DEPARTMENT OF TRANSPORT

SPOILBANK MARINA PROPOSAL: REVIEW OF POTENTIAL IMPACTS TO FLATBACK TURTLES

Prepared by

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For

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1 INTRODUCTION

1.1 Background

The Department of Transport (DoT) and Landcorp are proposing to construct a marina on the western side of a man-made spoilbank in Port Hedland. The proposed marina, referred to herein as the Spoilbank Marina, is situated approximately 1.7 km west of Cemetery Beach which provides nesting habitat for a breeding population of female flatback turtles (*Natator depressus*). Flatback turtles are a threatened migratory species, listed as a 'matter of National Environmental Significance' under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, and listed as vulnerable under the State *Biodiversity Conservation Act 2016*.

The Spoilbank Marina is proposed to include a basin featuring berth facilities for up to 80 pens, a four lane boat ramp, an entrance channel, and internal revetment walls. There will also be an inner and outer breakwater, with the latter acting as a sand trap and extending further offshore. Construction will also involve a capital dredging program, requiring the extraction of approximately 900,000 m^3 of marine sediment.

Due to the proximity of the proposed Spoilbank Marina to the flatback turtle nesting habitat at Cemetery Beach, the DoT have engaged Pendoley Environmental as subject matter experts, to provide advice on the Spoilbank Marina's potential to significantly impact the flatback turtle population at Port Hedland. This information will be used by the DoT to inform their preliminary assessment of the significance of impacts associated with the proposed action, in accordance with Matters of National Environmental Significance Significant Impact *Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999* (the Guidelines).

1.2 Scope of Work and Objectives

The scope of works and objectives includes:

- Review current literature on the biology and ecology of the flatback turtle population at Port Hedland.
- Consider potential pathways for a significant impact to the population from construction and operational activities associated with the Spoilbank Marina.
- Provide expert opinion on the assumption that the Spoilbank Marina has the potential to significantly impact the population of flatback turtles at Port Hedland.
- Outline monitoring survey work and/or management actions that could be implemented to mitigate any potential impacts to the flatback turtle population to an acceptable level that meets State and Commonwealth environmental objectives.

2 LITERATURE REVIEW: FLATBACK TURTLES AT PORT HEDLAND

2.1 Regional Setting of the Flatback Turtle Population

The breeding population of flatback turtles at Port Hedland is part of the Pilbara Coast genetic stock which also includes the populations at Barrow Island, Delambre Island, Montebello Islands, and Mundabullangana (Pittard 2010; FitzSimmons et al. *in prep*). The genetic stock is within the South East Indian Ocean Regional Management Unit (RMU) boundary, one of two RMU's recognised by the IUCN Marine Turtle Specialist Group for flatback turtles globally (Wallace et al. 2010).

Female flatback turtles will utilise habitat at two beaches in Port Hedland for nesting purposes; Cemetery Beach and Pretty Pool Beach. Based on capture-mark-recapture (CMR) field survey methods (i.e. tagging), the annual nester abundance of flatback turtles seen at Cemetery Beach between 2009/10 and 2013/14 ranged from 148 to 202 individuals (Pendoley et al. 2014; Waayers & Stubbs 2016). Based on track census data and an overnight count of successful nests, the estimated annual nester abundance at Pretty Pool Beach between 2005/06 and 2013/14 ranged from 31 to 222 individuals (Waayers & Stubbs 2016). In context with the size of other breeding populations within the same genetic stock, this places the overall Port Hedland population at the lower end of the scale (estimated annual nester abundance at Barrow Island and Mundabullangana in 2017 was 1,844 and 2,017, respectively; Chevron Australia 2018).

The footprint of the Spoilbank Marina overlaps with a biologically important area (BIA) for inter-nesting flatback turtles and is situated to the west of a BIA for breeding flatback turtles (situated offshore from Cemetery Beach). A BIA is a region where aggregations of individuals of a particular species are known or likely to display important behaviours.

2.2 Adult Flatback Turtles

2.2.1 Nesting Activity

Cemetery Beach is situated closest to the Spoilbank Marina, approximately 1.7 km to the east of the proposed development. Pretty Pool Beach is situated further east than Cemetery Beach, approximately 6 km from the proposed development. Note that due to the extended distance of Pretty Pool Beach from the Spoilbank Marina, there is no further consideration of the development's potential impact to adult and hatchling flatback turtles while nesting/hatching at this beach. There are no other records of flatback turtle nesting activity at other beaches within Port Hedland (including the area on the western side of the man-made spoilbank).

Nesting activities occur at Cemetery Beach from mid-October onwards and continues until January, with some seasons extending to late February on occasion (Waayers & Stubbs 2016). Nesting occurs across the entire 1 km length of Cemetery Beach and the highest nesting density is located at the eastern end of the beach.

The duration between a flatback turtle laying successive nests (i.e. the inter-nesting period) at Cemetery Beach has been recorded using satellite tracking data as 12.0 ± 1.9 days (range = 10 – 18, n = 27; Whittock et al. 2014) and using CMR data as 12.7 ± 1.5 days (n = 104; Waayers & Stubbs 2016). It is unknown how many times an individual will nest at Cemetery Beach during a single season.

2.2.2 Offshore Activity

2.2.2.1 Mating

Based on the timing of nesting activities at Cemetery Beach, mating activities for Port Hedland flatback turtles are likely to occur from September onwards and may continue throughout the nesting season (i.e. until January). When mating, male and female flatback turtles aggregate within their mating grounds (Godley et al. 2003). Satellite tracking of one female flatback turtle from Cemetery Beach, Port Hedland in 2009, indicated that a mating ground for the breeding population is situated approximately 7 km offshore, in an area 33 km north-west of Port Hedland (Whittock & Pendoley 2013). There are no known anecdotal records of observed flatback mating activities within the vicinity of the Spoilbank Marina.

2.2.2.2 Inter-nesting

When inter-nesting, female flatbacks are likely to aggregate offshore from their nesting habitat (Godley et al. 2003). Inter-nesting activities are likely to occur during the same period of nesting at Cemetery Beach i.e. mid-October to January/February.

Satellite tracking and time-depth recorder units attached to nesting flatback turtles at Cemetery Beach revealed that, during their inter-nesting period, they travelled a mean total distance of 57.6 ± 37.2 km (range = 14.4 – 145.8, *n* = 27) and reached a maximum displacement distance from the beach of 22.9 ± 16.4 km (range = 3.4 – 56.6, *n* = 27) before returning to lay a subsequent nest (Whittock et al. 2014). During their inter-nesting period, the majority of tracked turtles were identified as remaining close to Port Hedland (<10 km), utilising areas immediately offshore and north-east from Cemetery Beach. There were limited westerly movements of inter-nesting flatback turtles from Cemetery Beach, with no flatback turtles moving to the immediate offshore area on the western side of the spoilbank. Of those turtles that did move further west of the spoilbank, their closest offshore position to the Spoilbank Marina was situated 3 km to the north of the proposed development (see Pendoley Environmental 2010 and Whittock et al. 2014).

When situated offshore, inter-nesting flatback turtles spent the majority of their time diving (>2 m depth; 68.5 %) with the remainder of their time spent at the surface (<2 m depth; 31.5 %) (Pendoley Environmental 2010). The majority of their individual dives were <15 minutes in duration (75.0 %), with no dive exceeding a duration of 60 minutes. The tracked flatback turtles spent 85 % of their time in water that was <20 m deep and no dive exceeded a depth of 30 m. The maximum dive depth showed a very similar pattern to the time spent at depth, indicating that when the flatback turtles dived, they generally dived to the maximum depth (i.e. to the seabed) and remained close to the seabed for the duration of the dive. This is consistent with what has been documented elsewhere for other breeding populations within the genetic stock, including at Barrow Island (Whittock et al. 2017).

2.2.2.3 Foraging

Following the completion of nesting activities for the season, the breeding population will migrate distances of up to 2,511 km away from Port Hedland to their foraging grounds situated in the Kimberly region, and the Gulf of Carpentaria within Queensland state waters (Whittock et al. 2016).

2.3 Hatchling Flatback Turtles

2.3.1 Productivity

Within each nest at Cemetery Beach, flatback turtles will lay approximately 46.6 ± 9.4 eggs (range = 8 – 67, *n* = 83; Pendoley et al. 2014). The eggs will incubate for a period of approximately 46.0 ± 0.5 days (range = 40 – 50, *n* = 36) before hatching (Pendoley et al. 2014). The hatch success of eggs within each nest at Cemetery Beach has been found to be relatively low in comparison to other breeding sites within the same genetic stock. For example, the hatch success at Cemetery Beach was recorded as 57.3 ± 29.6 % (range = 2 – 97, *n* = 62) between 2010/11 and 2011/12 (Pendoley et al. 2014). In comparison, at Barrow Island a higher hatch success of 83.4 ± 19.3 % (range = 2 – 100, *n* = 254) has been recorded. The lower hatch success at Cemetery Beach is considered to be due to the higher natural sand temperature experienced during incubation compared to the more southerly populations within the genetic stock (Pendoley et al. 2014).

2.3.2 Behaviour

2.3.2.1 Onshore

The flatback turtle hatching season at Cemetery Beach occurs between December and March. Following hatching, hatchling flatback turtles will use a range of visual cues to find the sea (Salmon et al. 1992). Hatchlings visualise light over a low broad area (Lohmann et al. 1997) and will crawl towards a lower brighter horizon (as occurs over the ocean) and away from a tall dark horizon (i.e. the dune) (Limpus & Kamrowski 2013; Pendoley & Kamrowski 2015; Salmon et al. 1992). This behaviour can be disrupted by artificial lights interfering with the natural lighting and silhouettes on a nesting beach, reducing their ability to find the sea and potentially resulting in their mortality from exhaustion, heat exposure, or increased exposure to predation (Salmon 2003; Tuxbury & Salmon 2005; Verheijen 1985; Witherington & Martin 2003).

At Cemetery Beach, the measurement of the angles of hatchling tracks on the beach towards the water (i.e. hatchling fan mapping) indicated that hatchlings in nearly half of the recorded fan maps were disoriented, potentially due to existing sources of artificial light visible at the beach (Waayers & Stubbs 2016).

2.3.2.2 Offshore

There is no published data that indicates where hatchling flatback turtles move to offshore once they leave Cemetery Beach. Based on offshore tracking data recorded for flatback hatchlings at other nesting beaches within the same genetic stock (Thevenard Island), hatchlings are likely to move in the same direction as nearshore tidal driven currents (Wilson et al. 2018). At Port Hedland, a very large tidal range of up to 6 m occurs and the maximum flood tide rate is approximately 1.5 knots. On a flood tide (i.e. incoming), the nearshore current flows in an easterly direction and on an ebb tide (i.e. outgoing), the nearshore current flows in a north-westerly direction.

3 PATHWAYS FOR A SIGNIFICANT IMPACT & POTENTIAL MANAGEMENT ACTIONS

The following considers the pathway for a significant impact to flatback turtles at Port Hedland from all components of the Spoilbank Marina construction and operational activities. Furthermore, where a likelihood of a significant impact to the species is identified (based on the significant impact criteria within the Guidelines), potential management measures are also outlined that could remove or minimise the impact as much as possible to an acceptable level.

3.1 Sources of Artificial Light

Direct, point source lighting (e.g. unshielded lights) and indirect 'skyglow', an accumulation of artificial light from multiple sources, have the potential to deter adult female turtles from nesting beaches and disorientate/misorientate hatchling turtles on the beach and at sea (Kamrowski et al. 2014; Salmon 2006; Salmon et al. 1995). Impacts are more likely to occur where lighting is enriched in short wavelength light (Witherington 1992). For adult turtles, lighting has to be relatively close to the nesting habitat for an impact to occur, whereas hatchling turtles are considered more sensitive to light, with impacts recorded at nesting habitat situated over 18 km away from a light source (Hodge et al. 2007).

Potential sources of light associated with the Spoilbank Marina include night-time onshore (e.g. task lighting, vehicles) and offshore (e.g. vessels) construction activities (assuming activities will occur at night), and during night-time operations of the marina and its associated amenities. The direction of artificial light sources associated with the Spoilbank Marina will be in a westerly direction when viewed from Cemetery Beach.

3.1.1 Adult Flatback Turtles

3.1.1.1 Onshore

Spoilbank Marina construction and operational activities will be a distance of ~1.7 km from the nesting habitat at Cemetery Beach. Over this distance, associated sources of artificial light are not considered bright enough to deter flatback turtle nesting activity at the beach. This assumption is supported by the ongoing nesting activity that has been documented at Cemetery Beach since monitoring commenced in 2004/05 (Waayers & Stubbs 2016), despite the presence of other sources of artificial light (including streetlights and buildings) that are situated closer to the nesting habitat compared to the Spoilbank Marina. Therefore, there is no pathway for a significant impact from sources of artificial light during construction or operations on adult flatback turtles situated onshore at Port Hedland.

3.1.1.2 Offshore

Little is known about the impact of artificial light on adult turtles when they are situated offshore. The lack of evidence of an effect of light is likely due to inter-nesting turtles resting on the seabed, physically removing them from the surface activity of where lighting may be present (K. Pendoley pers. ob). Some studies suggest that marine turtles might be attracted to lights when foraging, however inter-nesting flatback turtles are not considered to feed during the breeding season (Limpus et al. 2013) meaning they are unlikely to move to well-lit areas, and their foraging grounds are situated

away from Port Hedland. Therefore, there is no pathway for a significant impact from sources of artificial light during construction or operations of the Spoilbank Marina on adult flatback turtles situated offshore.

3.1.2 Hatchling Flatback Turtles

3.1.2.1 Onshore

The orientation of Cemetery Beach in relation to the ocean results in hatchlings traversing the beach in a northerly direction under natural conditions. The westerly direction of artificial light associated with the Spoilbank Marina when viewed from Cemetery Beach, and the low lying topography between the beach and development location, could result in lights being visible as point sources within the horizon view of hatchlings as they depart the beach. These visible lights could, therefore, influence their sea-finding ability, and hence lead to their disorientation and mortality.

The duration of construction activities is not anticipated to exceed more than one hatching season, meaning any impact to hatchling flatback turtles would be temporary. Therefore, despite construction lighting providing a pathway for an impact to hatchling flatback turtles situated onshore, the relatively short timeframe within the context of the long-lived flatback turtle species, means that it will not lead to a long-term decrease in the size of the flatback population. Therefore, there will be no significant impact to the overall population from artificial lights during construction.

In the case of operations, night-time lighting will have a permanent and ongoing presence during the hatching season which could lead to consistent annual mortality of hatchling turtles and, in the long-term, a potential decrease in the overall size of the population. **Therefore, artificial light during operations provides a pathway for a significant impact to the flatback turtle population at Port Hedland.**

3.1.2.2 Offshore

The predominant current direction within the nearshore environment of Cemetery Beach (see **Section 2.3.2.2**) will likely result in hatchlings moving offshore and away from any night-time construction or operational activities associated with the Spoilbank Marina. In the event that a hatchling turtle situated offshore was attracted to artificial light sources, the presence of the man-made spoilbank would act as a physical barrier and inhibit any further movement in a westerly direction. Furthermore, the spoilbank extends ~1.5 km offshore and if a hatchling was to move around it, it is very unlikely that it would be physically able to move in a southerly direction towards the Spoilbank Marina due to the presence of strong currents in this area (as seen for flatback turtles at other locations; Wilson et al. 2018). There is, however, some evidence that artificial light can attract hatchlings back to shore, and even re-emerge back on to the beach (see Truscott et al. 2017). If this impact were to occur, it would likely affect very few hatchlings and would not lead to a long-term decrease in the size of the population.

3.1.3 Potential Management Actions & Targeted Field Survey Work

The following potential management action would minimise or mitigate the risk of a significant impact of artificial light on the flatback turtle population during operations as much as possible to an acceptable level:

- **Implementation of a Lighting Management Plan (LMP):** The LMP should outline best practice guidance on the management of lighting including the colour of the light (e.g. minimising use of colour with short wavelengths), intensity of light type (e.g. consideration of lumen output), use of shielding to prevent upward or horizontal light spill (particularly in an easterly direction towards Cemetery Beach), keeping lights low to the ground where possible, and the use of smart controls such as motion sensors, timers, dimmers etc. The LMP should align with the draft *Commonwealth Light Pollution Guidelines for Wildlife – Including Marine Turtles, Seabirds and Migratory Shorebirds* (Department Environment and Energy, in review 2019).

- **Reshape spoilbank to include a vegetated dune on the eastern side of the development:** Increasing the height of the topography by placing a man-made vegetated dune on the spoilbank on the eastern side of the development would potentially shield the visibility of point sources of artificial light from the Spoilbank Marina when viewed from Cemetery Beach.

While there was no potential significant impact to the flatback turtle population identified during construction, the potential temporary impacts from artificial lighting to hatchling flatback turtles during construction could be removed if the following potential management action was implemented:

- **Avoidance of night-time construction activities between December and March:** This would remove any pathway for an impact to hatchling flatback turtles during construction.

The localised effectiveness of potential management actions in reducing the risk of impact to hatchling flatback turtles could be assessed through the monitoring of artificial light visible at Cemetery Beach and measuring indices of hatchling orientation. Indices of hatchling orientation could be captured via hatchling fan mapping methods or using repeated hatchling arena trials on the beach. An arena trial involves releasing flatback hatchlings in the middle of a circular arena (~10 m diameter) on the beach and recording the angle of each hatchling track at the point they depart the arena boundary (as per Bertolotti & Salmon 2005).

The design of a light/hatchling orientation monitoring survey could involve an initial 'benchmark' assessment, establishing the existing sources of artificial light that are visible on the horizon and current indices of hatchling orientation on the beach. The benchmark level of hatchling orientation could then be used to define a trigger level that, if exceeded following a repeated survey when the Spoilbank Marina is operational, would determine the effectiveness of the LMP and determine if a significant impact has occurred. Furthermore, a repeated artificial light survey would demonstrate the direct visibility of operational lighting from the Spoilbank Marina and potentially assist with diagnosing and resolving (e.g. via the revision of the LMP with additional management actions) any exceedance in hatchling orientation.

The management of artificial light within Port Hedland is an ongoing issue for some stakeholders and the contribution of light from the operation of the Spoilbank Marina to the cumulative regional skyglow is still likely to occur, regardless of the implementation of the proposed management actions. To counteract or offset this contribution to cumulative skyglow, other sources of artificial light such as street lights or building lights within the Port Hedland region that are within the control of DoT, could be managed by following similar guidance with the proposed LMP for the Spoilbank Marina. This

would provide an opportunity for enhancement of the local environment and potentially improve stakeholder engagement.

3.2 Offshore Dredging Activities

3.2.1 Adult Flatback Turtles

3.2.1.1 Inter-nesting

There is no evidence of inter-nesting flatback turtles utilising the area within the vicinity of the Spoilbank Marina. However, as observed in other areas offshore from nesting habitat where dredging activities have occurred (e.g. Barrow Island), flatback turtles may move from their existing inter-nesting habitat to the areas being actively dredged where they will remain close to the seabed and hence at risk of entrainment within the drag head (see Whittock et al. 2017). The movement to an active dredge area is hypothesised to be driven by a predatory avoidance response, with flatback turtles utilising the highly turbid waters to avoid detection by predators (i.e. salt water crocodile or tiger shark).

Reproductively active marine turtles are considered to contribute disproportionately to sustaining the overall population compared to non-reproductively-active turtles (Gerber & Heppell 2004; Heppell et al. 1999). **Therefore, due to the potential for aggregation of reproductively active flatback turtles within the active dredge area and subsequent risk of mortality from entrainment within the dredge vessel's drag head, there is a potential pathway for a significant impact from dredging activities to the flatback turtle population at Port Hedland.**

3.2.1.2 Mating and Foraging

The mating and foraging grounds of female flatback turtles at Port Hedland are situated away from the vicinity of the Spoilbank Marina. Therefore, there is no considered pathway for a significant impact from dredging activities when flatback turtles are utilising these habitat areas (considered critical habitat for the survival of the species).

3.2.2 Hatchling Turtles

Due to the predominant tidal current direction and flow velocity in relation to the location of nesting habitat, hatchling turtles are not likely to be in the vicinity of the Spoilbank Marina. Furthermore, they are not considered to be able to dive deeper than 1 m and are therefore not at any risk from entrainment within the dredge vessel's drag head (which is only operational when at the seabed).

3.2.3 Potential Management Actions & Targeted Field Survey Work

The following potential management action would minimise or mitigate the risk of dredge entrainment to inter-nesting flatback turtles as much as possible to an acceptable level:

- **Avoidance of offshore dredging activities between October and February:** Note that outside of this period, there would still be a risk from dredging activities to other marine turtle species and life phases (i.e. juveniles and sub-adults) that are potentially present in the area.

If dredging cannot be avoided between the months of October and February, the implementation of the following potential management actions would likely minimise the risk of dredge entrainment to inter-nesting flatback turtles as much as possible to an acceptable level. This assumption is based on the demonstrated effectiveness of these management actions for the Gorgon Gas Development dredging program, which involved a study that investigated the movement and mortality of flatback turtles before, during, and after the dredging program (see Whittock et al. 2017):

- **Implementation of a Dredge Management Plan (DMP):** The DMP should outline management measures for managing potential impacts to flatback turtles, including:
    - **The use of a qualified Marine Fauna Observer (MFO) on the dredge vessel:** The MFO could ensure that, in the event a flatback turtle is sighted in close proximity to the vessel (i.e. 0 – 100 m), all operations would cease for a period of 20 minutes and only commence if there is no further sighting of a flatback turtle during this time. This would ensure that if the turtle remains in close proximity, it will be resighted when it breaches the surface to breathe within this 20 minute period (75 % of all dives recorded by the satellite tracking units were <15 minutes in duration; see **Section 2.2.2.2**).
    - **Use of turtle disturbance devices such as chains:** Depending on the dredge vessel type and feasibility, chains could be used on the dredge vessel's drag head. This control measure is designed to create noise or vibration to 'startle' and disperse any flatback turtles away from the path of the drag head and thus minimise the risk of entrainment at the seabed.
    - **Operating procedures and methods for the detection, recording, and reporting of any marine turtle injury or mortality from dredging activities:** These procedures would be implemented by the MFO for reporting purposes. This would assist with assessing the effectiveness of the management measures and identify adaptive management options if they are not effective at minimising or removing the risk of entrainment.

3.3 Offshore Vessel Movements

3.3.1 Adult Flatback Turtles

Vessel movements can strike turtles leading to their injury or mortality. Adult flatback turtles are at greatest risk of strike from vessel movements when they are at- or near to, the surface, and when vessel travel speeds exceed 11 km/hr or 6 knots (turtles failed to completely avoid vessels travelling at this speed leaving them vulnerable to collision; Hazel et al. 2007; Hazel & Gyuris 2006). At Port Hedland, inter-nesting flatback turtles spent 31.5 % of their time at- or close to, the surface which places them at risk of vessel strike.

During construction of the Spoilbank Marina, offshore vessels will be assisting with, or undertaking, dredging activities and are likely to be slow moving i.e. <11 km/hr. These slower speeds substantially reduce the potential risk of vessel strike (as indicated in Hazel et al. 2007). During operations, flatback turtles are unlikely to be in the vicinity of the Spoilbank Marina, with their mating and foraging grounds situated away from the development, and inter-nesting habitat situated on the eastern side of the spoilbank, and further north offshore from Port Hedland. Therefore, there is no pathway for a

significant impact from vessel movements during construction or operation of the Spoilbank Marina on the flatback turtle population at Port Hedland.

3.3.2 Hatchling Turtles

Due to the predominant tidal current direction and flow velocity in relation to the location of the nesting habitat, hatchling turtles are not likely to be located in the vicinity of the Spoilbank Marina. Furthermore, their small size removes the risk of strike from vessels.

3.3.3 Potential Management Actions & Targeted Field Survey Work

During construction, potential management actions for reducing the risk of vessel strike to adult flatback turtles should align with the Port Hedland Port Authority Regulation 2001 guidance for controlling vessel speed i.e. *the vessel must not move at a speed that exceeds the maximum speed at which the vessel can be safely moved in the port*. Further restrictions may be considered including, placing a vessel speed restriction of 5 knots on smaller, faster vessels used to support dredging activities.

During operations, vessel speed restrictions should be considered for those vessels departing/arriving the Spoilbank Marina. Speed restrictions of 5 knots within the marina basin and channel would minimise the risk of vessel strike to flatback turtles and any other marine turtle species or life phases (i.e. juveniles or sub-adults).

3.4 Physical Footprint of Infrastructure

The onshore footprint of the infrastructure does not provide habitat utilised by the flatback turtle population for nesting activities. This is supported by the absence of any records of flatback turtle nesting activity on the western side of the man-made spoilbank and in the vicinity of the Spoilbank Marina footprint. Therefore, there is no pathway for a significant impact from construction of the Spoilbank Marina infrastructure on the flatback turtle population at Port Hedland.

Due to the location of the Spoilbank Marina on the western side of the man-made spoilbank, its distance from Cemetery Beach, and the limited extent of the breakwater offshore, the development is not considered large enough to interfere with any long-shore sediment drifts that supports the nesting habitat at Cemetery Beach.

3.5 Noise & Vibration

Little is known about the impact of underwater noise and vibration on marine turtles. Electro physical studies have indicated that the best hearing range for marine turtles is in the 100 to 700 Hz range (Popper et al. 2014).

During construction, underwater noise sources may include impulsive emissions such as pile driving activities during construction of the offshore breakwaters (or placement of rock revetment). Continuous noise emissions from vessel activity may occur throughout construction and operation.

Because of their rigid external anatomy, it is possible that sea turtles are highly protected from impulsive sound (Popper et al. 2014). Popper et al. (2014) provided injury thresholds of turtles to pile driving emissions at >207 dB re 1 µPa (PK) although no thresholds were provided for behavioural

disturbance. McCauley et al. (2003) and O'Hara & Wilcox (1990), reported behavioural responses of caged green and loggerhead turtles in response to impulsive noise between 166 and 176 dB re 1 µPa (SPL). Noise emissions from pile driving can exceed these thresholds depending on technical specification (e.g. pile diameter and hammer type) and substrate type (e.g. JASCO 2018). Should thresholds be exceeded during construction of the Spoilbank Marina, inter-nesting females could be disturbed or displaced. However, without understanding pile driving activities, including duration, **it is not possible to assess whether there is a potential pathway for significant impact from impulsive noise emissions associated with construction of the Spoilbank Marina infrastructure on the flatback turtle population at Port Hedland**.

Although marine turtle behavioural responses, including startle responses (abrupt movements, increase in swimming) and prolonged inactivity, have been documented in response to continuous, low frequency noise (Lenhardt et al. 1983, 1996; Lenhardt 1994), turtles have also been observed rapidly acclimating to regular, continuous noise (O'Hara & Wilcox 1990; Dickerson et al. 2004; Geraci & Aubin 1980; Whittock et al. 2017), with the response dependent on the distance from the sound source (Bartol et al. 1999). Impact thresholds for continuous noise emissions have not been defined, however, Popper et al. (2014) identified mortality or permanent injury as being low risk to marine turtles, and temporary threshold shifts is moderate close to the source (within tens of meters) only. It is considered that impacts to marine turtles from continuous noise during construction and operational activities will be a temporary behavioural response. Therefore, there is no pathway for a significant impact from vessel activities during construction and operation of the Spoilbank Marina on the flatback turtle population at Port Hedland.

3.5.1 Potential Management Actions & Targeted Field Survey Work

If pile driving activities are required during the construction of the Spoilbank Marina, the following potential management action would minimise the risk of disturbance or displacement of inter-nesting flatback turtles to an acceptable level:

- **Avoidance of pile driving activities between October and February:** Note that outside of this period, there would still be a risk from pile driving activities to other marine turtle species and life phases (i.e. juveniles and sub-adults) that are potentially present in the area.

If pile driving cannot be avoided between the months of October and February, the implementation of the following potential management action would allow further assessment of potential for significant impact:

- **Site-specific noise modelling:** Using technical specifications specific to the activity, noise emission levels, and distances from the source at which impact thresholds are exceeded, can be predicted.

4 CONCLUSION

The primary sources of potential significant impact from the Spoilbank Marina to the flatback turtle population at Port Hedland are from dredging activities during construction (impact to reproductively active flatback turtles), and artificial light during operations (impacts to hatchling flatback turtles). Both of these activities could lead to a long-term decrease in the size of the population.

With the proposed management actions in place, it is our opinion that the identified potential significant impacts could be removed entirely, or minimised as much as possible to an acceptable level. This opinion is formed based on published studies and guidance that demonstrates the effectiveness of the proposed management actions at removing or minimising the impact as much as possible. To further verify and assess the localised effectiveness of any implemented management actions at the Spoilbank Marina location, hatchling orientation and artificial light monitoring field surveys could be conducted prior to construction and during operations, and MFOs could be used to detect injury or mortality from dredging activities. The results of the field surveys and MFO records could then be used to apply any corrective adaptive management options to further improve their effectiveness at minimising the impact as much as possible.

Due to the known locations of mating, nesting, inter-nesting, and foraging habitats for the flatback turtle population, there are no activities associated with the Spoilbank Marina that could impact these areas of habitat (considered critical to the survival of the flatback population), their occupancy within their habitat, or fragment the population into two or more populations. Furthermore, activities would not modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species could decline.

There is no potential for the Spoilbank Marina activities to introduce disease that may cause the flatback turtle population to decline, or result in a harmful invasive species being established within the flatback turtle habitat.

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