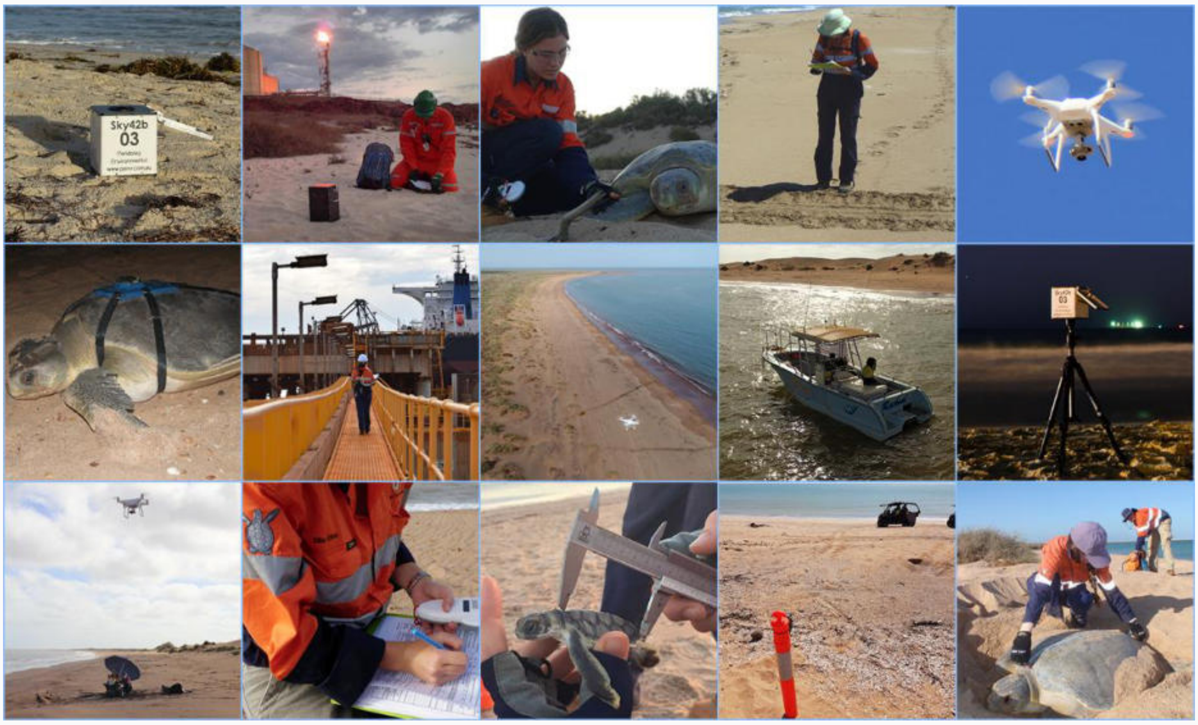
CARDNO, INC.

PERDAMAN UREA PROJECT: MARINE FAUNA DESKTOP ASSESSMENT



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1 Introduction

Perdaman Chemicals and Fertilisers Pty Ltd (Perdaman) plans to construct and operate a urea plant on Sites C and F within a Development Envelope in the Burrup Strategic Industrial Area (BSIA) on the Burrup Peninsula (Appendix 1). The urea product will be transported by closed conveyor from the plant to Dampier Port, where new urea export facilities will include storage shed, ship loader and conveyor. Environmental approvals for the conveyor, storage and loadout facilities will be the responsibility of Perdaman, Dampier Port Authority will be responsible for the shipping berths.

The Environmental Protection Authority (EPA) determined that the Perdaman Urea Project is to be assessed under Part IV of the Environmental Protection Act 1986 (EP Act). A referral under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), submitted to the Commonwealth Department of the Environment and Energy (DoEE), was deemed a controlled action (accredited assessment). Subsequently, an Environmental Review Document (ERD) is required to address matters of relevance for environmental impact assessment pursuant to both the EP Act and EPBC Act.

1.1 Objectives

As part of the ERD, consideration of impacts to marine fauna is required. The objectives of this report are to:

- Describe the marine fauna likely to be impacted by the Perdaman Urea Project, including identification of critical habitat and ecological windows for affected species.
- Assess the values and significance of marine fauna likely to be impacted by the Perdaman Urea Project in both a local and regional context.
- Quantify the likely direct, indirect and cumulative impacts to marine fauna in terms of the extent, duration and severity.
- Advise on proposed mitigation measures and monitoring strategies to avoid and/or minimise impacts on marine fauna.
- Advise on appropriate offsets in case residual impacts cannot be avoided, reduced, mitigated or subsequently restored.

Locations considered in scope include the Development Envelope (Appendix 1), coastal waters of the Dampier Archipelago and any regional island rookery assessed as at-risk.

2 POTENTIAL IMPACTS

The draft Perdaman Urea Project Environmental Scoping Document (Cardno, 2019) identifies introduction of marine pests, accidental discharges, underwater noise during construction and artificial light as potential impacts and risks to marine fauna from the Project. Activities that could result in introduction of marine pests, accidental discharges to the marine environment or underwater noise emissions are those associated with construction of shipping berths which are not within the scope of Perdaman's approvals and are not discussed further. Artificial light associated with the onshore facilities (production plant and port facilities) has the potential to impact marine fauna as described below.

2.1 Artificial Light

Artificial light at night can alter critical behaviours in wildlife. For some species, artificial lighting may extend diurnal or crepuscular behaviours by improving an animal's ability to forage (e.g. Hill 1990). For nocturnal species, artificial light can result in detrimental changes in behaviour.

2.1.1 Zooplankton

Diel vertical migration (DVM) is an omnipresent phenomenon in plankton communities whereby plankton migrate to surface waters at dusk and return to deeper waters at dawn (see Hays, 2003) for review). Although evidence has shown that DVM also occurs in the deep sea where no direct and background sunlight penetrates (van Haren & Compton, 2013), light levels in the water column are thought to be strong cues for DVM (Hays, 2003). These vertical migrations of zooplankton are integral to structuring pelagic communities since they influence the behaviour of predators (Hays, 2003). Gliwicz (1986) reports high predation of zooplankton by fish during nights when the full moon rose hours after sunset. While Gliwicz (1986) describes a natural occurrence, it is possible to infer that artificial light spill could attract predatory species and/or disrupt predator–prey interactions.

2.1.2 Fish

Behavioural responses of fish to artificial light have been demonstrated in various fish species (Marchesan et al. 2005). Aggregation of both small, shoaling fish, and large predatory fish, was detected in estuarine habitat in response to increased artificial lighting (Becker et al., 2013). Since many predatory fish rely on visual cues to locate and capture prey, increased light can lead to changes in predator-prey interactions. For example, the proportion of herring *Clupea harengus* feeding increased with prey density in high light intensity experiments, while under dark conditions, increased food availability failed to trigger a similar increased feeding response (Batty et al., 1990).

2.1.3 Marine Mammals

There is a paucity of research investigating the effects of artificial lighting on marine mammals and direct effects of artificial lighting on cetaceans and dugongs have not been reported. Many dolphin species are thought to be diurnal, or at least more active during the day, possibly related to prey availability (Sekiguchi & Kohshima 2003). Since fish species may pool in areas of light spill, dolphins may be indirectly attracted to lit structures or illuminated marine environments for foraging purposes.

As herbivores, dugongs will be less likely affected by artificial lighting influencing food availability. In addition, dugongs feed both diurnally and nocturnally depending on the region (Ichikawa et al. 2006), with feeding generally constrained by tidal range (Anderson & Birtles, 1978) rather than light availability. Research reporting direct effects of artificial lighting on dugongs is lacking.

Since mammals use variations in the length of day to anticipate environmental changes and time their reproduction, light pollution which affects day length perception could lead to changes in biological functions. However, the extent to which this occurs will be dependent on the fidelity of individuals and populations to an artificially lit area.

2.1.4 Marine Reptiles

2.1.4.1 Seasnakes

Documentation of the effects of artificial lighting on sea snakes is lacking. However, as active and intensive foragers, that display prolonged episodes (weeks) of continuous effort in search of prey (Bonnet, 2012), sea snakes may be attracted to well-lit areas around marine infrastructure due to the associated attraction of prey species.

2.1.4.2 Marine turtles

Adverse effects of artificial light on marine turtle behaviour is well recognised by a substantial body of research (see Withington and Martin, 2003; Lohmann et al., 1997; Salmon, 2003 for reviews). Artificial lighting can impact individuals at different stages of the life cycle, including nesting adult females and hatchlings.

Adult female marine turtles return to land, predominantly at night, to nest on sandy beaches, relying on visual cues to select, and orient on, nesting beaches. Artificial lighting on or near beaches has been shown to disrupt nesting behaviour (see Witherington and Martin, 2003 for review). Beaches with artificial light, such as urban developments, roadways and piers, often have lower densities of nesting females compared to beaches with less development (Salmon, 2003; Hu et al., 2018).

Hatchling turtles emerge from the nest, typically at night (Mrosovsky & Shettleworth, 1968), and must rapidly reach the ocean to avoid predation (Salmon 2003). Hatchlings locate the ocean using a combination of topographic and brightness cues, orienting towards the lower, brighter oceanic horizon, and away from elevated darkened silhouettes of dunes and/or vegetation behind the beach (Pendoley & Kamrowski, 2015; Lohmann et al 1997; Limpus & Kamrowski 2013).

Artificial lights interfere with natural light levels and silhouettes disrupting hatchling sea finding behaviour (Withington and Martin, 2003; Pendoley & Kamrowski, 2015; Kamrowski, et al., 2014). Hatchlings may become disorientated - where hatchlings crawl on circuitous paths; or misorientated - where they move in the wrong direction, possibly attracted to artificial lights (Withington and Martin, 2003; Lohmann et al., 1997; Salmon 2003). On land, movement of hatchlings in a direction other than the sea often leads to death from predation, exhaustion or dehydration.

Once in nearshore waters, artificial lights on land can also interfere with the dispersal of hatchlings. Lights can slow down their in-water dispersal (Witherington & Bjorndal, 1991; Wilson et al., 2018), increase their dispersion path or even attract hatchings back to shore (Truscott et al., 2017). In addition to interfering with swimming, artificial light can influence predation rates, with increased predation of hatchlings in areas with significant sky glow (Gyuris 1994; Pilcher et al 2000). Since the nearshore area tends to be predator-rich, hatchling survival may depend on them exiting this area rapidly (Gyuris, 1994). Should this be the case, aggregation of predatory fish occur in artificially lit areas (see Section 2.1.2 above) may further increase predation of hatchlings.

2.1.5 Birds

2.1.5.1 Seabirds

That seabirds are attracted to artificial light sources is well known, with reports of collisions with lighthouses extending as far back as 1880 (Allen, 1880) and exploitation by humans who used fire to attract seabirds to hunt them for food (Murphy, 1936). More recently artificial light associated with the rapid urbanisation of coastal areas has been linked to increased seabird mortality (Gineste et al., 2016) and today, 56 procellariform species worldwide are known to be impacted by artificial lighting (Rodríguez et al. 2017a; Rodríguez et al. 2017b).

Responses to lighting include collision, entrapment, stranding, grounding, disorientation or interference with navigation (being drawn off course from usual migration route) potentially resulting in injury and/or death. High rates of “fallout”, or the collision of birds with structures, has been reported in seabirds nesting adjacent to urban or developed areas (Montevecchi 1998; Rodríguez et al., 2017a). The degree of impact is mediated by a combination of physical, biological and environmental factors including the location, visibility, colour and intensity of the light, its proximity to other infrastructure, landscape topography, moon phase, atmospheric and weather conditions and the life stage of the bird.

Seabirds that are active at night while migrating, foraging or returning to colonies can be impacted directly. Indirect impacts to seabirds may arise from artificial light extending daytime activities of diurnal predators such as gulls, increasing predation risk and impacting colony attendance.

Among species with a nocturnal component to their life cycle, such as procellariforms (shearwaters, petrels and albatrosses), artificial light impacts adult and fledgling life-stages differently. Adult procellariforms are vulnerable to fall out or predation when returning to and leaving the nesting colony. A recent study shows artificial light disrupts adult nest attendance and thus affects weight gain in chicks (Cianchetti-Benedetti et al., 2018). Fledglings are more vulnerable to artificial light than adults due to the naivety of their first flight, the immature development of ganglions in the eye at fledging and the potential connection between light and food (Montevecchi, 2006; Mitkus et al., 2016). The bulk of the literature concerning impacts of lighting upon seabirds relate to the synchronised mass exodus of fledgling seabirds from their nesting sites (Deppe et al., 2017; Raine et al., 2007; Rodriguez et al., 2015a; Rodriguez et al., 2015b; Le Corre et al., 2002; Reed et al., 1985). For example, fledging procellariforms depart the nesting colony for the sea under the cover of darkness (Warham, 1990) which may increase vulnerability to impacts from artificial lighting (Reed et al., 1985). Artificial lights are thought to override the sea-finding cues provided by the moon and star light at the horizon (Telfer et al., 1987) and fledglings can be attracted back to onshore lights after reaching the sea (Podolsky, 1998; Rodriguez et al., 2014). It is possible that artificial lighting effects the ability of fledglings to imprint upon their natal colony, preventing them from returning to nest when they mature (Raine et al., 2007), with currently unknown consequences on the viability of a breeding seabird populations (Griesemer and Holmes, 2011).

2.1.5.2 Shorebirds

Artificial lighting has been shown to influence the nocturnal foraging behaviour in shorebirds. Santos et al. (2010) demonstrated improved foraging success by three species of plover and two species of sandpiper by exploiting sites where streetlights provided extra illumination. Similarly, Dwyer et al. (2013) showed artificial light generated from a large industrial site significantly altered the foraging strategy of common redshanks within an estuary. The greater nocturnal illumination of the estuary from the industrial site permitted common redshanks to forage for extended periods using a visual foraging strategy, which was deemed a more effective foraging behaviour when compared to tactile foraging (Dwyer et al., 2013).

However, artificial light may also act as a bird-deterrent. Rogers et al. (2006) suggested that nocturnal shorebird roost sites were selected with low exposure to artificial lighting (e.g. streetlights and traffic), and where the risk of predation is perceived to be low (Rogers et al., 2006). Additionally, the density of black-tailed godwit nests in wet grasslands has been reported to be significantly lower within 300 m of light sources (De Molenaar et al., 2000). Furthermore, the overall density of shorebirds in suitable foraging areas is expected to decline with increased distance to the nearest roost, due to the greater energetic cost travelling between areas (De Molenaar et al., 2000). The artificial illumination (or lack thereof) of nocturnal roost sites is therefore likely to significantly influence the abundance of shorebirds in nearby foraging areas.

3 MARINE FAUNA

EPBC listed threatened and/or migratory marine species within 10 km of the Dampier port location were identified via the Protected Matters Search Tool (DoEE, 2019a), and are summarised in Appendix 2.

Of the species identified, the potential impacts of artificial light on seasnakes, marine mammals, sharks and rays are expected to be limited to local aggregation only. Artificial light has the potential to impact turtle and marine bird behaviour, with implications on life-history processes. A such, the following species description and impact assessment is focussed on potential impacts of the Perdaman Urea Project on marine birds and turtles only.

3.1 Marine Birds

A number of listed threatened and/or migratory marine birds may occur in and around islands of the Dampier Archipelago (Appendix 2).

3.1.1 Seabirds

Several species of threatened and/or migratory seabird may occur in the waters of the Dampier Archipelago (Appendix 2). Some species, such as the streaked shearwater, are non-breeding visitors to Australian waters, for others, such as the southern giant petrel, lesser frigate bird and common noddy, breeding occurs in Australia but has not been recorded at the Dampier Archipelago. For these species, the waters of the Dampier Archipelago may provide foraging habitat during non-breeding periods or for juvenile birds yet to reach sexual maturation. Seasonality of likely presence in the Dampier Archipelago is summarised in Table 1.

Four seabird species, the wedge-tailed shearwater, Caspian tern, roseate tern and Australian fairy tern, are known to breed on islands of the Dampier Archipelago (Table 2). For all except the Caspian tern, the area has been recognised as Biologically Important Areas (BIAs) based on known breeding activity (DoEE, 2019).

The wedge-tailed shearwater is a common breeding visitor to the Pilbara (Johnstone et al., 2013), and has been recorded breeding on several islands of the Dampier Archipelago (Johnstone et al., 2013; CALM, 1990), the closest of which is Conzinc Island, 9 km from Dampier Port (Table 2; Figure 1). Adults are absent from their breeding colonies during the interbreeding period and return from their tropical Indian Ocean over-wintering grounds from late June onwards to re-excavate their burrows. This species is highly synchronous in timing of breeding; all eggs within a colony are laid within a ten-day period. They lay their single egg during early November, which is then incubated until the chick hatches (after 53 days) in early January. Once hatched, adults leave the burrows to forage locally during the day returning at night to feed chicks until they are ready to fledge in mid-April (Nicholson 2002; Table 1). Adults may not return to feed chicks each night; in Australia, wedge-tailed shearwater foraging trips have been recorded at 1 – 3 days (Rodney, 2006). Dual foraging strategies, whereby parents alternate or mix short and long trips, have been recorded in several shearwater species (sooty shearwaters (Weimerskirch, 1998), little shearwaters (Booth et al., 2000), Cory's shearwaters (Granadeiro et al., 1998; Magalhães et al., 2008), streaked shearwaters (Ochi et al., 2010), Manx shearwaters (Shoji et al 2015)). It is possible that wedge-tailed shearwaters breeding on the Dampier Archipelago also exhibit dual foraging strategies comprising short trips in local waters and longer trips at greater distances from the breeding colonies.

The Australian fairy tern has been recorded breeding at several islands of the Dampier Archipelago, the closest being Elphick Nob 20 km from Dampier Port (CALM, 1990; Table 2; Figure 1). Eggs are laid in late July to early Sept (Johnstone et al., 2013) and incubated for approximately 18 days (Higgins & Davies, 1996). Once hatched, chicks are guarded by at least one parent continually until approximately 14–15 days of age (Higgins & Davies, 1996). If breeding fails at one area, the birds will often move to new locations to attempt relaying within the same season (Higgins & Davies, 1996). Colonies tend to occupy areas rather than specific sites, and nest sites are often abandoned after one year, regardless of success (Saunders & de Rebeira, 1985). Australian fairy terns favour sheltered inshore waters and appear to be present around breeding sites throughout the year (Johnstone et al., 2013).

Caspian terns have been recorded breeding on several islands of the Dampier Archipelago (CALM, 1990), the closest being Conzinc Island, 9 km from Dampier Port (Table 2; Figure 1). The typical breeding season is shown in Table 1 (CALM, 1990). Following egg laying, incubation takes approximately 22 days, with chicks fledging after approximately 35 days (DoEE, 2019). Although the species may forage up to 60 km from their nesting site (DoEE, 2019), they favour sheltered seas, flooded coastal samphire flats, brackish pools on lower courses of rivers and saltwork ponds (Johnstone et al., 2013) and therefore are likely to forage in the vicinity of Dampier Port.

Roseate terns have been recorded breeding on Goodwyn Island, 22 km from Dampier Port (Higgins and Davies, 1996; Table 2; Figure 1). Little is known about movement patterns of roseate terns in Australia; they are known to move away from breeding colonies following breeding, but their non-breeding range is not well defined (Higgins & Davies, 1996). They are usually associated with coral reefs and may also forage around islands on the continental shelf. They are rarely recorded foraging in shallow sheltered inshore waters usually venturing into these areas only accidentally, when nesting islands are nearby (Higgins & Davies, 1996). It is possible that roseate terns will forage with waters of the Dampier Archipelago, though habitat preferences suggest they will not be as common as Caspian or Australian fairy terns described above.

3.1.2 Shorebirds

Australia is situated within the East Asian – Australian (EAA) Flyway, a geographic region supporting populations of migratory shorebirds throughout their annual cycle. Of the shorebirds identified in Appendix 2, all but one species (the Australian painted snipe) undertake annual migrations from breeding sites in the northern hemisphere to more southern non-breeding sites within the EAA Flyway (Bamford et al 2008). An approximate annual cycle for shorebirds in the EEA Flyway has been identified as: breeding (May to August); southward migration (August to November); non-breeding (December to February); and northward migration (March to May), although exact timing varies between species (Bamford et al., 2008). Migratory shorebird species are mostly present in Australia during the non-breeding period, in coastal and inland habitats where adult birds build up the energy reserves necessary to support northward migration and subsequent breeding (Commonwealth of Australia, 2017). Within the EEA Flyway, sites of international importance are identified as “a wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird” (Ramsar Convention

Bureau, 2000). The Dampier Saltworks, located ~8 km south of the Development Envelope (Figure 1), has been recognised as such as site for the oriental plover and curlew sandpiper (Bamford et al., 2008), the latter of which is listed critically endangered. The Dampier Saltworks has also been recorded supporting large numbers of sharp-tailed sandpiper and is recognised by BirdLife International as an Important Bird Area (BirdLife International, 2019).

The Australian painted snipe is the only shorebird listed in Appendix 2 that breeds in Australia. Females typically breed every two years (del Hoyo et al., 1996; Marchant & Higgins, 1993). The species has been recorded at wetlands in all states of Australia (Barrett et al., 2003; Blakers et al., 1984; Hall, 1910b), however, it is most common in eastern Australia, and there are no records of this species breeding within the Dampier Archipelago.

The coastal fringes of the Burrup Peninsula and Dampier Archipelago contain a range of intertidal habitats including sandy beaches, rocky beaches, sand and mudflats and shallow rock platforms, providing habitat for numerous migratory and resident shorebirds. Table 2 summarises the presence of threatened and/or migratory shorebirds within the Dampier Archipelago.

Table 1: Seasonal presence of seabirds, and other marine birds, in the Dampier Archipelago

<table>
<tr><th>Species</th><th>J</th><th>F</th><th>M</th><th>A</th><th>M</th><th>J</th><th>J</th><th>A</th><th>S</th><th>O</th><th>N</th><th>D</th></tr>
<tr><td>Osprey[1]</td><td colspan="4">Non-breeding presence</td><td colspan="6">Breeding known to occur</td><td colspan="2"></td></tr>
<tr><td>Fork tailed swift[2]</td><td colspan="3">Non-breeding presence</td><td colspan="6"></td><td colspan="3">Non-breeding presence</td></tr>
<tr><td>Australian fairy tern[1]</td><td colspan="7">Non-breeding presence</td><td colspan="4">Breeding known to occur</td><td></td></tr>
<tr><td>Southern giant petrel[3]</td><td colspan="2">Low level juvenile presence</td><td colspan="5">Low level juvenile and non-breeding adult presence</td><td colspan="5">Low level juvenile presence</td></tr>
<tr><td>Common noddy[1]</td><td colspan="12">Presence within water of the Dampier Archipelago</td></tr>
<tr><td>Wedge-tailed shearwater[1,7]</td><td colspan="4">Breeding known to occur</td><td colspan="5"></td><td colspan="3">Breeding known to occur</td></tr>
<tr><td>Streaked shearwater[4]</td><td colspan="5">Non-breeding presence</td><td colspan="2"></td><td colspan="5">Non-breeding presence</td></tr>
<tr><td>Lesser frigatebird[5]</td><td colspan="12">Non-breeding presence</td></tr>
<tr><td>Caspian tern[1]</td><td colspan="6">Non-breeding presence</td><td colspan="4">Breeding known to occur</td><td colspan="2"></td></tr>
<tr><td>Roseate tern[6]</td><td colspan="7"></td><td colspan="5">Breeding known to occur</td></tr>
<tr><td colspan="13">[1]CALM, 1990
[2]Higgins, 1999
[3]DSEWPAC (2011)
[4]Marchant, S & Higgins, PJ 1990b
[5]Commonwealth Australia, 2012
[6]Higgins & Davies, 1996
[7]Nicholson, 2002</td></tr>
</table>

Table 2: Sightings (s) and breeding (b) of EPBC listed threatened/migratory shorebirds and seabirds on islands of the Dampier Archipelago (CALM, 1990; BirdLife International, 2019; Higgins and Davies, 1996)

Island/ location	Dampier Saltworks	Angel Island	Brigadier Island	Cohen Island	Collier Rocks	Conzinc Island	Delambre Island	Dolphin Island	Eaglehawk Island	East Intercourse Island	Elphick Nob	Egret Island	Enderby Island	Gidley Island	Goodwyn Island	Hauy Island	High Point	Keast Island	Kendrew Island	Lady Nora Island	Legendre Island	Malus Island	Millers Rock	Nelson Rocks	Roly Rocks	Rosemary Island	West Lewis Island
Approx. distance to Dampier Port (km)	8	12	23	23	26	9	38	13	31	6	20	33	17	21	22	30	11	25	26	21	28	12	22	20	28	20	10
Shorebirds																											
Red Knot									s																		
Curlew sandpiper	s							s					s														
Greater sand plover								s												s		s					
Lesser sand plover								s					s			s				s						s	
Bar-tailed godwit		s						s	s																		
Common sandpiper								s					s														s
Ruddy turnstone		s		s		s	s	s	s	s	s		s			s		s	s	s			s			s	s

Island/ location	Dampier Saltworks	Angel Island	Brigadier Island	Cohen Island	Collier Rocks	Conzinc Island	Delambre Island	Dolphin Island	Eaglehawk Island	East Intercourse Island	Elphick Nob	Egret Island	Enderby Island	Gidley Island	Goodwyn Island	Hauy Island	High Point	Keast Island	Kendrew Island	Lady Nora Island	Legendre Island	Malus Island	Millers Rock	Nelson Rocks	Roly Rocks	Rosemary Island	West Lewis Island
Sharp-tailed sandpiper	s								s				s														
Red-necked stint								s																		s	
Oriental plover	s												s							s							
Whimbrel		s	s										s	s						s	s			s			
Grey plover								s	s																		
Grey-tailed tattler				s		s		s					s		s						s	s					
Seabirds																											
Australian fairy tern				s	s		s				b				b			s	b	s			s	s	s		
Wedge-tailed shearwater				b	b	b	b				b				b	b			b	b	b	b			b		
Caspian tern			s	b		b	s	s				b	b		s			b	s	b		s		s	s	b	s
Roseate tern								s					s		b												

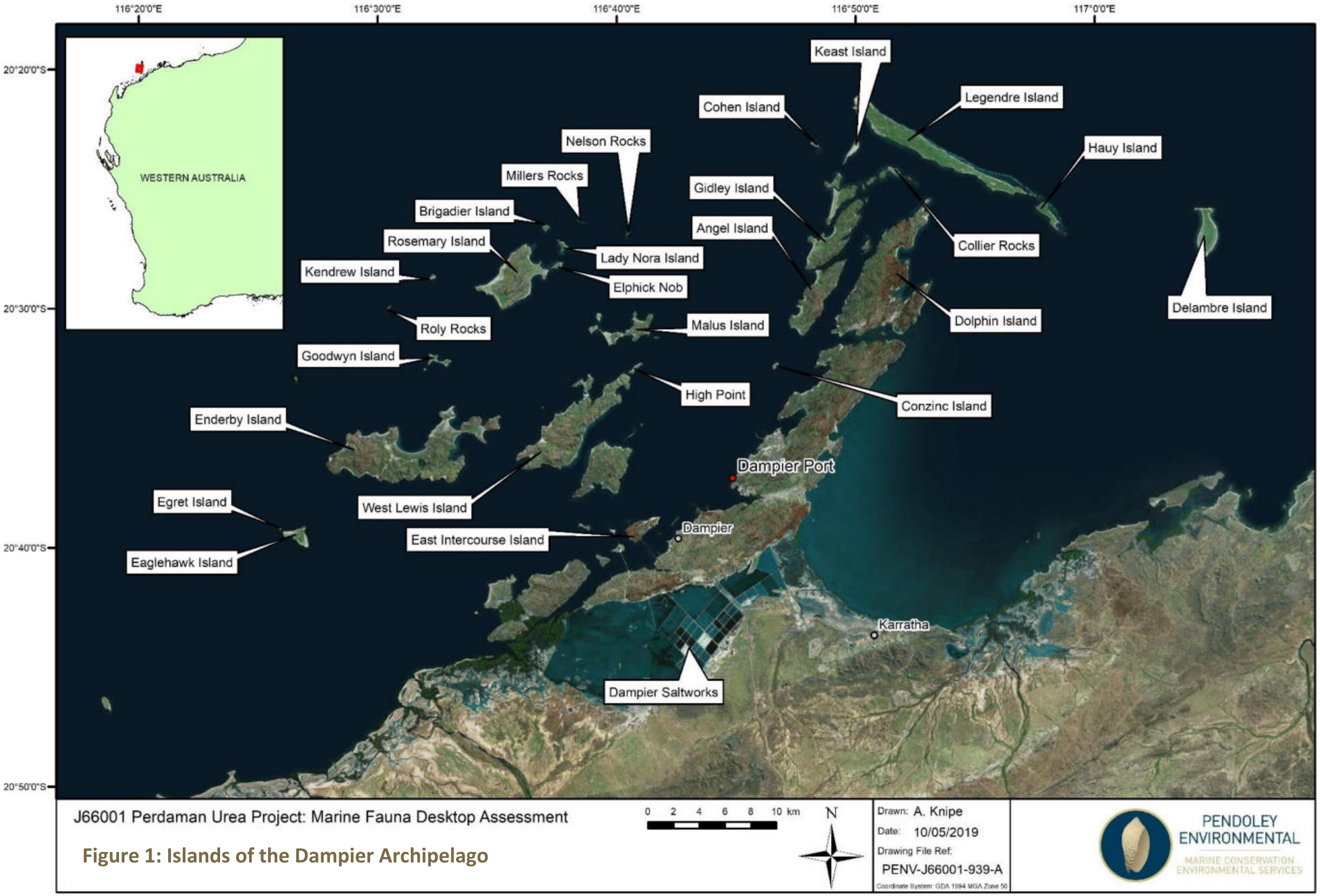

Figure 1: Islands of the Dampier Archipelago

3.2 Marine Turtles

All marine turtle species share a very similar life cycle pattern, including a breeding migration from foraging areas to mating and nesting areas. During the breeding period, males and females will migrate to the mating areas, which may or may not be close to the nesting beach (Miller 1997, Hamann et al., 2002) and typically demonstrate strong site fidelity, laying each of their clutches on the same beach or island. After mating, the males return to the foraging areas while the females will spend several months at the nesting area, laying multiple clutches of eggs. Between nesting, females will move to internesting areas. As capital breeders, marine turtles are understood to show inactive behaviour during the internesting period (the period between a successful clutch and the next nesting attempt) (Hays et al., 1999, Fossette et al., 2012), presumably to conserve energy for successive reproductive events (see Hays et al. 1999). Once the last clutch of eggs is laid, females will return to the foraging areas, building up their fat reserves before the next breeding migration. Most females will not nest in consecutive years (Miller, 1996). Flatback turtles have a slightly different life cycle to this generalised sea turtle life cycle, as they do not have an oceanic phase. Juveniles grow to maturity in shallow coastal waters, thought to be close to their natal beaches (Musick & Limpus, 1996). Parmenter (1994) and Whittock et al (2016) suggest flatback turtles engage in long distance migrations between feeding grounds and remote nesting beaches.

3.2.1 Mating, Nesting and Internesting Habitat in the Dampier Archipelago

Significant nesting and aggregation areas for marine turtles within the Dampier Archipelago were reported by CALM (2005) and identified as critical habitat in The Recovery Plan for Marine Turtles in Australia 2017-2027 (Commonwealth Australia, 2017).

Turtle nesting activity has been observed on a number of islands of the Dampier Archipelago, as summarised in Table 3 (CALM, 1990; Pendoley et al. 2016). Furthermore, turtle nesting has been recorded, albeit in low numbers, at two beaches on the Burrup Peninsular in close proximity to Dampier Port (Holden Beach and No Name Bay (Woodside, 2018)). Although Table 3 indicates loggerhead turtle nesting activity on Cohen Island (CALM, 1990), Pendoley et al (2016) did not find any evidence of loggerhead nesting activity in over 20 years of track data. The northern most key loggerhead nesting areas include the North West Cape and Muiron Islands and any nesting activity by loggerhead turtles in the Dampier Archipelago will not represent significant rookeries for this species. No major leatherback turtle rookeries are known to occur in Australia, with scattered nesting reported in Queensland (Limpus & MacLachlan 1979, 1994; Limpus et al. 1984b) and the Northern Territory (Hamann et al. 2006; Limpus & MacLachlan 1994) only.

Within the Dampier Archipelago, Rosemary Island, 20 km form Dampier Port, has the most significant nesting beaches, determined as mean number of hawksbill, green and flatback turtle tracks per day (Pendoley et al 2016) and is recognised as an internationally significant rookery for hawksbill turtles. Other islands that also had moderate nesting activity (11 – 100 tracks per day) for all three species, include Delambre Island, Enderby Island, Eaglehawk Island and Angel Island (Pendoley et al 2016), 38 km, 17 km, 31 km and 12 km from Dampier Port respectively. Delambre Island has been recognised as the largest flatback turtle rookery in Australia with an estimated 3500 nesting females per year (Chaloupka, 2018).

Although the body of literature describing marine turtle movement patterns during the breeding season is increasing, information specific to the Dampier Archipelago is more limited. Pendoley (2005) provides details of tracking data for green and hawksbill turtles nesting on Rosemary Island. Results suggested that nesting female hawksbill turtles remained within 1 km of nesting beaches on Rosemary Island (Pendoley, 2005). Female green turtles travelled greater distances, up to 5 km, but typically remained within shallow, nearshore waters between 0 and 10 m deep (Pendoley, 2005).

Studies on the movements of internesting flatback turtles nesting within the Dampier Archipelago are lacking. However, internesting movements have been investigated at Barrow Islands and mainland Australia. Compared to green and hawksbill turtles, flatback turtle internesting movements extend further offshore and up to 62 km from nesting beaches, primarily in a longshore direction or from islands towards the mainland (Whittock, Pendoley and Hamann, 2014). Other studies have showed flatback turtles travelled at least 26 km and up to 48 km in all directions from nesting beaches on the Lacepede Islands during internesting (Waayers et al. 2011). Given the distances travelled at other flatback turtle rookeries, it is possible that internesting females could occur anywhere in the waters of the Dampier Archipelgo.

3.2.2 Non-Breeding Habitat Use in the Dampier Archipelago

Non-breeding habitat use may include migratory pathways or foraging areas for loggerhead, green, hawksbill, leatherback and flatback turtles.

During non-breeding, green turtles typically occupy nearshore, coastal bays, feeding on seagrasses and macroalgae (Bjorndal, 1997; Bolten, 2003). They are herbivorous for the majority of their life history; however, post-hatching green turtles are omnivorous in their pelagic stage, and recent findings point to an oceanic diet including sea jellies for some populations (Arthur et al., 2008; Bolten, 2003). Flipper tagging data suggest WA waters are probable foraging grounds for green turtles that nest not only in WA, but also the Northern Territory and Indonesia (Prince, 1997). Flatback turtle foraging areas have been found to occur in waters shallower than 130 m and within 315 km of the shore, with many areas located in 50 m water depth and 66 km from shore (Whittock et al., 2016). Their main diet comprises algae, squid, invertebrates, and molluscs. Loggerheads feed on benthic invertebrates including molluscs and crustaceans (Shigenaka, 2003). Loggerhead turtles are a nearshore species who prefer warm, shallow continental shelves and coastal bays and estuaries (Shigenaka, 2003). Hawksbill turtles are the most tropical of all sea turtle species and are found within rock and reef habitats, coastal areas and lagoons. They are known to forage amongst vertical underwater cliffs, on coral reefs and on gorgonian (soft coral) flats, as well as seagrass or algae meadows (Bjorndal, 1996). Hawksbills feed primarily on sponges, but will also consume shrimp, squid, anemones, algae, seagrass, sea cucumber and soft corals (Bjorndal, 1996). Leatherback turtle diet is dominated by gelatinous organisms such as jellyfish, salps, squid and siphonophores (Bjorndal 1997) which influences their distribution (Leary, 1957; Lazell, 1980) both in the open ocean (Lazell, 1980) and close to shore (Hoffman & Fritts, 1982; Suarez, 2000).

Tracking data has highlighted the importance of the Dampier Archipelago for both green and hawksbill turtles on migration, though tracks indicted individuals stayed on the further most islands of the Archipelgo, and the eastern side of the Burrup Peninsular, rather than waters close to Dampier Port (Pendoley, 2005). The tracking data from Pendoley (2005) did not identify any foraging grounds for greens and hawksbills within the Dampier Archipelago. However, foraging aggregations of unidentified sea turtles during a mid-winter aerial marine fauna survey of the North West Shelf region were concentrated in warm shallow waters off the offshore islands (Prince et al., 2001). Since all marine turtle species identified in Appendix 2 can be found in shallow water habitats, it remains plausible that foraging individuals occur within the waters of the Dampier Archipelago.

Table 3: Records of nesting behaviour of EPBC listed marine turtles on islands of the Dampier Archipelago (CALM, 1990; Pendoley et al., 2016)

	Angel Island	Cohen Island	Delambre Island	Dolphin Island	Eaglehawk Island	Elphick Nob	Enderby Island	Goodwyn Island	Hauy Island	Keast Island	Lady Nora Island	Legendre Island	Malus Island	Rosemary Island	West Lewis Island
Approx. distance to Dampier Port (km)	**12**	**23**	**38**	**13**	**31**	**20**	**17**	**22**	**30**	**25**	**21**	**28**	**12**	**20**	**10**
Loggerhead turtle		x													
Green turtle	x	x	x	x	x		x	x	x	x	x	x	x	x	x
Hawksbill turtle	x		x	x	x	x	x	x					x	x	
Flatback turtle			x				x		x	x		x			

Table 4: Peak activity of nest females and emerging hatchlings of green, flatback and hawksbill turtles in the North West Shelf region.

Species	Activity	Jul		Aug		Sep		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
Green	Nesting								■	■	■	■	■	■	■	■	■								
	Emergence											■	■	■	■	■	■	■	■	■	■				
Hawksbill	Nesting				■	■	■	■	■	■	■	■	■	■	■										
	Emergence									■	■	■	■	■	■	■	■	■							
Flatback	Nesting									■	■	■	■	■	■	■	■	■							
	Emergence													■	■	■	■	■	■	■	■	■			

4 IMPACT ASSESSMENT

Artificial light has the potential to directly impact marine fauna including turtles, seabirds and shorebirds in the waters of the Dampier Archipelago. Potential impacts to relevant marine fauna (marine turtles, shorebirds and seabirds) are described in Section 2. In absence of lighting designs and/or modelling estimating the extent of potential light spill, the possibility that additional light associated with the Perdaman Urea Project port facilities resulting in direct light spill of the adjacent waters is credible. Depending on the positioning and height of light fixtures, light spill could occur at turtle nesting habitat at Holden Beach and No Name Bay. Existing development on the north shore of King Bay may already result in direct light spill onto the marine habitats. The Perdaman Urea Project may result in additional light spill from the east (Site C) and north (Site F), resulting in a cumulative increase in the extent and severity of light spill. In addition, the proposed location of Site C and F occur on currently undeveloped land increasing the overall area of development on the Burrup Peninsular, and consequently, the artificial light footprint.

Turtles are most at risk from impacts during nesting, hatchling emergence and at-sea dispersal. Low level turtle nesting has been recorded at Holden Beach and No Name Bay, ~0.5 – 1 km from the Development Envelope. Should additional light spill occur on these beaches, or an increase in glow occur on the horizon, nesting by females may be disrupted. Additionally, the presence of nesting females suggests that females and post-dispersal hatchlings will occur in waters subjected to potential direct light spill from the port facilities. This may lead to decreased hatchling survival due to disorientation at sea, entrapment and increased predation. Given the size of the nesting population at these beaches (Woodside, 2018), impacts are unlikely to result in population-level effects.

Fledgling seabirds and adults returning to colonies may also be attracted to the additional lighting, resulting in collision and potential injury of individuals, or in disruption of breeding and foraging behaviours, with consequences on breeding success. The closest known seabird breeding sites to Dampier Port occur on Conzinc Island (9 km from Dampier Port), where wedge-tailed shearwaters and Caspian terns have been recorded breeding. At this distance, impacts to fledglings making their first flight are unlikely to be significantly disorientated from light associated with the Perdaman Urea Project. However, adult birds are known to forage at greater distances from the nesting sites. Should artificial light effect foraging ability or result in injury or death, survival of chicks may be compromised.

Habitats in King Bay include mudflats and mangroves, which could be used by shorebirds for foraging and roosting, though evidence of this has not been recorded. Potential impacts of light spill on these marine habitats could include increased foraging through improved light conditions, or displacement from nocturnal nesting sites. Migrating shorebirds, flying over the area, may be attracted to the light from the port facilities, and Sites C and F, disorientating them away from key foraging and roosting grounds.

Artificial light associated with the port facilities of the Perdaman Urea Project may also effect fish and zooplankton (Section 2) leading to community level effects, indirectly impacting marine turtles, seabirds and shorebirds through changes in predator and/or prey distribution and abundance.

Considering the size and extent of the proposed Development Envelope, additional artificial light is unlikely to result in impacts over and above those occurring from the existing light sources at Dampier Port and across the Burrup Peninsular. However, the additional lighting will contribute to the overall light pollution levels in the Dampier Archipelago, although to what extent is difficult to quantify in absence of detailed lighting designs, including number, intensity and specification of lights proposed. As development increases, glow, as seen from islands potentially up to 20 km away, may become brighter and occupy a larger proportion of the horizon. Considered cumulatively, light glow from industrial development on the Burrup has potential to impact more significant marine turtle and seabird nesting sites on islands of the Dampier Archipelago.

4.1 Recommendations

The following recommendations would better inform the above impact assessment:

- Development of detailed lighting plans including descriptions of lighting designs, including number and specification of lights proposed to better understand the intensity and extent of biologically meaningful light on the surrounding area, taking into account natural topography.

5 MITIGATIVE AND OFFSET MEASURES

5.1 Mitigation Measures

Considering the outcomes of the impact assessment and recommendations, the following points should be considered in the development of preventative and mitigative control measures, with respect to lighting design and management:

- Light placement

Maintain any natural barriers (e.g. dune and/or vegetation screen) present between turtle nesting beaches (e.g. Holden Beach), seabird nesting sites and shorebird nocturnal foraging/roost areas (if present), and sources of artificial light. Maintaining a dark buffer zone between seabird nesting and shorebird nocturnal foraging/roost habitats (if present) and sources of artificial light, would reduce potential disturbance.

- Direction of lighting

Aim external light downwards onto the exact surface area requiring illumination. The use of shielding on lights to prevent vertical light spill upwards, reducing visibility to overflying migrating shorebirds, and outside the footprint of the target area away from nesting beaches and open water. In buildings, use window coverings to contain internal light.

- Light specifications

Avoid lights high in blue light, such as; metal halides, fluorescent, halogens, mercury vapour and most LEDs. Avoid white LEDs or only use LEDs filtered or manufactured to reduce the amount of short wavelength blue light. If possible, the use of intermittent lights, instead of fixed beam, should be considered.

- Lighting management plan

A lighting management plan should be developed for implementation during the operational phase of the project, ensuring that the above points are considered in ongoing operations and in any maintenance, repair or modification activities. Adaptive management controls should also be considered, for example, if grounded birds are encountered, implementation of a rescue plan has been shown to reduce mortality.

5.2 Offset Measures

To further our understanding of marine fauna habitat use in the Dampier Archipelago in areas of high industry presence, collaborative studies involving local industry operators and proponents, Government and research institutions could include:

- Light monitoring at islands throughout the Dampier Archipelgo to assess the relative visibility and scale of the night sky illuminated by light associated with industrial development on the Burrup Peninsula.

- Surveys to identify significant areas of nesting, foraging and/or roosting sites for seabirds and shorebirds on islands of the Dampier Archipelago to provide updated knowledge regarding distribution and abundance of listed marine bird species.
- Turtle satellite tracking studies to better understand habitat use of adult marine turtles during breeding and non-breeding within waters of the Dampier Archipelago, and interactions with industry.
- Hatchling orientation studies on regional Dampier Archipelago beaches to better understand the impact of existing industry lighting on hatchling sea finding from nesting beaches.
- Hatchling dispersal studies to better understand fate of hatchlings post-sea finding and interactions with industry.

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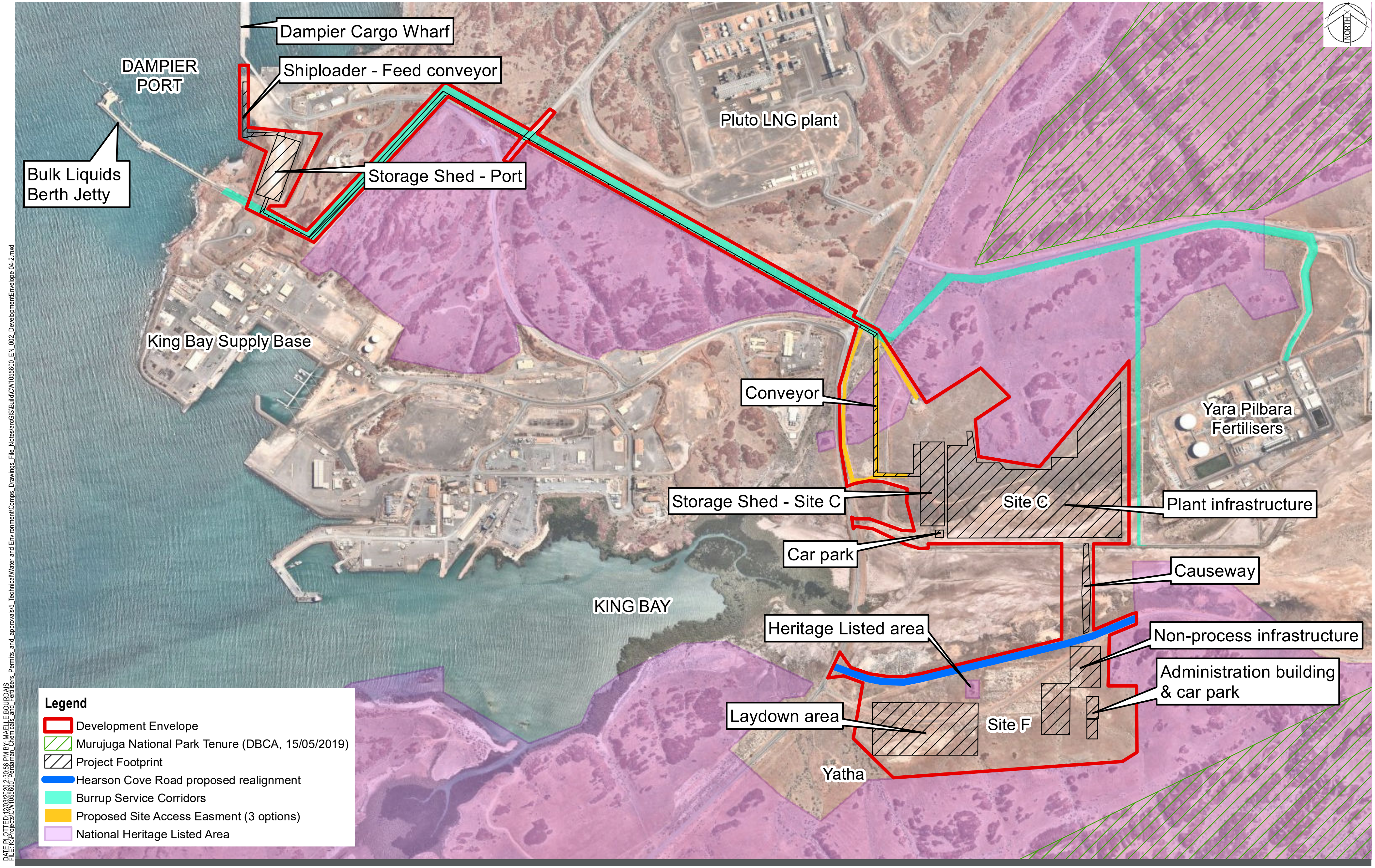
Appendix 1: Development Envelope for the Perdaman Urea Project



Date
12/03/2020

Size
A4

Scale
1:18,000

DEVELOPMENT ENVELOPE AND INDICATIVE INFRASTRUCTURE

PERDAMAN UREA PROJECT

FIGURE 2

CW1055600_EN_002_DEVELOPMENTENVELOPE 04-2

0 125 250 375 500m

Appendix 2: EPBC listed threatened and/or migratory marine species

Species	**Common name**	**Threatened**	**Migratory**
Shorebirds			
Calidris canutus	Red Knot	Endangered	y
Calidris ferruginea	Curlew sandpiper	Critically endangered	y
Calidris tenuirostris	Great knot	Critically endangered	y
Charadrius leschenaultii	Greater sand plover	Vulnerable	y
Charadrius mongolus	Lesser sand plover	Endangered	y
Limosa lapponica			
Limosa lapponica baueri	Bar-tailed godwit	Vulnerable	y
Limosa lapponica menzbieri		Critically endangered	
Numenius madagascariensis	Eastern curlew	Critically endangered	y
Rostratula australis	Australian painted snipe	Endangered	
Actitis hypoleucos	Common sandpiper		y
Arenaria interpres	Ruddy turnstone		y
Calidris acuminata	Sharp-tailed sandpiper		y
Calidris alba	Sanderling		y
Calidris melanotos	Pectoral sandpiper		y
Calidris ruficollis	Red-necked stint		y
Calidris subminuta	Long-toed stint		Y
Charadrius veredus	Oriental plover		y
Glareola maldivarum	Oriental pranticole		y
Limicola falcinellus	Broad-billed sanpiper		y
Limosa limosa	Black-tailed godwit		y

Species	Common name	Threatened	Migratory
Numenius phaeopus	Whimbrel		Y
Phalaropus lobatus	Red-necked phalarope		y
Pluvialis fulva	Pacific golden plover		y
Pluvialis squatarola	Grey plover		y
Tringa brevipes	Grey-tailed tattler		Y
Tringa nebularia	Common greenshank		y
Tringa stagnatilis	Marsh sandpiper		y
Tringa totanus	Common redshank		y
Xenus cinereus	Terek sandpiper		y
Seabirds			
Sternula nereis nereis	Australian fairy tern	Vulnerable	
Macronectes giganteus	Southern giant petrel	Endangered	y
Anous stolidus	Common noddy		y
Ardenna pacifica	Wedge-tailed shearwater		y
Calonectris leucomelas	Streaked shearwater		y
Fregata ariel	Lesser frigatebird		y
Hydroprogne caspia	Caspian tern		y
Sterna dougallii	Roseate tern		y
Other birds			
Apus pacificus	Fork-tailed swift		y
Pandion haliaetus	Osprey		y
Marine mammals			
Balaenoptera musculus	Blue whale	Endangered	y
Megaptera novaeangliae	Humpback whale	Vulnerable	y

Species	Common name	Threatened	Migratory
Balaenoptera edeni	Bryde's whale		y
Orcinus orca	Orca		y
Sousa chinensis	Indo-Pacific humpback dolphin		y
Tursiops aduncus	Spotted bottlenose dolphin		
Dugong dugon	Dugong		y
Marine reptiles			
Aipysurus apraefrontalis	Short-nosed seasnake	Critically endangered	
Caretta caretta	Loggerhead turtle	Endangered	y
Chelonia mydas	Green turtle	Vulnerable	y
Dermochelys coriacea	Leatherback turtle	Vulnerable	y
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	y
Natator depressus	Flatback turtle	Vulnerable	y
Sharks and rays			
Carcharias taurus	Grey nurse shark	Vulnerable	
Carcharodon carcharias	White shark	Vulnerable	y
Pristis clavata	Dwarf sawfish	Vulnerable	y
Pristis zijsron	Green sawfish	Vulnerable	y
Anoxypristis cuspidata	Narrow sawfish		y
Rhincodon typus	Whale shark	Vulnerable	y
Manta alfredi	Reef manta ray		y
Manta birostris	Giant manta ray		y