers of national or international significance. The overall shorebird abundance and diversity do not meet national significance criteria either, so the site should be not be regarded as important for migratory shorebirds. When the area of the proposed BBF is considered in the context of the adjoining and surrounding control count areas, it has a relatively low conservation importance for migratory shorebirds. Despite this, the site still provides valuable foraging habitat for the low numbers of shorebirds that use the site, so we recommend that steps are taken wherever possible to avoid or mitigate the potential for the project to negatively impact these shorebirds.

Note that no surveys were conducted during the migratory shorebird breeding season (Austral winter). The EPBC Act Policy Statement 3.21 states that at least one survey must be conducted to assess shorebird numbers during this period. A further recommendation of this report is that one more field trip takes place in July or August to comply with the survey requirements of the EPBC Act Policy Statement 3.21.

Low numbers of shorebirds may be impacted by the proposed BBF project primarily from habitat loss, and potentially also from habitat degradation, disturbance to shorebirds, and direct mortality to shorebirds. Sources of potential habitat degradation include the possibility of pollution via spills, and the possibility of accidental introduction of invasive species. Potential disturbance to shorebirds may result from construction activities (loud noise, vibration, artificial lighting, moving personnel and vehicles, pest predators), and from operational use of the facility (loud noise, artificial lighting, pest predators, beach users and unrestrained dogs). Direct mortality to shorebirds may result from accidental introduction of pests, especially mammalian predators, increased use of the beach involving unrestrained dog-walking, and spills of fuel or other substances.

We are confident that the adoption of the recommended mitigation measures outlined in this report will reduce the chance of any significant impacts on migratory shorebirds using the site A2 where the proposed BBF project will be located.

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Appendix 1. Detailed breakdown of abundance and richness for 17 migratory shorebird species recorded in the Broome Peninsula study area (sites A1-A4) from December 2019 to February 2020. Maximum abundance for any single survey and mean abundance across all surveys (± one standard error) are shown for each species within each site, and each tide level (high/low). Total abundance and species richness are also shown in this way, while total species richness is shown for each site (combining tidal levels). Rows and cells which are shaded indicate statistics that cross the national significance threshold.

Species	National significance threshold (0.1% flyway population)	A1				A2				A3				A4			
		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide		Low Tide		High Tide	
		Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE	Max	Mean ± SE
Bar-tailed Godwit	325	0	0	0	0	0	0	0	0	0	0	0	0	25	3.8 ± 2.2	96	7.4 ± 7.4
Common Greenshank	110	0	0	0	0	0	0	0	0	0	0	0	0	10	1.0 ± 0.7	10	0.8 ± 0.8
Common Sandpiper	190	12	2.1 ± 0.9	3	0.5 ± 0.2	4	1.1 ± 0.3	2	0.3 ± 0.2	3	0.8 ± 0.2	2	0.3 ± 0.2	5	0.9 ± 0.4	1	0.4 ± 0.1
Curlew Sandpiper	90	1	0.1 ± 0.1	0	0	0	0	7	0.5 ± 0.5	0	0	0	0	42	4.1 ± 2.7	10	1.8 ± 0.9
Great Knot	425	0	0	0	0	0	0	0	0	0	0	0	0	112	16.5 ± 9.1	32	2.9 ± 2.4
Greater Sand Plover	200	0	0	15	1.5 ± 1.1	3	0.7 ± 0.3	10	0.8 ± 0.8	4	0.9 ± 0.3	40	3.3 ± 3.1	150	23.3 ± 10.1	69	13.8 ± 7.0
Grey Plover	80	3	0.8 ± 0.3	0	0	2	0.2 ± 0.1	0	0	0	0	0	0	30	2.6 ± 1.9	15	1.5 ± 1.2
Grey-tailed Tattler	70	1	0.1 ± 0.1	1	0.1 ± 0.1	0	0	10	0.8 ± 0.8	38	3.4 ± 2.5	14	1.2 ± 1.1	280	51 ± 18.2	250	60.4 ± 18.9
Lesser Sand Plover	180	6	0.4 ± 0.4	5	0.4 ± 0.4	2	0.2 ± 0.1	0	0	0	0	0	0	14	10.6 ± 1.0	0	0
Pacific Golden Plover	120	1	0.1 ± 0.1	5	0.6 ± 0.4	2	0.6 ± 0.2	4	0.3 ± 0.3	2	0.3 ± 0.2	6	0.6 ± 0.5	20	1.8 ± 1.2	15	2.5 ± 1.2
Red Knot	110	4	1.0 ± 0.3	1	0.1 ± 0.1	0	0	0	0	0	0	0	0	40	2.7 ± 2.5	30	2.3 ± 2.3
Red-necked Stint	475	0	0	1	0.1 ± 0.1	0	0	2	0.2 ± 0.2	0	0	0	0	60	8.3 ± 4.3	60	4.6 ± 4.6
Ruddy Turnstone	30	23	4.6 ± 1.7	25	6.9 ± 2.8	6	1.6 ± 0.4	15	2.2 ± 1.3	33	7.1 ± 2.3	40	5.5 ± 3.8	25	3.7 ± 1.9	70	10.8 ± 5.6
Sanderling	30	1	0.1 ± 0.1	4	0.3 ± 0.3	17	1.8 ± 1.3	0	0	0	0	0	0	0	0	40	3.1 ± 3.1
Sharp-tailed Sandpiper	85	0	0	0	0	0	0	0	0	0	0	0	0	2	0.1 ± 0.1	0	0
Terek Sandpiper	50	0	0	0	0	0	0	0	0	1	0.1 ± 0.1	15	1.2 ± 1.1	80	12.3 ± 5.2	40	8.2 ± 3.9
Whimbrel	65	1	0.1 ± 0.1	0	0	0	0	1	0.1 ± 0.1	4	0.8 ± 0.3	4	0.5 ± 0.3	6	1.9 ± 0.6	12	1.8 ± 0.9
Total abundance	2,000 migratory shorebirds	32	9.4 ± 2.6	31	10.5 ± 3.4	23	6.1 ± 1.7	39	5.1 ± 3.1	41	13.4 ± 3.4	105	12.6 ± 8.7	383	135.4 ± 33.9	388	122.2 ± 33.4
Species richness	15 migratory shorebird species	7	2.6 ± 0.6	5	1.9 ± 0.5	5	2.3 ± 0.5	7	0.9 ± 0.5	5	2.8 ± 0.3	7	1.2 ± 0.6	12	5.9 ± 1.0	9	4.7 ± 0.8
Total species richness	15 migratory shorebird species	12				11				7				17			

Appendix 2. Maximum abundance of 22 migratory shorebird species that were recorded in Roebuck Bay Nature Reserve from December 2019 to February 2020. Each site was surveyed several times and the maximum abundance for each species is shown. Rows and cells which are shaded indicate statistics that cross the national significance threshold. Some species were not present in nationally significant numbers in any one site, but were significant across an entire survey of Roebuck Bay (Common Greenshank, Grey Plover, Red Knot). Rows and cells which are shaded indicate statistics that cross the national significance threshold.

Species	National significance threshold (0.1% flyway population)	Maximum abundance												
		RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08	RB09	RB10	RB11	RB12	RB13
Bar-tailed Godwit	325	300	30	90	42	60	50	1	150	81	190	100	2000	15
Black-tailed Godwit	160	0	0	0	2	0	0	0	1	0	2	0	500	0
Broad-billed Sandpiper	30	0	0	30	0	0	0	0	0	0	0	0	10	0
Common Greenshank	110	0	60	15	5	27	1	5	30	8	50	60	0	0
Common Sandpiper	190	0	3	3	0	0	0	0	1	1	0	0	0	0
Curlew Sandpiper	90	0	0	0	0	0	0	1	0	0	0	0	1200	0
Far Eastern Curlew	35	0	0	1	136	60	150	50	300	0	0	0	10	0
Great Knot	425	0	0	300	30	10	40	80	220	0	110	65	4000	0
Greater Sand Plover	200	1000	80	800	50	85	20	10	50	40	240	15	700	600
Grey Plover	80	0	0	40	0	20	14	0	6	25	25	5	30	0
Grey-tailed Tattler	70	0	30	75	20	30	3	0	40	410	200	3	200	0
Lesser Sand Plover	180	0	0	125	5	0	5	0	0	25	17	2	50	0
Oriental Plover	230	0	0	0	0	0	0	0	0	0	0	0	1	0
Oriental Pratincole	2880	0	0	3	10	5	0	20	0	0	0	15	0	0
Pacific Golden Plover	120	0	20	11	0	12	0	0	10	0	2	1	4	6
Red Knot	110	0	0	100	25	15	20	1	60	6	0	5	4	0
Red-necked Stint	475	1000	0	2000	60	40	100	80	0	30	300	4000	200	0
Ruddy Turnstone	30	0	0	200	2	40	5	8	30	21	34	2	10	0
Sanderling	30	0	0	200	0	0	30	0	0	0	200	0	0	0
Sharp-tailed Sandpiper	85	0	0	0	0	12	3	0	40	40	0	0	0	30
Terek Sandpiper	50	0	0	0	0	1	2	1	10	10	30	0	50	0
Whimbrel	65	40	60	60	3	14	45	2	20	33	4	100	15	5

	National significance threshold	RB01	RB02	RB03	RB04	RB05	RB06	RB07	RB08	RB09	RB10	RB11	RB12	RB13
Total abundance	2,000 migratory shorebirds	2340	283	2962	240	260	240	132	443	416	1011	4000	8951	656
Total species richness	15 migratory shorebird species	4	7	17	13	15	15	12	15	13	14	13	17	5

Appendix 3. Maximum number of birds per kilometre of coastline of 22 migratory shorebird species that were recorded in Roebuck Bay Nature Reserve or Broome Peninsula study area from December 2019 to February 2020. Birds per km statistics for each site were based on the maximum abundance per species for each site. Birds per km for A1-4 combined and RB all sites combined are based on the maximum abundance per species for all sites across an entire single survey of Broome Peninsula sites and Roebuck Bay sites, respectively.

Species	Maximum birds per km of coastline							
	A0	A1	A2	A3	A4	A5	A1-4 combined	RB all sites combined
Bar-tailed Godwit	0	0	0	0	47.2	171.4	51.1	1,029.4
Black-tailed Godwit							0	212.8
Broad-billed Sandpiper							0	12.8
Common Greenshank	0	0	0	0	18.9	400.0	5.3	59.6
Common Sandpiper	2.2	23.5	11.1	6.3	9.4	78.6	10.6	1.3
Curlew Sandpiper	0	2.0	19.4	0	79.2	1,857.1	22.9	511.1
Far Eastern Curlew							0	217.0
Great Knot	0	0	0	0	211.3	3,285.7	59.6	1,980.4
Greater Sand Plover	4.3	0	27.8	8.3	283.0	1,928.6	85.1	595.7
Grey Plover	1.4	5.9	5.6	0	56.6	0	16.0	37.9
Grey-tailed Tattler	0	2.0	27.8	79.2	528.3	1,235.7	148.9	174.5
Lesser Sand Plover	0.7	11.8	5.6	0.0	26.4	285.7	7.4	53.2
Oriental Plover							0	0.4
Oriental Pratincole							0	22.6
Pacific Golden Plover	1.4	2.0	11.1	4.2	37.7	7.1	12.8	13.2
Red Knot	0	7.8	0	0	75.5	0	21.3	97.0
Red-necked Stint	1.4	0	5.6	0	113.2	285.7	31.9	1,737.9
Ruddy Turnstone	5.0	45.1	41.7	68.8	47.2	114.3	59.0	85.1
Sanderling	10.1	2.0	47.2	0	0	0	23.4	170.2
Sharp-tailed Sandpiper	0	0	0.0	0	3.8	0	1.1	17.9
Terek Sandpiper	0	0	0	2.1	150.9	785.7	42.6	22.6
Whimbrel	1.4	2.0	2.8	8.3	11.3	121.4	6.9	76.6
All species	28.1	62.7	108.3	85.4	722.6	9,278.6	234.0	4,756.2

Appendix 4. Conservation significant migratory shorebirds listed under the EPBC Act, and terns included in the CAMBA, JAMBA and/or ROKAMBA bilateral shorebird agreements. All species included here are listed in international agreements (IA) and some species are listed as threatened: vulnerable (VU), endangered (EN) or critically endangered (CR).

Species Name		Cons. Code		Habitat	Likelihood of Occurrence	Suitable Habitat				Comments on likelihood in Study Area
Scientific	**Common**	**Cth**	**WA**			**Beach**	**Rock Outcrops**	**Dunes**	**Disturbed areas**	
Charadriiformes										
Actitis hypoleucos	Common Sandpiper	IA	IA	A non-breeding migrant to Australia, occupying a wide range of coastal or inland wetlands feeding on rocky or muddy shores. Often found around estuaries however can have a strong preference for rocky areas including rocky coastal shores or breakwaters. Do not favour open mudflats.	High	Y	Y	-	Y	Site contains suitable foraging, loafing and roosting areas.
Arenaria interpres	Ruddy Turnstone	IA	IA	Non-breeding migrant to Australia. Occurring in a wide range of habitats within Australia tending towards coastal regions including rocky shores, tidal pools, and open mudflats. Often roosting on beaches above the tide line, among rocks or other debris for shelter, or on rocky platforms.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Calidris acuminata	Sharp-tailed Sandpiper	IA	IA	A non-breeding migrant, Australia is used as an overwintering site for most of the world's population. They feed on exposed mud or in shallow water, foraging along the water's edge of brackish wetlands, across intertidal mudflats and around estuaries. Roost along the edges of wetlands, on open mud or among saltmarsh.	Moderate	Y	-	-	-	Site contains suitable foraging, and roosting areas.

Calidris alba	Sanderling	IA	IA	Non-breeding migrant to Australia. Almost always on the coast, usually on open beaches, sand bars, sand spits, and other areas exposed to waves. Forages among the waves on the shore's edge, running with the water movements. Sometimes among beach washed debris or kelp, often roosting on bare sand among clumps of debris for shelter.	High	Y	-	-	-	Site contains suitable foraging, loafing and roosting areas.
Calidris canutus	Red Knot	IA, EN	IA, EN	Non-breeding migrant to Australia found predominantly on the coast. Feeding on exposed intertidal mudflats and in soft substrate along water's edge of sandy beaches. May feed in nearby brackish estuaries or lagoons during high tides, but very rarely found in freshwater.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Calidris ferruginea	Curlew Sandpiper	IA, CR	IA, CR	A non-breeding migrant to Australia which prefers intertidal mudflats in more sheltered areas including bays, estuaries, lagoons. They also use non-tidal lakes and swamps near the coast. Foraging on both exposed wet mud and in shallow water.	High	-	-	-	-	Site contains suitable foraging, loafing and roosting areas.
Calidris melanotos	Pectoral Sandpiper	IA	IA,	A rare non-breeding austral summer migrant to Australia. A coastal or near-coastal species that is found along estuaries, saltmarshes, coastal lagoons and fresh to saline wetlands. Rarely on open mudflats, preferring shallow water or along edges of wetlands.	Low	-	-	-	-	Site contains possible roosting area for migrants, but species is more associated with freshwater.

Calidris ruficollis	Red-necked Stint	IA	IA	Non-breeding migrant and Australia's most common Palearctic shorebird. Widespread across all coastal regions, with sporadic inland records. Occurring on intertidal mudflats, lagoons, sand bars and wetlands mostly foraging on exposed wet mud or in very shallow water.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Calidris subminuta	Long-toed Stint	IA	IA	A regular summer visitor to Australia, preferring fresh or brackish water. Using a wide variety of shallow-water habitats including wetlands, river floodplains, muddy shorelines, ephemeral lakes, and lagoons.	Low	Y	Y	-	-	Site contains possible foraging or roosting area, but species is more associated with freshwater.
Calidris tenuirostris	Great Knot	IA, CR	IA, CR	Non-breeding migrant to Australia found on large intertidal mudflats and sandflats including inlets, estuaries, lagoons, and bays. They forage on bare soft substrate or in shallow water often following the receding tide line.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Charadrius dubius	Little Ringed Plover	IA	IA	A vagrant to Australia found on inland habitats such as the muddy shores of lakes, wetlands, and rivers. May also use grassy fields near water, and are occasionally seen on intertidal coastal areas, tidal creeks, estuaries, and mudflats.	Low	-	-	-	-	Site could host a migrant in transit however
Charadrius leschenaultii	Greater Sand Plover	IA, VU	IA, VU	A Non-breeding migrant to Australia and almost entirely coastal. Roosting on sand bars or beaches and can be found foraging on the bare, exposed areas of intertidal mudflats or sandflats.	High	Y	-	-	-	Site contains suitable foraging, loafing and roosting areas.

Charadrius mongolus	Lesser Sand Plover	IA, EN	IA, EN	Non-breeding migrant to Australia. Found on sheltered estuaries and bays that have intertidal mudflats or sandflats.	High	Y	-	-	-	Site contains suitable foraging, loafing and roosting areas.
Charadrius veredus	Oriental Plover	IA	IA	A Non-breeding visitor to Australia generally found inland, in arid and semi-arid zones, except for at migration times. Utilizing a wide variety of habitat including terrestrial wetlands, estuarine mudflats, claypans, sparsely vegetated plains and tidal mudflats and beaches.	Moderate	Y	-	-	-	Site contains beach and rocky areas that could host a migrant in transit.
Gallinago megala	Swinhoe's Snipe	IA	IA	A Non-breeding migrant to Australia, its distribution here is not well known. In Non-breeding regions occurring in dense rushes and grasses around the edges of fresh and brackish waters such as wetlands and marshes.	Low	-	-	-	-	Although sand area could be suitable for feeding it is unlikely due to exposure of site and lack of cover.
Gallinago stenura	Pin-tailed Snipe	IA	IA	An uncommon Non-breeding migrant to Australia, its distribution here is not well known. In non-breeding regions they tend occur in a wide variety of wetland habitats, foraging along the muddy shores of flooded fields, swamps, streams, and marshland.	Low	-	-	-	-	Although sand area could be suitable for feeding it is unlikely due to exposure of site and lack of cover.
Glareola maldivarum	Oriental Pratincole	IA	IA	Non-breeding migrant to Australia. Occurring on open ground, often near water. Suitable habitat is varied including flood plains, mudflats, coastal wetlands and other areas with sparse vegetation and open ground. Often using disturbed areas such as airports, parking lots and fields. They forage by hawking over open ground and wetlands.	High	Y	Y	-	Y	Site contains suitable foraging, loafing and roosting areas.

Tringa brevipes (formerly *Heteroscelus brevipes*)	Grey-tailed Tattler	IA	IA	Non-breeding migrant to Australia. Found on sheltered coasts with rocky areas that become exposed at low tide. Also use intertidal mudflats and estuaries, though they usually forage on hard intertidal substrates.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Limicola falcinellus	Broad-billed Sandpiper	IA	IA	A non-breeding migrant in Australia found predominantly in coastal regions. Feeds on exposed, soft intertidal mudflats, around the edges of coastal wetlands and on soft mud in estuaries and around mangroves. Roosting on sheltered sand or shell beaches.	High	Y	-	-	-	Site contains suitable foraging, loafing and roosting areas.
Limnodromus semipalmatus	Asian Dowitcher	IA	IA	Regular summer visitor to NW Australia in small numbers and a rare vagrant elsewhere. Occurring in sheltered coastal habitats with exposed mud or sand flats. These include estuaries, tidal creeks, and lagoons..	Moderate	Y	Y	-	-	Site contains beach and rocky areas that could host a migrant in transit but is not favoured habitat.
Limosa lapponica baueri	Bar-tailed Godwit (Western Alaskan *ssp*.)	IA, VU	IA, VU	Non-breeding migrant to Australia. They are mainly coastal, preferring large intertidal sandflats and sand bars, but also found on mudflats, inlets, coastal lagoons, and estuaries. The forage in soft substrate near the water's edge or in shallow water.	High	Y	-	-	-	Site contains suitable foraging roosting areas.
Limosa lapponica menzbieri	Bar-tailed Godwit (Northern Siberian *ssp*.)	IA, CR	IA, CR	Non-breeding migrant to Australia. Mainly coastal, preferring large intertidal sandflats and sand bars, but also found on mudflats, inlets, coastal lagoons, and estuaries. They forage in soft substrate near the water's edge or in shallow water.	High	Y	-	-	-	Site contains suitable foraging and roosting areas.

Limosa limosa	Black-tailed Godwit	IA	IA	Non-breeding migrant to Australia. In Australia predominantly coastal, usually found in sheltered lagoons, estuaries and bays with large intertidal mudflats and sandflats. Also known to frequent drying marshy wetlands or saltmarsh. Similar to Bar-tailed Godwit, they feed in soft mud and shallow waters.	High	Y	-	-	-	Site contains suitable foraging and roosting areas.
Numenius madagascariensis	Eastern Curlew	IA, CR	IA, CR	Non-breeding migrant to Australia they are found in coastal and near-coastal regions, usually in estuaries, lagoons, and inlets with large intertidal mudflats. Occasionally on coastal beaches and may also roost and forage on islets and rocky platforms.	High	Y	Y	-	-	Site contains suitable foraging and roosting areas.
Numenius minutus	Little Curlew	IA	IA	A regular non-breeding migrant to Australia. Prefer short grasslands, dry flood plains and open ground. They occasionally are found in dry saltmarshes or on mudflats or sandflats of sheltered estuaries or coastal swamps.	Moderate	Y	-	-	-	Site contains beach and rocky areas that could host a migrant in transit but is not favoured habitat.
Numenius phaeopus	Whimbrel	IA	IA	A regular non-breeding migrant to Australia found in coastal and near-coastal regions, usually in estuaries, harbours, and inlets with intertidal mudflats and possibly mangroves.	High	Y	Y	-	-	Site contains suitable foraging, and roosting areas.
Phalaropus lobatus	Red-necked Phalarope	IA	IA	Rare summer visitor to Australia. Infrequently encountered on coasts or in near-coastal wetlands, more often in pelagic waters outside of breeding season. Occasionally they visit coastal wetlands, lagoons, estuaries, and small pool or lakes.	Low	-	-	-	-	Not often on shore or close to shore when foraging. Could potentially roost on beach.

Philomachus pugnax	Ruff	IA	IA	A rare summer visitor to Australia they can be found in fresh, brackish, or saline wetlands. They forage along the exposed mudflat at the edges of the water or across stretches of exposed mud or shallow water.	Low	Y	-	-	-	Site contains possible foraging or roosting area, but species is more associated with freshwater.
Pluvialis fulva	Golden Plover (Pacific Golden Plover)	IA	IA	Uncommon non-breeding migrant to Australia. Found in coastal regions on sandy and rocky shores, saltmarsh, and intertidal mudflats. They forage along the edges of saline coastal wetlands and lagoons.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Pluvialis squatarola	Grey Plover	IA	IA	Common non-breeding migrant to Australia. Common in coastal regions they can be found along sandy and rocky coastal beaches, exposed reefs, sand bars, areas of intertidal mudflats and tidal pools. They also forage along the edges of saline wetlands and lagoons.	High	Y	Y	-	Y	Site contains suitable foraging, loafing and roosting areas.
Tringa glareola	Wood Sandpiper	IA	IA	Common non-breeding migrant to Australia they prefer fresh or brackish water. They use a wide variety of shallow-water habitats including wetlands, estuaries, muddy shorelines, ephemeral lakes, and lagoons.	Moderate	Y	Y	-	-	Site contains possible foraging or roosting area, but species is more associated with freshwater.
Tringa nebularia	Common Greenshank	IA	IA	Common non-breeding migrant to Australia they use a wide variety of including wetlands, estuaries, intertidal mudflats, muddy shorelines, ephemeral lakes, and lagoons. They forage predominantly on exposed mud or in shallow water over soft substrates.	High	Y	-	-	-	Site contains suitable foraging, loafing and roosting areas.

Tringa stagnatilis	Marsh Sandpiper	IA	IA	Non-breeding migrant to Australia. They predominantly feed on exposed mudflats and in soft substrate along water's edge. It occurs in both fresh and saline habitats but in some areas seems to have a preference to one. Forages in shallow intertidal and non-tidal water sources, in the soft mud of estuaries, lagoons and wetlands.	Moderate	Y	-	-	-	Site contains possible foraging or roosting area, but species is more associated with freshwater.
Tringa totanus	Common Redshank	IA	IA	Non-breeding migrant and vagrant to parts of Australia. During migrations they may visit inland flooded grasslands and the muddy shores of rivers and lake. On their wintering grounds they are largely coastal, frequenting tidal estuaries, mudflats, saltmarshes, both rocky and sandy beaches, and lagoons.	Moderate	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Xenus cinereus	Terek Sandpiper	IA	IA	Non-breeding migrant to Australia. On non-breeding grounds they usually feed on exposed mudflats or sand bars in open intertidal estuaries, saltmarsh creeks and coastal lagoons. During migration they may visit freshwater wetlands and lakes with muddy edges.	High	Y	-	-	-	Site contains suitable foraging, loafing and roosting areas.
Hydroprogne caspia	Caspian Tern	IA	IA	Resident breeder in Australia. They use a variety of habitats, both fresh and saline, including estuaries, wetlands, lakes, lagoons, and open coastal waters. They prefer clear waters as they forage by sight, and they use sand spits, beaches, or islands when roosting.	High	Y	Y		Y	Site contains suitable foraging, loafing and roosting areas.

Sterna hirundo	Common Tern	IA	IA	A non-breeding migrant to northern Australia and a vagrant further south, they are a coastal species. They occur in all marine zones but are more typical in offshore and pelagic regions, foraging in coastal waters. They roost on sand bars, intertidal sandy ocean beaches and lagoon shores.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Sternula albifrons	Little Tern	IA	IA	Both a resident breeder and migrant visitor to Australia, they are a coastal species. Occurring in many coastal environments including estuaries, lakes, bays, inlets, and lagoons, they tend not to venture far from shore. They forage in shallow waters of sheltered areas such as river mouths or lagoons, and roost on sand spits, islets, and sandy ocean beaches.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Gelochelideon nilotica	Gull-billed Tern	IA	IA	There are two subspecies: one a migratory non-breeder and the other a resident breeder. They occur in either fresh or saline water environments. They forage in shallow wetlands, lakes and lagoons, preferring ones with mudflats.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.
Thalasseus bergii	Greater Crested Tern (Crested tern)	IA	IA	Resident breeder in Australia. They use a wide variety of habitats, both fresh and saline, including estuaries, wetlands, lakes, and lagoons, particularly those with mudflats, tidal sand flats, or sand spits. Very often forage in open waters along the coast or around islands.	High	Y	Y	-	Y	Site contains suitable foraging, loafing and roosting areas.

Chlidonias leucopterus	White-winged Tern	IA	IA	Non-breeding migrant to Australia that occurs in coastal and near-coastal areas of both fresh and saline water. They forage aerially, hawking over water or the muddy edges of wetlands. They use sand spits, islets, banks, and rocks around the edge of wetlands to roost and loaf.	High	Y	Y	-	-	Site contains suitable foraging, loafing and roosting areas.

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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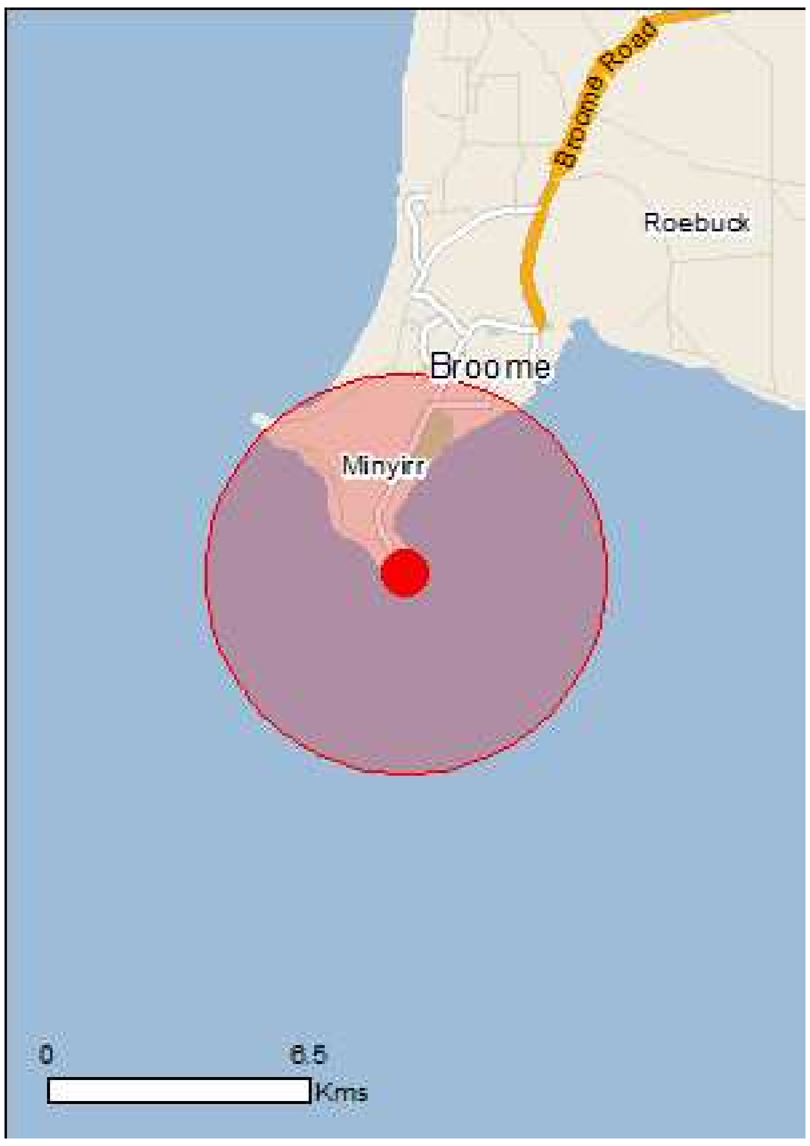

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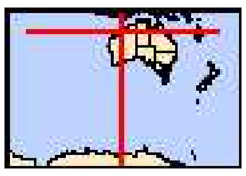

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	1
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	29
Listed Migratory Species:	65

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	104
Whales and Other Cetaceans:	12
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

National Heritage Properties [Resource Information]

Name	State	Status
Natural		
The West Kimberley	WA	Listed place

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Roebuck bay	Within 10km of Ramsar

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Monsoon vine thickets on the coastal sand dunes of Dampier Peninsula	Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Polytelis alexandrae Princess Parrot, Alexandra's Parrot [758]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Tyto novaehollandiae kimberli Masked Owl (northern) [26048]	Vulnerable	Species or species habitat may occur within area
Mammals		
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Macrotis lagotis Greater Bilby [282]	Vulnerable	Species or species habitat known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Saccolaimus saccolaimus nudicluniatus Bare-rumped Sheath-tailed Bat, Bare-rumped Sheathtail Bat [66889]	Vulnerable	Species or species habitat likely to occur within area
Plants		
Seringia exastia Fringed Fire-bush [88920]	Critically Endangered	Species or species habitat known to occur within area
Reptiles		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Sharks		
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Species or species

Name	Status	Type of Presence
		habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Sternula albifrons Little Tern [82849]		Foraging, feeding or related behaviour known to occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Dugong dugon Dugong [28]		Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta		Species or species habitat may occur within

Name	Threatened	Type of Presence
Ray [84994]		area
Manta birostris		
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Orcaella heinsohni		
Australian Snubfin Dolphin [81322]		Species or species habitat known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Pristis clavata		
Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis pristis		
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron		
Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Breeding known to occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may occur within area
Sousa chinensis		
Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Tursiops aduncus (Arafura/Timor Sea populations)		
Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Migratory Terrestrial Species		
Cecropis daurica		
Red-rumped Swallow [80610]		Species or species habitat may occur within area
Cuculus optatus		
Oriental Cuckoo, Horsfield's Cuckoo [86651]		Species or species habitat known to occur within area
Hirundo rustica		
Barn Swallow [662]		Species or species habitat known to occur within area
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat known to occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Arenaria interpres		
Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Roosting known to occur

Name	Threatened	Type of Presence
		within area
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area

Name	Threatened	Type of Presence
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Tringa brevipes Grey-tailed Tattler [851]		Roosting known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land - Defence - BROOME TRAINING DEPOT

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus Common Noddy [825]		Species or species habitat likely to occur within area
Anseranas semipalmata Magpie Goose [978]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Arenaria interpres Ruddy Turnstone [872]		Roosting known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting known to occur within area

Name	Threatened	Type of Presence
Calidris alba Sanderling [875]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris tenuirostris Great Knot [862]	Critically Endangered	Roosting known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat known to occur within area
Charadrius bicinctus Double-banded Plover [895]		Roosting known to occur within area
Charadrius leschenaultii Greater Sand Plover, Large Sand Plover [877]	Vulnerable	Roosting known to occur within area
Charadrius mongolus Lesser Sand Plover, Mongolian Plover [879]	Endangered	Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Roosting known to occur within area
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat known to occur within area
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat known to occur within area
Fregata minor Great Frigatebird, Greater Frigatebird [1013]		Species or species habitat known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Roosting known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Heteroscelus brevipes Grey-tailed Tattler [59311]		Roosting known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area

Name	Threatened	Type of Presence
Hirundo daurica Red-rumped Swallow [59480]		Species or species habitat may occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat known to occur within area
Limicola falcinellus Broad-billed Sandpiper [842]		Roosting known to occur within area
Limnodromus semipalmatus Asian Dowitcher [843]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Motacilla flava Yellow Wagtail [644]		Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting known to occur within area
Numenius phaeopus Whimbrel [849]		Roosting known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Papasula abbotti Abbott's Booby [59297]	Endangered	Species or species habitat may occur within area
Pluvialis fulva Pacific Golden Plover [25545]		Roosting known to occur within area
Pluvialis squatarola Grey Plover [865]		Roosting known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna albifrons Little Tern [813]		Foraging, feeding or related behaviour known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur

Name	Threatened	Type of Presence
		within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Tringa totanus Common Redshank, Redshank [835]		Roosting known to occur within area
Xenus cinereus Terek Sandpiper [59300]		Roosting known to occur within area
Fish		
Campichthys tricarinatus Three-keel Pipefish [66192]		Species or species habitat may occur within area
Choeroichthys brachysoma Pacific Short-bodied Pipefish, Short-bodied Pipefish [66194]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Corythoichthys flavofasciatus Reticulate Pipefish, Yellow-banded Pipefish, Network Pipefish [66200]		Species or species habitat may occur within area
Cosmocampus banneri Roughridge Pipefish [66206]		Species or species habitat may occur within area
Doryrhamphus excisus Bluestripe Pipefish, Indian Blue-stripe Pipefish, Pacific Blue-stripe Pipefish [66211]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area
Halicampus brocki Brock's Pipefish [66219]		Species or species habitat may occur within area
Halicampus grayi Mud Pipefish, Gray's Pipefish [66221]		Species or species habitat may occur within area
Halicampus nitidus Glittering Pipefish [66224]		Species or species habitat may occur within area
Halicampus spinirostris Spiny-snout Pipefish [66225]		Species or species habitat may occur within area
Haliichthys taeniophorus Ribboned Pipehorse, Ribboned Seadragon [66226]		Species or species habitat may occur within area
Hippichthys penicillus Beady Pipefish, Steep-nosed Pipefish [66231]		Species or species habitat may occur within area
Hippocampus histrix Spiny Seahorse, Thorny Seahorse [66236]		Species or species habitat may occur within area
Hippocampus kuda Spotted Seahorse, Yellow Seahorse [66237]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		Species or species habitat may occur within area
Hippocampus spinosissimus Hedgehog Seahorse [66239]		Species or species habitat may occur within area
Hippocampus trimaculatus Three-spot Seahorse, Low-crowned Seahorse, Flat-faced Seahorse [66720]		Species or species habitat may occur within area
Micrognathus micronotopterus Tidepool Pipefish [66255]		Species or species habitat may occur within area
Solegnathus hardwickii Pallid Pipehorse, Hardwick's Pipehorse [66272]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Solenostomus cyanopterus Robust Ghostpipefish, Blue-finned Ghost Pipefish, [66183]		Species or species habitat may occur within area
Syngnathoides biaculeatus Double-end Pipehorse, Double-ended Pipehorse, Alligator Pipefish [66279]		Species or species habitat may occur within area
Trachyrhamphus bicoarctatus Bentstick Pipefish, Bend Stick Pipefish, Short-tailed Pipefish [66280]		Species or species habitat may occur within area
Trachyrhamphus longirostris Straightstick Pipefish, Long-nosed Pipefish, Straight Stick Pipefish [66281]		Species or species habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Foraging, feeding or related behaviour known to occur within area
Reptiles		
Acalyptophis peronii Horned Seasnake [1114]		Species or species habitat may occur within area
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat likely to occur within area
Aipysurus duboisii Dubois' Seasnake [1116]		Species or species habitat may occur within area
Aipysurus eydouxii Spine-tailed Seasnake [1117]		Species or species habitat may occur within area
Aipysurus laevis Olive Seasnake [1120]		Species or species habitat may occur within area
Aipysurus tenuis Brown-lined Seasnake [1121]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area
Crocodylus porosus Salt-water Crocodile, Estuarine Crocodile [1774]		Species or species habitat likely to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Breeding likely to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Disteira major Olive-headed Seasnake [1124]		Species or species habitat may occur within area
Emydocephalus annulatus Turtle-headed Seasnake [1125]		Species or species habitat may occur within area
Ephalophis greyi North-western Mangrove Seasnake [1127]		Species or species habitat may occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding likely to occur within area
Hydrelaps darwiniensis Black-ringed Seasnake [1100]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis mcdowelli null [25926]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Lapemis hardwickii Spine-bellied Seasnake [1113]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
Pelamis platurus Yellow-bellied Seasnake [1091]		Species or species habitat may occur within area

Whales and other Cetaceans [Resource Information]

Name	Status	Type of Presence
Mammals		

Name	Status	Type of Presence
Balaenoptera edeni Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Delphinus delphis Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
Grampus griseus Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Breeding known to occur within area
Orcaella brevirostris Irrawaddy Dolphin [45]		Species or species habitat known to occur within area
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Breeding known to occur within area
Stenella attenuata Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
Tursiops aduncus Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
Tursiops aduncus (Arafura/Timor Sea populations) Spotted Bottlenose Dolphin (Arafura/Timor Sea populations) [78900]		Species or species habitat known to occur within area
Tursiops truncatus s. str. Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Sturnus vulgaris Common Starling [389]		Species or species habitat likely to occur within area
Frogs		
Rhinella marina Cane Toad [83218]		Species or species

Name	Status	Type of Presence
		habitat may occur within area
Mammals		
Canis lupus familiaris		
Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus		
Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Mus musculus		
House Mouse [120]		Species or species habitat likely to occur within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Plants		
Cenchrus ciliaris		
Buffel-grass, Black Buffel-grass [20213]		Species or species habitat likely to occur within area
Dolichandra unguis-cati		
Cat's Claw Vine, Yellow Trumpet Vine, Cat's Claw Creeper, Funnel Creeper [85119]		Species or species habitat likely to occur within area
Jatropha gossypifolia		
Cotton-leaved Physic-Nut, Bellyache Bush, Cotton-leaf Physic Nut, Cotton-leaf Jatropha, Black Physic Nut [7507]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area
Ramphotyphlops braminus		
Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat known to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-18.00726 122.20977

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

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Please feel free to provide feedback via the Contact Us page.

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