Government of Western Australia
Department of Water and Environmental Regulation

Our ref: APP-0000421
Enquiries: Troy Sinclair, Ph 6364 6425

Adam Parker
Manager Project Approvals
Mineral Resources Limited
20 Walters Drive, OSBORNE PARK WA 6017

[redacted]

Dear [redacted]

MINISTERIAL STATEMENT 1204 – ASHBURTON INFRASTRUCTURE PROJECT – ARTIFICIAL LIGHT MANAGEMENT PLAN

Thank you for submitting the Ashburton Infrastructure Project – Artificial Light Management Plan, 5 March 2024, Rev 8, to the Department of Water and Environmental Regulation (DWER) on the 6 March 2024 for review.

I note the plan has been prepared to satisfy condition B3-4 of Ministerial Statement 1204 which states:

> B3-4 The proponent must update the Artificial Light Impact Assessment and Management Plan Revision 6, that satisfies the requirements of condition C5 and demonstrates how achievement of the marine fauna environmental objectives in condition B3-1(3) and condition B3-1(4) will be achieved and submit it to the CEO.

I am satisfied that the Ashburton Infrastructure Project – Artificial Light Management Plan, 5 March 2024, Rev 8, meets the requirements of condition B3-4 of Ministerial Statement 1204, and that the proponent must now implement the provisions of the Management Plan as required by condition C2-1.

Please note the requirements of condition C2-6 that the plan must now be made publicly available.

[redacted]

A/Manager
Infrastructure Branch
for the Chief Executive Officer under authorisation dated 7 October 2022

7 March 2024

ASHBURTON INFRASTRUCTURE PROJECT: ONSLOW, WA

ARTIFICIAL LIGHT MANAGEMENT PLAN

5 MARCH 2024

REVISION 8

MS STATEMENT NO.: 1204

EPBC NUMBER: 2021/9064

ONSLOW INFRACO
ABN: 56 612 668 201

DOCUMENT INFORMATION

[redacted]

[redacted]

Revision History and Document Review

Rev	Issue Date	Prepared by	Reviewed By	Approved By	Document Purpose
6	26/10/2022	Pendoley Environmental	Sarah Osborne	Adam Parker	Final for Approval by DCCEEW and DWER
7 (0)	19/12/2023	Pendoley Environmental / MinRes	Sarah Osborne, Adam Cross, Luke Calvert	Adam Parker	Revised ALMP for review and confirmation by DWER review and approval by DCCEEW
8	29/02/2023	Pendoley Environmental / MinRes	Sarah Osborne, Adam Cross, Luke Calvert	Adam Parker	Revised ALMP addressing DWER review comments for confirmation and review and approval by DCCEEW

Declaration of Accuracy

In making this declaration, I am aware that section 491 of the E*nvironment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) makes it an offence in certain circumstances to knowingly provide false or misleading information or documents to specified persons who are known to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth). The offence is punishable on conviction by imprisonment or a fine, or both. I am authorised to bind the approval holder to this declaration and that I have no knowledge of that authorisation being revoked at the time of making this declaration.

Signed:	
Full name:	[redacted]
Organisation:	Mineral Resource Limited
Date:	29/02/2024

Approvals

Version	Approval Requirements and Regulatory Agency	Approved by	Date
6	Ashburton Infrastructure Project, Appendix G - Artificial Light Impact and Assessment and Management Plan (ALMP), Revision 6, J88001	DCCEEW	12/12/2022
8	Updated of ALMP V6 as required under Condition B4-3 of MS 1204 (DWER) including Response to DWER comments on ALMP V7	DWER	TBC
8	Revised ALMP V6 as required under Conditions 40 and 41 of EPBC: 2021/9064 (DCCEEW) including Response to DWER comments on ALMP V7	DCCEEW	TBC

Acknowledgement of Country

MinRes is committed to reconciliation and recognises and respects the significance of Aboriginal and Torres Strait Islander peoples' communities, cultures, and histories. MinRes acknowledges and respects Aboriginal and Torres Strait Islander peoples as the traditional custodians of the land.

EXECUTIVE SUMMARY

This Artificial Light Management Plan (**ALMP**) has been prepared to outline Mineral Resource's (**MinRes**; **the Proponent**) approach to managing artificial light impacts to marine turtle, seabirds and migratory shorebirds as per **Table ES-1** for the Ashburton Infrastructure Project (**AIP**, **the Project**).

The ALMP has been developed to meet the requirements of the State 'Instructions on how to prepare *Environmental Protection Act 1986* (**EP Act**) Part IV Environmental Management Plans' (EPA 2021) and the Commonwealth requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**), Environmental Management Plan (**EMP**) Guidelines (Commonwealth of Australia 2014).

The AIP was assessed by the Department of Climate Change, Energy, the Environment and Water (**DCCEEW**) and approved under the EPBC Act on 12 December 2022 via EPBC: 2021/9046. It was assessed by the Western Australian (**WA**) Department of Water and Environmental Regulation (**DWER**) and Environmental Protection Authority (**EPA**) and approved under the EP Act on 3 July 2023 via Ministerial Statement (**MS**) 1204.

This Version (7) of the ALMP has been developed to meet Condition B3-4 (MS1204), and incorporates responses to comments from DWER and Department of Biodiversity, Conservation and Attractions (**DCBA**) received 5 September 2023 on a *Baseline Adult Turtle and Benchmark Hatchling Turtle Orientation: Trigger and Threshold Criteria Memo* (PENV 2023c) prepared to support ALMP Version 6 (*Artificial Light Impact and Assessment and Management Plan (ALMP), Revision 6, J88001*) (approved by DCCEEW on 12 December 2022). A key recommendation from DWER was that the *Trigger and Threshold Criteria Memo* and ALMP (V6) be combined and restructured, to meet the requirements of EPA's (2021) *How to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans - Instructions*.

This ALMP provides a combination of an objective and outcome-based approach to manage potential significant impacts on listed marine fauna arising from Project artificial lighting. Outcome-based provisions are applied where an achievable and measurable environmental outcome can be established (EPA 2021). Objective-based provisions are applied where the monitoring of an action or target is more effective or appropriate than a measurable outcome (EPA 2021). This hybrid environmental management plan (EMP) will ensure that potential direct and indirect impacts to marine fauna, specifically marine turtles, seabirds and migratory shorebirds, are not greater than predicted.

Table ES-1: Summary and Purpose of this ALMP

<table>
<tr><th>Project Title / Proposal Name:</th><th colspan="3">Ashburton Infrastructure Project (AIP, the Project)</th></tr>
<tr><td>Proponent Name</td><td colspan="3">Onslow Infraco Pty Ltd (ACN: 649 012 395, herein MinRes), a wholly owned subsidiary of Mineral Resources Limited (ACN: 118 549 910)</td></tr>
<tr><td>Ministerial Statement No.</td><td colspan="3">MS 1204</td></tr>
<tr><td>EPBC Referral No.</td><td colspan="3">EPBC: 2021/9064
ALMP V6 Approved under EPBC Act for implementation 12 December 2022</td></tr>
<tr><td>MS 1204: Short Description</td><td colspan="3">Ashburton Infrastructure Project; AIP (The Project) will include a fully sealed private road, approximately 125 kilometres (km) in length, starting from about 45 km southwest of Pannawonica to access the Port of Ashburton, where landside and marine facilities will be developed for export of up to 40 million tonnes of ore per annum (Mtpa) over a minimum 30-year period.</td></tr>
<tr><td>Scope and Purpose of ALMP</td><td colspan="3">The purpose of the ALMP is to comply with conditions set out in MS 1204 and EPBC 2021/9064. This will be achieved by providing detailed management and mitigation measures that will be implemented to protect sensitive marine fauna, specifically marine turtles, seabirds and migratory shorebirds, from potential impacts caused by Project artificial lighting present during construction and operational phases. The measures aim to minimise the duration, intensity and extent of artificial light exposure on Matters of National Environmental Significance (MNES).</td></tr>
<tr><td rowspan="2">Key Environmental Factor / Outcome/s and/or Objectives</td><td colspan="2">Key Factor</td><td>Objectives / Outcomes</td></tr>
<tr><td colspan="2">Listed Marine Fauna including:
• Marine Turtles;
• Seabirds; and
• Migratory Shorebirds.</td><td>• Minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island.
• Minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate.
• Minimise artificial light impacts on listed marine fauna and listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds.</td></tr>
<tr><td rowspan="4">MNES Impacts and Primary Management Strategies</td><td>MNES</td><td>Impact</td><td>Primary Strategies Planned to Address these Impacts</td></tr>
<tr><td>Marine Turtles</td><td rowspan="3">Generation of artificial light during AIP construction and operational phases.</td><td rowspan="3">Implement this ALMP</td></tr>
<tr><td>Seabirds</td></tr>
<tr><td>Migratory Shorebirds</td></tr>
<tr><td>Condition Clauses</td><td colspan="3">The ALMP has been prepared in accordance with the following conditions to support implementation of the AIP under the EP Act (of MS 1204), and EPBC Act (EPBC:2021/9064).
MS1204:
• Condition A1 (Limitations and extent of proposal);
• Condition B3-1(3): “The proponent must minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island”; and
• Condition B3-1(4) Marine Fauna: “The proponent must minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate”.
• Condition B3-4 Marine Fauna: “The proponent must update the Artificial Light Impact Assessment and Management Plan Revision 6 (Report number J88001), that satisfies the requirements of condition C5 and demonstrates how achievement of the marine fauna environmental objectives in condition B3-1(3) and condition B3-1(4) will be achieved and submit it to the Chief Executive Officer (CEO).”
• Condition C5-1 to C5-2 Environmental Management Plans: Conditions Related to Management Actions and Targets for Objective Based Conditions. Specifically Condition C1-1 (1): " The proponent must within six (6) months of the publication of the Statement, submit the environmental management plan required by condition B3-4 that meets the requirements of that condition and condition C5, and must not commence port operational activities in the landside and near shore development envelopes until the CEO has confirmed in writing that the management plan meets the requirements of these conditions;
EPBC: 2021/9064:
• Condition 10 Part A – Conditions specific to the Action
“The approval holder must implement the Artificial Light Impact Assessment and Management Plan (ALMP) for the life of the approval. By implementing the ALMP the approval holder must achieve the objectives of the ALMP to minimise artificial lighting impacts on listed marine fauna and listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds”</td></tr>
<tr><td>Key Components in the ALMP</td><td colspan="3">The key provisions in the ALMP are detailed in Section 1.4. These include outcome-based and objective based provisions which will be applied to the Project.</td></tr>
<tr><td>Proposed Construction Dates</td><td colspan="3">Q1/2023</td></tr>
<tr><td>Proposed Operational Dates</td><td colspan="3">Q2/2024</td></tr>
<tr><td>MS 1204: ALMP required pre-construction?</td><td colspan="3">Yes ☐ No ☒</td></tr>
</table>

TABLE OF CONTENTS

Figures

Tables

Appendices

ABBREVIATIONS

Abbreviation	Definition
ACR	Annual Compliance Report
ALARP	As low as reasonably practicable
ALMP	Artificial Light Management Plan
ANSIA	Ashburton North Strategic Industrial Area
APIM	Australian Premium Iron Management
BC Act	Biodiversity Conservation Act 2016
BIA	Biologically Important Area
CAMBA	The China–Australia Migratory Bird Agreement
CAR	Compliance Assessment Report
CEO	Chief Executive Officer
CME	Chamber of Minerals and Energy
CMS	Convention on Migratory Species
CRG	Community Reference Group
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DevWA	Development WA
DoT	Department of Transport
DPLH	Department of Planning, Lands and Heritage
EMS	Environmental Management System
EP Act	Western Australian Environmental Protection Act 1986
EPA	Western Australian Environmental Protection Authority
EPAS	Environmental Protection Authority Services
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
FEMP	Framework Environmental Management Plan
ha	Hectare
ICAM	Incident Cause Analysis Method
JAMBA	The Japan Australia Migratory Bird Agreement
JTSI	Department of Jobs, Tourism, Science and Innovation
km	Kilometre
m	Metre
MinRes	Mineral Resources Limited, the Proponent
MNES	Matters of National Environmental Significance
Mtpa	Million tonnes per annum
NLPGW	National Light Pollution Guidelines for Wildlife
nm	Nanometre
No.	Number
OCCI	Onslow Chamber of Commerce and Industry

Abbreviation	Definition
OGV	Ocean-going Vessel
PDCA	Plan-Do-Check-Act model
PER	Public Environmental Report
RAMP	Revised Action Management Plan
ROKAMBA	Republic Of Korea Australia Migratory Bird Agreement
Thalanyji	Buurabalayji Thalanyji Aboriginal Corporation
The Project	Ashburton Infrastructure Project; AIP
The Proponent	Mineral Resources Limited, MinRes
TSV	Trans-shipment Vessel
WA	Western Australian
WAFIC	WA Fishing Industry Council

GLOSSARY

Term	Definition
MS1204 Definitions	
Adverse impact / adversely impacted	Negative change that is neither trivial nor negligible that could result in a reduction in health, diversity or abundance of the receptor/s being impacted, or a reduction in environmental value. Adverse impacts can arise from direct or indirect disturbance, or other impacts from the proposal such as (but not limited to) hydrological change, spread or introduction of environmental weeds, altered fire regimes, introduction or spread of disease, changes in erosion/deposition/accretion and edge effects.
CEO	The Chief Executive Officer (**CEO**) of the Department of the Public Service of the State responsible for the administration of section 48 of the Environmental Protection Act 1986, or the CEO's delegate.
Confirmed	In relation to a plan required to be made and submitted to the CEO, means, at the relevant time, the plan that the CEO confirmed, by notice in writing, meets the requirements of the relevant condition. In relation to a plan required to be implemented without the need to be first submitted to the CEO, means that plan until it is revised, and then means, at the relevant time, the plan that the CEO confirmed, by notice in writing, meets the requirements of the relevant condition
Contingency measures	Planned actions for implementation if it is identified that an environmental outcome, environmental objective, threshold criteria or management target are likely to be, or are being, exceeded. Contingency measures include changes to operations or reductions in disturbance to reduce impacts and must be decisive actions that will quickly bring the impact to below any relevant threshold, management target and to ensure that the environmental outcome and/or objective can be met.
Detecting / Detectable	The smallest statistically discernible effect size that can be achieved with a monitoring strategy designed to achieve a statistical power value of at least 0.8 or an alternative value as determined by the CEO
Hybrid EMP	An EMP the includes both outcome and objective-based EMP components.
Management action/s	The identified actions implemented with the intent of to achieving the environmental objective.

Term	Definition
Management target/s	A type of indicator to evaluate whether an environmental objective is being achieved.
Port operational activities	Activities associated with port facilities including handling and storage of ore product, ship loading, operation of vessels, power generation, seawater intake and bring discharge.
Significant marine fauna	Includes turtles, cetaceans, dugongs, sawfish and other marine fauna species listed under state or Commonwealth legislation.
Trigger criteria	Indicators that have been selected for monitoring to provide a warning that if exceeded the environmental outcome may not be achieved. They are intended to forewarn of the approach of the threshold criteria and trigger response actions.
Threshold criteria	The indicators that have been selected to represent limits of impact beyond which the environmental outcome is not being met.
EPBC: 2021/9064 Definitions	
Artificial Light Impact Assessment and Management Plan (**ALMP**)	Artificial Light Impact Assessment and Management Plan (**ALMP**) means the document titled the Ashburton Infrastructure Project, Appendix G - Artificial Light Impact and Assessment and Management Plan (**ALMP**), Revision 6, J88001, or any version revised in accordance with these conditions.
Listed marine fauna	Listed marine fauna means the EPBC Act listed migratory marine species, including but not limited to: Flatback Turtle (Natator depressus), Loggerhead Turtle (Caretta caretta), Green Turtle (Chelonia mydas), Hawksbill Turtle (Eretmochelys imbricata), Leatherback Turtle (Dermochelys coriacea), Blue Whale (Balaenoptera musculus), Humpback Whale (Megaptera novaeangliae), Southern Right Whale (Eubalaena australis), Whale Shark (Rhincodon typus), Green Sawfish (Pristis zijsron), Dwarf Sawfish (Pristis clavata), Giant Manta Ray (Mobula birostris), Reef Manta Ray (Mobula alfredi), Dugong (Dugong dugon), Australian Humpback Dolphin (Sousa sahulensis), Australian Snubfin Dolphin (Orcaella heinsohni) and Spotted Bottlenose Dolphin (Tursiops aduncus (Arafura/Timor Sea populations)
Listed migratory bird species	Listed migratory bird species means the EPBC Act listed migratory shorebird and marine bird species, including but not limited to: Bar-tailed Godwit (Limosa lapponica), Black-tailed Godwit (Limosa limosa), Bridled Tern (Onychoprion anaethetus), Caspian Tern (Hydroprogne caspia), Common Greenshank (Tringa nebularia), Common Sandpiper (Actitis hypoleucos), Common Tern (Sterna hirundo), Crested Tern (Thalasseus bergii), Curlew Sandpiper (Calidris ferruginea), Eastern Curlew (Numenius madagascariensis), Glossy Ibis (Plegadis falcinellus), Greater Crested Tern (Thalasseus bergii), Great Knot (Calidris tenuirostris), Grey Plover (Pluvialis squatarola), Greater Sand Plover (Charadrius leschenaultii), Grey-tailed Tattler (Tringa brevipes), Gull-billed Tern (Gelochelidon nilotica), Lesser Sand Plover (Charadrius mongolus), Little Curlew (Numenius minutus), Little Tern (Sternula albifrons), Oriental Pratincole (Glareola maldivarum), Oriental Plover (Charadrius veredus), Osprey (Pandion haliaetus), Pectoral Sandpiper (Calidris melanotos), Red Knot (Calidris canutus), Red-necked Stint (Calidris ruficollis), Roseate Tern (Sterna dougallii), Ruddy Turnstone (Arenaria interpres), Sanderling (Calidris alba), Sharp-tailed Sandpiper (Calidris acuminata), Streaked Shearwater (Calonectris leucomelas), Wedge-tailed shearwater (Ardenna pacifica), White-winged Black Tern (Chlidonias leucopterus), Whimbrel (Numenius phaeopus) and Wood Sandpiper (Tringa glareola).
Management Plans	Management Plans means any one or more of: the Terrestrial MNES Management Plan, Marine Operational Environmental Monitoring and Management Plan, Underwater Noise Management Protocol, Marine Construction Environmental Management Plan, Dredging and Spoil Disposal Management Plan and Artificial Light Impact Assessment and Management Pla
Monitoring data	Monitoring data means the data required to be recorded under the conditions of this approval.
Operational management plan	Operational management plans means the Terrestrial MNES Management Plan, Marine Operational Environmental Monitoring and Management Plan, Underwater Noise Management Protocol and Artificial Light Management Plan.
Recovery Plan(s)	Recovery Plan(s) is a recovery plan made or adopted by the Minister under the EPBC Act.
Threat abatement plan(s)	Threat abatement plan(s) is a threat abatement plan made or adopted by the Minister under the EPBC Act

1. CONTEXT, SCOPE AND RATIONALE

1.1 Project

1.1.1 Project Overview

Onslow Infraco Pty Ltd, a wholly owned subsidiary of Mineral Resources Limited (**MinRes**; **the Proponent**), is undertaking planning for the Ashburton Infrastructure Project (**AIP**, **the Project**) to service iron ore mining and export developments in the West Pilbara region of Western Australia (**WA**) (**Figure 1**). The geographic extent of the Project and its regional location is illustrated in **Figure 1**.

The Project involves the development of a fully sealed private road, approximately 125 kilometres (**km**) in length, starting from about 45 km southwest of Pannawonica to access the Port of Ashburton (**the Port**), where landside and marine facilities will be developed for export of up to 40 million tonnes of ore per annum (**Mtpa**) over a minimum 30-year period.

The Proposal consists of four main components, which are a private haul road, port landside facilities and port (nearshore and offshore) marine facilities to support approved mine developments, as follows:

- Ashburton Haul Road (Haul Road Development Envelope (**DE**)– a 125 km fully sealed private haul road from starting from about 45 km southwest of Pannawonica to access continuing west to Onslow Road;
- Port Landside Facilities (Landside DE) – storage and bulk handling of iron ore, a water desalination plant, a power station, bulk storage of fuel, administration building, and a wastewater treatment plant at the Port of Ashburton; and
- Port Marine Facilities (Nearshore and Offshore DEs) – a nearshore dedicated berthing pocket, modular jetty wharf, and ship loader at the Port of Ashburton (Nearshore DE), with a transhipment area in port waters managed by the Pilbara Ports Authority (**PPA**) . Offshore shipping activities will involve the operation of Transshipment Vessel's (**TSV**) which will utilise an existing shipping channel to access an anchorage area (Offshore DE) for out-loading of iron ore from the TSV's to an Ocean-Going Vessel (**OGV**) located to the north-west of Thevenard Island in 30 – 50 m water depth within WA State Waters.

The components are collectively referred to as the Project for the purposes of this Artificial Light Management Plan (**ALMP**).

1.1.2 Project Elements

A summary of the Project elements, limitations, and extents relevant to this EMP as summarised in Ministerial Statement (**MS**) 1204 under the *Environmental Protection Act 1986* (**EP Act**) are provided in **Table 1** and **Figure 1**.below.

Table 1: MS 1204 Project Elements, Limitations and Extents (Source: EPA 2023)

Proposal Element	Location	Maximum extent
Physical Elements		
Landside DE	**Figure 1 (EPA 2023)**	No clearing of native vegetation of port development
Nearshore DE, including a dedicated berth pocket and jetty (excluding dredging)	**Figure 1** (EPA 2023)	Disturbance of no more than 5 hectares (ha) of seabed (consisting of bare substrate) withing a 11 ha development envelope
Offshore DE, including the offshore anchorage points	**Figure 1** (EPA 2023)	Disturbance of no more than 1,347 ha of seabed (consisting of bare substrate) within a 4,483 ha development envelope for up to 5 offshore anchorage points
Timing Elements		
Life of Project	-	30 years from the date of this statement

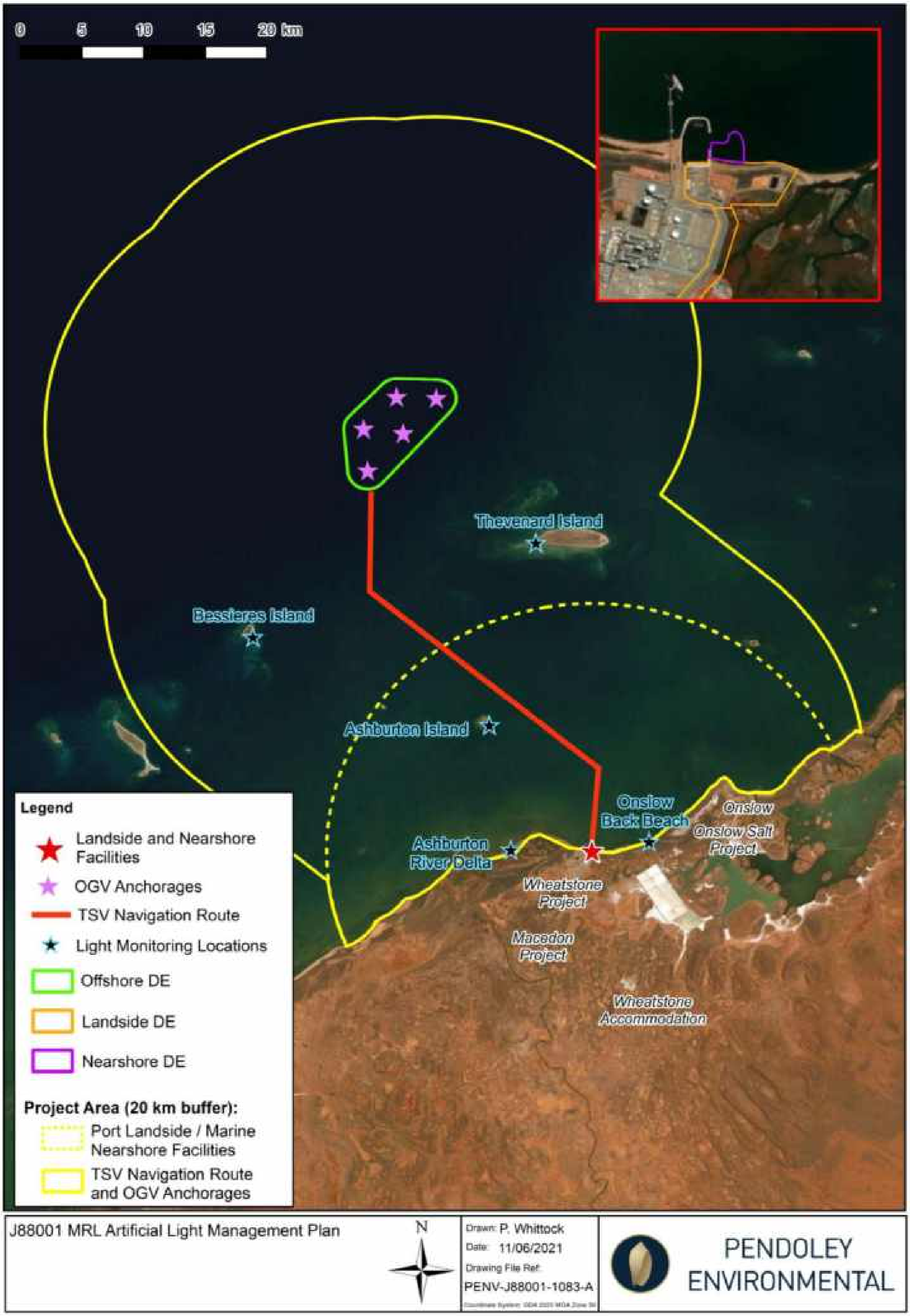


Figure 1: Development Envelope and Indicative Footprint

1.1.3 Approvals History

The AIP was referred to the Australian Department of Climate Change, Energy, the Environment and Water (**DCCEEW**, previously Department of Agriculture, Water and Environment (**DAWE**)) for consideration of Matters of National Environmental Significance (**MNES**) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**). The AIP was deemed a Controlled Action with the controlling provisions being; Listed threatened species and communities (**Sections 18 & 18A**); and Listed migratory species (**Sections 20 & 20A**) on the 16 November 2021.Following the acceptance of MinRes's request for an independent assessment of the Proposed Action (ref. EPBC 2021-9064) under the EPBC Act, a decision was made on 16 February 2022 under Section 87 of the EPBC Act to assess this project by "Public Environment Report" (**PER**). The AIP was approved under **the EPBC Act** on **12 December 2022** as **EPBC2021/9064.** MinRes formally notified the (**DCCEEW**) that works associated with the implementation of the AIP under EPBC:2021/9064 substantially commenced on 12 September 2023.

The Project was also referred to the Environmental Protection Authority (**EPA**) under s38 of the Environmental Protection Act (EP Act) on 26 October 2021. On 23 February 2022, the EPA decided to assess the Project at the level of Assessment on Referral Information with additional information required. The EPA published the referral supporting document including additional information on its website for public review for 2 weeks (from 25 July 2022 to 8 August 2022).

Based upon the outcomes of the EPA assessment of the AIP, the EPA recommended that the Proposal may be implemented subject to conditions recommended in MS 1204 (EPA, 2023). On 3 July 2023, MS 1204 was issued under Section 45(5) of the EP Act for the Proposal.

This Version (7) of the ALMP has been developed to meet Condition B3-4 (MS1204), and incorporates responses to comments from DWER and Department of Biodiversity, Conservation and Attractions (**DCBA**) received 5 September 2023 on a *Baseline Adult Turtle and Benchmark Hatchling Turtle Orientation: Trigger and Threshold Criteria Memo* (PENV 2023c, **Appendix E**) prepared to support ALMP Version 6 (*Artificial Light Impact and Assessment and Management Plan (ALMP), Revision 6, J88001,* **Appendix B**) (approved by DCCEEW on 12 December 2022). A key recommendation from DWER was that the *Trigger and Threshold Criteria Memo* and ALMP (V6) be combined and restructured, to meet the requirements of EPA's (2021) *How to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* - Instructions.

1.2 Scope and Purpose

This ALMP has been developed to meet requirement of Conditions set out in MS 1204 and EPBC 2021/9064 discussed in detail in (**Section 1.4**). The purpose of the ALMP is to demonstrate how the Proponent will avoid, mitigate, and reduce potential impacts from artificial light generated by infrastructure, equipment, and vessels during construction and operation of the AIP relevant to marine turtles, seabirds and migratory shorebirds and demonstrate compliance against our State and Commonwealth approvals conditions.

The overarching management objective for the AIP under MS 1204 is to *minimise artificial light impacts from construction and operational activities on listed marine fauna, specifically marine turtles, seabirds and migratory shorebirds.* Under the EPBC:2021/9064 the management objective for the AIP is to implement the ALMP *minimise artificial lighting impacts on listed marine fauna and listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds.*

This ALMP has been developed to identify and manage key risks and potential impacts to Marine Fauna, specifically species of marine turtles, seabirds, and migratory shorebirds, listed as MNES, occurring within the vicinity (~20 km) of the AIP footprint. In particular, it is targeted at those species that have the potential to experience altered behaviours during key biological windows in response to artificial light. MNES relevant to this ALMP, with Biologically Important Areas (**BIAs**) or Habitat Critical to the species coinciding with the AIP footprint, are summarised in **Table 2**, alongside their listing status under both the EPBC Act, and the *Biodiversity Conservation Act 2016* (**BC Act**). A more extensive list of light-sensitive marine fauna species identified using the Protected Matters Search Tool (**PMST**) (DCCEEW 2023) for the Project area is provided in **Appendix A**.

This ALMP has been prepared in accordance with the State Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans (EPA 2020) and the Commonwealth requirements under the EPBC Act, Environmental Management Plan Guidelines (Commonwealth of Australia 2014).

Table 2: Listed Species with Biologically Important Areas or Habitat Critical coinciding with the Project DEs

Name	Presence type	Listing status	
		BC Act	EPBC Act
Marine Turtles			
Flatback Turtle (*Natator depressus*)	Nesting and inter-nesting Habitat Critical	Vulnerable	Vulnerable Marine Migratory
Green Turtle (*Chelonia mydas*)	Nesting and inter-nesting Habitat Critical	Vulnerable	Vulnerable Marine Migratory
Hawksbill Turtle (*Eretmochelys imbricata*)	Nesting and inter-nesting Habitat Critical	Vulnerable	Vulnerable Marine Migratory
Seabirds			
Fairy tern (*Sternula nereis nereis*)	Breeding	Vulnerable	Vulnerable Marine
Little tern (*Sternula albifrons sinensis*)	Breeding	Migratory	Migratory Marine
Roseate tern (*Sterna dougallii*)	Breeding	Migratory	Migratory Marine
Wedge-tailed shearwater (Ardenna pacifica)	Breeding Foraging	Migratory	Migratory Marine
Migratory Shorebirds			
Bar-tailed godwit (*Limosa lapponica*)	Habitat	Migratory	Migratory Marine
Common greenshank (*Tringa nebularia*)	Habitat	Migratory	Migratory Marine
Greater sand plover (*Charadrius leschenaultii*)	Habitat	Vulnerable	Vulnerable Migratory Marine
Grey-tailed tattler (*Heteroscelus brevipes*)	Habitat	Migratory P4 – Rare, near threatened and other species in need of monitoring	Migratory Marine
Ruddy turnstone (*Arenaria interpres interpres*)	Habitat	Migratory	Migratory Marine
Sanderling (*Calidris alba*)	Habitat	Migratory	Migratory Marine

1.3 Key Environmental Factors

The EPA Key Environmental Factor applicable to this management plan is Marine Fauna. The EPA objective for Marine Fauna is to '*protect marine fauna so that biological diversity and ecological integrity are maintained*' (EPA 2016).

AIP activities and associated potential artificial light impacts applicable to listed species of marine turtles, seabirds and migratory shorebirds are summarised in **Table 3**. Further information regarding potential impacts to listed species is provided in **Section 1.7.1**, **1.8.1** and **Appendix B**.

Table 3: Environmental Factor, Significance and Relationship to the Project

Project Activity	Significance
Key Environmental Factor – Marine Fauna	
Artificial lighting used on infrastructure, equipment, and vessels during construction and operation of the Project.	Potential Impacts (Marine Turtles): • Misorientation or disorientation of marine turtle hatchlings, resulting in mortality via exhaustion or predation. • Misorientation or disorientation of adult marine turtles. • Changes in turtle nesting habitat utilisation. Potential Impacts (Seabirds and Migratory Shorebirds): • Interactions between seabirds or shorebirds and artificial light sources, causing disorientation or grounding of fledglings. • Mortality or injury caused from collision with artificially lit infrastructure. • Starvation due to disruptions in the ability to forage at sea and on shore. • Disruption to nesting where artificial light is situated adjacent to rookeries. • Alteration in foraging behaviour, such as a shift to night-time feeding in artificially lit areas.

1.4 Approval Condition Requirements

This ALMP has been prepared in accordance with conditions B3-1, B3-4, C1-1 and C5-2 of MS 1204 and Conditions 1, of EPBC 2021/9064 to support implementation of the AIP under the EP Act and EPBC Act.

A Conditions of Approval Reference Table detailing the MS 1204 and EPBC 2021/9064 condition requirements, including required outcomes and/or objectives and in which section/s they are addressed within the ALMP, are provided in **Table 4**.

Table 4: Conditions of Approval MS1204 and EPBC 2021/9064 Reference Table

Reference	Condition Requirement	ALMP Reference
Ministerial Statement 1204		
A1 Limitations and Extent		
Condition A1-1	The proponent must ensure that the Project is implemented in such a manner that the limitations or maximum extents / capacities / ranges are not exceeded (**Table 1**)	**Table 1** **Section 1.1.2**
B3 Marine Fauna		
Condition B3-1 (3)	The proponent must implement the proposal to meet the following environmental objectives: (3) minimise the risk of adult marine turtles and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate	**Section 2** **Table 10** **Table 11**
Condition B3-1 (4)	The proponent must implement the proposal to meet the following environmental objectives: (4) minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate.	**Section 2** **Table 10** **Table 11**
Condition B3-4	The proponent must update the Artificial Light Impact Assessment and Management Plan Revision 6 (Report number J88001), that satisfies the requirements of condition C5 and demonstrates how achievement of the marine fauna environmental objectives in condition B3-1(3) and B3-1(4) will be achieved and submit it to the CEO.	This ALMP **Appendix B**
C1 Environmental Management Plans: Conditions Related to Commencement of Implementation of the Proposal		
Condition C1-1 (1)	The proponent must: (1) Within six (6) months of the publication of the Statement, submit the environmental management plan required by condition B3-4 that meets the requirements of that conditions and condition C5, and must not commence port operational activities in the landside near shore development envelopes until the CEO has confirmed in writing that the management plan meets the requirements of these conditions.	This ALMP
Condition C2-1	Upon being required to implement an environmental management plan under Part B, or after receiving notice in writing from the CEO under condition C1-1 that the environmental management plan(s) required in Part B satisfies the relevant requirements, the proponent must: (1) implement the most recent version of the confirmed environmental management plan; and (2) continue to implement the confirmed environmental management plan referred to in condition C2-1(1) other than for any period which the CEO has confirmed by notice in writing that it has been demonstrated that the relevant requirements for the environmental management plan have been met or are able to be met under another statutory decision-making process, in which case the implementation of the environmental management plan is no longer required for that period.	**Section 6.5.2**
Condition C2-2	The proponent: (1) may review and revise a confirmed environmental management plan provided it meets the relevant requirements of that environmental management plan, including any consultation that may be required when preparing the environmental management plan; (2) must review and revise a confirmed environmental management plan and ensure it meets the relevant requirements of that environmental management plan, including any consultation that may be required when preparing the environmental management plan, as and when directed by the CEO.	**Section 8.6**
Condition C2-3	Despite condition C2-1, but subject to conditions C2-4 and C2-5, the proponent may implement minor revisions to an environmental management plan if the revisions will not result in new or increased adverse impacts to the environment or result in a risk to the achievement of the limits, outcomes or objectives which the environmental management plan is required to achieve.	**Section 8.6**
Condition C2-4	If the proponent is to implement minor revisions to an environmental management plan under condition C2-3, the proponent must provide the CEO with the following at least twenty (20) business days before it implements the revisions: (1) the revised environmental management plan clearly showing the minor revisions; (2) an explanation of and justification for the minor revisions; and (3) an explanation of why the minor revisions will not result in new or increased adverse impacts to the environment or result in a risk to the achievement of the limits, outcomes or objectives which the environmental management plan is required to achieve.	**Section 8.6**
Condition C2-5	The proponent must cease to implement any revisions which the CEO notifies the proponent (at any time) in writing may not be implemented.	**Section 8**
Condition C2-6	Confirmed environmental management plans, and any revised environmental management plans under condition C2-4(1), must be published on the proponent's website and provided to the CEO in electronic form suitable for online publication by the Department of Water and Environmental Regulation within twenty (20) business days of being implemented, or being required to be implemented (whichever is earlier).	**Section 8.7**
Condition C3-1	The proponent must undertake monitoring capable of: (1) substantiating whether the proposal limitations and extents in Part A are exceeded; and (2) detecting and substantiating whether the environmental outcomes identified in Part B are achieved (excluding any environmental outcomes in Part B where an environmental management plan is expressly required to monitor achievement of that outcome).	**Section 5.2** **Section 6.5**

Reference	Condition Requirement	ALMP Reference
Condition C3-2	C3-2 The proponent must submit as part of the Compliance Assessment Report required by condition D2, a compliance monitoring report that: (1) outlines the monitoring that was undertaken during the implementation of the proposal; (2) identifies why the monitoring was capable of substantiating whether the proposal limitation and extents in Part A are exceeded; (3) for any environmental outcomes to which condition C3-1(2) applies, identifies why the monitoring was scientifically robust and capable of detecting whether the environmental outcomes in Part B are met; (4) outlines the results of the monitoring; (5) reports whether the proposal limitations and extents in Part A were exceeded and (for any environmental outcomes to which condition C3-1 (2) applies) whether the environmental outcomes in Part B were achieved, based on analysis of the results of the monitoring; and (6) reports any actions taken by the proponent to remediate any potential non-compliance.	**Section 5.2** **Section 6.5**
C5 Environmental Management Plans: Conditions Related to Management Actions and Targets for Objective Based Conditions		
Condition C5-1	C5-1 The environmental management plans required under condition B3-2, condition B3-3, condition B3-4, condition B5-13, condition B6-3 and condition B6-4 must contain provisions which enable the achievement of the relevant objectives of those conditions and substantiation of whether the objectives are reasonably likely to be met, and must include: (1) management actions; (2) management targets; and (3) contingency measures if management targets are not met; and (4) reporting requirements.	**Section 2** **Table 11**
Condition C5-2	C5-2 The environmental management plan required under condition B3-4 is also required to be updated to include management actions, management targets and contingency measures that will establish whether the proposal is having a detectable difference on marine turtle orientation and nesting beach utilisation as described in conditions B3-1(3).	**Section 2** **Table 10** **Table 11**
D1 Non-compliance Reporting		
Condition D1-1	If the proponent becomes aware of a potential non-compliance, the proponent must: (1) report this to the CEO within seven (7) days; (2) implement contingency measures; (3) investigate the cause; (4) investigate environmental impacts; (5) advise rectification measures to be implemented; (6) advise any other measures to be implemented to ensure no further impact; and (7) provide a report to the CEO within twenty-one (21) days of being aware of the potential non-compliance, detailing the measures required in conditions D1-1(1) to D1-1(6) above.	**Section 6.5.2**
Condition D1-2	Failure to comply with the requirements of a condition, or with the content of an environmental management plan required under a condition, constitutes a noncompliance with these conditions, regardless of whether the contingency measures, rectification or other measures in condition D1-1 above have been or are being implemented.	**Section 6.5.2**
D2 Compliance Reporting		
Condition D2-4	Each annual Compliance Assessment Report must: (1) state whether each condition of this Statement has been complied with, including (a) exceedance of any proposal limits and extents; (b) achievement of environmental outcomes; (c) achievement of environmental objectives; (d) requirements to implement the content of environmental management plans; (e) monitoring requirements (f) implement contingency measures; (g) requirements to implement adaptive management; and (h) reporting requirements; (2) include the results of any monitoring (inclusive of any raw data) that has been required under Part C in order to demonstrate that the limits in Part A, and any outcomes or any objectives are being met.	**Section 6.5.2**

Reference	Condition Requirement	ALMP Reference
EPBC 2021/9064		
Annexure A: Part A Conditions specific to the Action		
Condition 10	The approval holder must implement the Artificial Light Impact Assessment and Management Plan (ALMP) for the life of the approval. By implementing the ALMP the approval holder must achieve the objectives of the ALMP to minimise artificial lighting impacts on listed marine fauna and listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds.	This ALMP (V7 once approved) **Appendix B**
Condition 13	In the event any threshold criterion specified in a given Management Plan is at any time exceeded, the approval holder must: a. Report the details of the location, nature, and magnitude of the exceedance in writing to the Department within five (5) business days of becoming aware of the exceedance. b. Within two (2) business days, commence implementing the applicable threshold exceedance contingency actions specified in the Management Plan. c. Provide to the Department, within twenty-one (21) days of becoming aware of the exceedance, a report specifying the cause(s) of the threshold exceedance and the extent of any resulting impact(s) to protected matter(s) and/or protected matter(s) habitats. d. Within six (6) months of any such exceedance event(s) have the relevant Management Plan(s) reviewed by an independent suitably qualified expert to advise how the relevant Management Plan(s) should be amended to prevent the exceedance reoccurring. e. Within ten (10) months of detecting any exceedance of a threshold criterion related to protected matter(s), submit to the Department the advice of the report of the independent suitably qualified expert and a version of the Management Plan(s) revised to address the advice of the independent suitably qualified expert to the Minister for approval. f. If the revised Management Plan(s) has/have not been provided to the Minister for approval within 18 months of the detection of any exceedance of a threshold criterion or have not been suitably revised to meet the advice of the independent suitably qualified expert and/or the requirements of the Department, the Minister may notify the approval holder that the Management Plan(s) have not been submitted or is not suitable for approval. The Minister may, at least two (2) months after, so notifying the approval holder, approve a version of the Management Plan(s) revised by the Department. The approval holder must implement the approved Management Plan(s), for the remainder of the life of the approval, until marine construction and dredging is completed, and/or until a revised version of Management Plan(s) have been approved according to Condition 17 of this approval.	**Section 2** **Section 3**
Condition 14	Within six (6) months of detecting any exceedance of a threshold criterion, as outlined in the Management Plan(s) related to protected matter(s), submit to the Department for the Minister's approval, a Remediation Plan to address the impacts to protected matters identified in the report provided in Condition 13 of this approval. If approved, the Remediation Plan must be implemented for the life of the approval. The Remediation Plan must include: a. corrective action(s) to remediate impacts to protected matter(s) and their habitat, and b. timeframes, completion criteria, and reporting schedules.	**Section 3**
Condition 15	If the Minister informs the approval holder in writing that it is not possible to adequately remediate the impacts on protected matters of one or more exceedance outlined in the Remediation Plan (as required to be submitted in Condition 14 of this approval), then the approval holder must, within three (3) months of receiving such advice from the Minister, submit to the Department, an Exceedance Offset Management Plan (EOMP) addressing the exceedance(s) as specified by the Minister in writing for the Minister's approval. The EOMP must meet the requirements specified in Attachment M.	**Section 6**
Condition 16	If the EOMP has not been approved by the Minister within six (6) months of the Minister informing the approval holder in writing as described in condition 15 of this approval, and the Minister notifies the approval holder that the EOMP is not suitable for approval, the Minister may, at least two months after so notifying the approval holder, approve a version of the EOMP revised by the Department. The approval holder must implement the approved EOMP for the remainder of the life of this approval or until a revised version of the EOMP is endorsed.	**Section 6**
Condition 17	At least three (3) months prior to each fifth anniversary of this approval decision, the approval holder must have an independent suitably qualified expert review each of the operational management plans to advise if the triggers and thresholds are still effective and meet industry standards, whether further mitigation measures need to be applied and whether the management actions have been implemented. In the event the independent suitably qualified expert recommends revisions to one or more operational management plans, the approval holder must revise that/those operational management plans in accordance with the recommendations of the independent suitably qualified expert. Each revised operational management plans must be submitted to the Department for Minister approval within six (6) months of the five-year anniversary of this approval decision. The approval holder must implement each approved revised operational management plan(s).	**Section 6.2.2**
Condition 26	The approval holder must ensure that any monitoring data (including sensitive ecological data), surveys, maps, and other spatial and metadata required under the conditions of this approval are prepared in accordance with the Department's Guidelines for biological survey and mapped data (2018), or any subsequent official version or as otherwise specified by the Minister in writing.	**Section 3.3**
Condition 27	The approval holder must ensure that any monitoring data (including sensitive ecological data), surveys, maps, and other spatial and metadata required under the conditions of this approval are prepared in accordance with the Guide to providing maps and boundary data for EPBC Act projects, Commonwealth of Australia 2021, or any subsequent official version or as otherwise specified by the Minister in writing.	**Section 3.3**
Condition 28	The approval holder must submit all monitoring data (including sensitive ecological data), surveys, maps, other spatial and metadata and all species occurrence record data (sightings and evidence of presence) electronically to the Department within 12 months of the approval or in accordance with the requirements of the Management Plan(s).	**Section 3.3**
Condition 33	The approval holder must notify the Department electronically, within five (5) business days of becoming aware of any incident and/or potential non-compliance and/or actual non-compliance with the conditions or commitments made in a Management Plan(s).	**Section 3.1** and **Section 3.2**
Condition 34	The approval holder must specify in the notification: a. Any condition or commitment made in a Management Plan(s) which has been or may have been breached. b. A short description of the incident and/or potential non-compliance and/or actual noncompliance.	**Section 3.1** and **Section 3.2**

Reference	Condition Requirement	ALMP Reference
	c. The location (including co-ordinates), date, and time of the incident and/or non-compliance. Note: If the exact information cannot be provided, the approval holder must provide the best information available.	
Condition 40	The approval holder may, at any time, apply to the Minister for a variation to any of the Management Plans approved by the Minister, or as subsequently revised in accordance with these conditions, by submitting an application in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (**RAMP**) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.	**Section 6.2.2**
Condition 41	The revised management plans must meet the environmental objectives of each of the Management Plans outlined in Condition 6 to Condition 10 of this approval.	**Section 6.2.2**
Condition 42	If the approval holder makes the choice under Condition 40 of this approval to revise an action Management Plan(s) without submitting it for approval, the approval holder must: a. notify the Department in writing that the approved action management plan has been revised and provide the Department with: i. an electronic copy of the RAMP; ii. an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP; iii. an explanation of the differences between the approved action management plan and the RAMP; iv. the reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact; v. written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department. b. subject to condition 43 of this approval, implement the RAMP from the RAMP implementation date.	**Section 6.2.2**
Condition 46	The approval holder must submit: a. submit all plans electronically to the Department. b. unless otherwise agreed to in writing by the Minister, publish each plan on the website within 20 business days of the date; i. of this approval, if the version of the plan to be implemented is specified in these conditions; or ii. that the plan is submitted to the Minister or the Department if the plan does not require the approval of the Minister but was not finalised before the date of this approval; or iii. that the plan was approved by the Minister in writing, if the plan requires the approval of the Minister; c. exclude or redact sensitive ecological data from plans that are to be published on the website or provided to a member of the public; and d. keep plans published on the website until the end date of this approval.	**Section 6.2.2**
Condition 47	The approval holder must ensure that any monitoring data (including sensitive ecological data), surveys, maps, and other spatial and metadata required under conditions of this approval, is prepared in accordance with the Department's Guidelines for biological survey and mapped data (2018) and submitted electronically to the Department in accordance with the requirements of the Management Plan(s).	**Section 6.2.2**

1.5 Rationale and Approach

The results of baseline and targeted surveys (see **Section 1.7.3** and **Section 1.8.3**) have been used to inform the management approach for meeting the environmental objectives and outcomes of this ALMP. The identified management actions and targets include a combination of outcome-based (**Section 2.1** and objective-based measures (**Section 2.2**) to develop a Hybrid EMP (EPA, 2021).

Monitoring data and audits will be used to evaluate compliance with the proposed management actions, and management targets will be used to assess whether management actions are effective in meeting the environmental objectives of the ALMP.

Conditions under MS1204 relate to artificial light impacts on marine turtles (B3-1 and B3-4; **Table 4**), with no conditions specifically applied to seabirds or migratory shorebirds. Therefore, surveys have been targeted towards gathering information on marine turtles nesting and hatching within the vicinity of the AIP. Surveys were designed and undertaken in line with the recommendations of the *National Light Pollution Guidelines for Wildlife* (**NLPGW**)(Commonwealth of Australia, 2023) with the intention of creating a pre-construction baseline against which outcome-based management provisions could be developed. **Section 1.7.3** provides a summary of desktop analyses and field-surveys undertaken to determine the pre-construction artificial lighting environment and behaviour of nesting and hatching marine turtles, including a summary of key assumptions and uncertainties.

In addition to outcome-based provisions, objective-based provisions have been developed to more broadly protect light-sensitive MNES, including marine turtles, seabirds and migratory shorebirds (**Table 2** and **Appendix B**). These provisions meet the objectives of approval conditions under both MS1204 (C5-1 and C5-2) and 2021/9064 (**Condition 10; Table 4**). Objective-based provisions were developed using the *Best Practice Lighting Principles* as stated in the NLPGW (Commonwealth of Australia, 2023), which includes reducing overall AIP artificial light emissions via considered lighting design, engineering, and behavioural lighting controls.

The overall Management Approach applied under this ALMP and the rationale for choice of indicators and/or management actions for Marine Fauna are addressed in **Section 1.9** and **Table 6**.

1.6 Policy and Guidance relevant to Marine Turtles, Seabirds and Migratory Shorebirds

The management of potential impacts on MNES have been determined in the context of:

- The application of the mitigation hierarchy including avoidance, minimisation, rehabilitation, and offset measures to the design and implementation of the Project; and
- Ensuring the outcomes align with Recovery Plan or conservation advice actions for MNES likely to be impacted by the Project.

In addition to the above consideration of the Matters of National Environmental Significant Impact Guidelines 1.1 (Commonwealth of Australia 2013) has been given to MNES during the assessment of the Project (**Appendix A**).

Approved conservation advice and recovery plans exist for MNES known or likely to occur in the vicinity of the AIP. These guidance documents identify overall conservation objectives, critical habitat, important populations, key threats, and priority management actions and are therefore relevant to the assessment process. The Minister must consider the content of approved conservation advice to ensure the AIP aligns with the conservation advice and/or recovery plan objectives.

Guidance and policy documents relevant to MNES impacted by AIP activities include:

- National Light Pollution Guidelines for Wildlife (Commonwealth of Australia 2023);
- Recovery Plan for Marine Turtles in Australia (Commonwealth of Australia 2017a);
- Environmental Assessment Guideline for protecting marine turtles from light impacts (EAG 5) (EPA 2010)
- Marine Bioregional Plan for the North-west Marine Region (Commonwealth of Australia 2012);
- Wildlife Conservation Plan for Seabirds (Commonwealth of Australia 2022);
- EPBC Act Policy Statement 3.21– Industry Guidelines for Avoiding, Assessing and Mitigating Impacts on EPBC Act Listed Migratory Shorebird Species (Commonwealth of Australia 2017b); and

- Wildlife Conservation Plan for Migratory Shorebirds (Commonwealth of Australia 2015).

1.7 Marine Turtles

Marine turtles in Australia belong to discrete, species-specific genetic stocks, which are defined by the presence of regional breeding aggregations. Marine turtle breeding aggregations that overlap with the AIP Area include the Flatback – Pilbara (**F-Pil**), Green – North West Shelf (**G-NWS**), and Hawksbill – Western Australia (**H-WA**) genetic stocks (Commonwealth of Australia 2017a). The Recovery Plan for Marine Turtles in Australia 2017 – 2027 (recovery plan) (Commonwealth of Australia 2017a) provides information for each stock (including details of important nesting areas) and lists the greatest threats for each stock. Light pollution was assessed as a high-risk threat to all three genetic stocks occurring within the AIP Area. Population information for each relevant genetic stock to this ALMP includes:

- Flatback turtles: The population trend of the F-Pil genetic stock is currently unknown. Important nesting areas within the AIP Area include Thevenard Island (minor);
- Green turtles: The population trend for the G-NWS stock is reported as stable. Important nesting areas within the AIP Area include Thevenard Island (minor).; and
- Hawksbill turtles: The population trend for the H-WA stock is also unknown. The recovery plan does not define any important nesting areas within the AIP Area.

The recovery plan also defines areas of onshore nesting and offshore inter-nesting (the period of time between successive nesting events) habitat considered critical for the survival of the species. Critical habitat for nesting and inter-nesting that overlaps with the AIP Area includes areas for *flatback* (Thevenard Island), green (Thevenard Island), and hawksbill (Cape Preston to mouth of Exmouth Gulf) turtles (Commonwealth of Australia 2017a).

BIAs are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding (nesting and inter-nesting), foraging, resting, or migration (available within the National Conservation Values Atlas held by DCCEEW). BIAs that overlap with the Project Area have been defined for the following marine turtle species:

- Flatback turtle onshore nesting habitat on Thevenard Island;
- Flatback turtle offshore inter-nesting habitat around Thevenard Island;
- Hawksbill turtle onshore nesting habitat on Thevenard Island;
- Hawksbill turtle offshore inter-nesting habitat around Thevenard Island; and
- Habitat Critical to nesting for flatback, green and hawksbill turtles onshore and offshore from Onslow.

There are no discrete genetic stocks, breeding aggregations, defined areas of critical habitat, or BIAs for leatherback, loggerhead, or olive ridley turtles that overlap with the AIP Area and therefore these species have not been considered further within this ALMP.

Further information on the marine turtle species addressed by this plan, including genetic stock profiles, life history stages, and the regional importance of nesting sites is provided in **Appendix B**.

1.7.1 Threatening Process: Artificial Light

Adverse effects of artificial light on marine turtle behaviour are well recognised by a substantial body of research (see Withington & 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.

In general, artificial light most disruptive to marine turtles are those rich in short wavelength blue and green light (400 – 550 nanometre (**nm**)) (Fritsches 2012; Pendoley 2005; Witherington 1992a). The attractiveness to light differs by species (Horch et al. 2008; Pendoley 2005; Wang et al. 2007; Witherington & Bjorndal 1991a, 1991b), however, green, flatback, hawksbill and loggerhead turtles all show increased sensitivity to wavelengths <600 nm (Fritsches 2012; Pendoley 2005; Levenson et al. 2004). Furthermore, green and flatback turtles show stronger preference for blue light <500 nm (Fritsches 2012; Pendoley 2005). Thus, cooler, whiter lights are more likely to attract turtles in comparison to warmer, amber lights.

Although longer wavelengths of light are less attractive than shorter wavelengths, long wavelength light can still disrupt the ability of hatchlings to locate the sea (Robertson et al. 2016; Pendoley 2005; Pendoley & Kamrowski 2015), and if bright enough can elicit a similar response to shorter wavelength light (Mrosovsky 1972; Mrosovsky & Shettleworth 1968; Pendoley & Kamrowski 2015; Cabrera-Cruz et al. 2018). Hence, the disruptive effect of light on hatchlings is also strongly correlated with intensity. However, red light (~650 – 700 nm) must be almost 600 times more intense than blue light before green turtle hatchlings show an equal preference for the two colours (Mrosovsky 1972).

In the absence of competing light sources, there is potential for artificial light to result in behavioural impacts to marine turtles, should the intensity be great enough, even if spectral output of light sources are outside the peak sensitivity of marine turtles (i.e. >600 nm).

1.7.1.1 Adults: Nesting

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 & 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).

In addition to potential impacts to nesting females prior to or during nesting, artificial light also has the potential to impact post-nesting behaviour. On completion of laying, nesting females are thought to use light cues to return to open ocean, orientating towards the brightest light (Witherington & Martin 2003). However, observations of nesting females and emerging hatchlings at the same beach showed that females were disorientated much less frequently than hatchlings (Witherington 1992b) indicating that nesting females are less vulnerable to impacts of artificial light on sea-finding behaviour post nesting.

1.7.1.2 Hatchlings: Onshore

Artificial lights interfere with natural light levels and silhouettes disrupting onshore hatchling sea finding behaviour (Withington & Martin 2003; Pendoley & Kamrowski 2015; Kamrowski et al. 2014). Hatchlings may become disorientated - where hatchlings crawl in circuitous paths; or mis-orientated - where they move in the wrong direction, possibly attracted to artificial lights (Withington & 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 (Withington & Martin 2003).

Hatchling orientation has been shown to be disrupted by light produced at distances of up to 18 km from the nesting beach (Hodge et al. 2007; Kamrowski et al. 2014), although the degree of impact would likely be influenced by a number of factors including light intensity, visibility (a function of lamp orientation and shielding), spectral power distribution (wavelength and colour), atmospheric scattering, cloud reflectance, spatial extent of sky glow, duration of exposure, horizon elevation, and lunar phase.

1.7.1.3 Hatchlings: Offshore

Once in nearshore waters, artificial lights on land can interfere with the dispersal of hatchlings. The presence of artificial light can slow down their in-water dispersal (Witherington & Bjorndal 1991; Wilson et al. 2018) or increase their dispersion path, potentially depleting yolk reserves, or even attract hatchings back to shore (Truscott et al. 2017). In addition to interfering with their offshore dispersal, artificial light can influence predation rates, with increased predation of hatchlings in offshore 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 occurring in artificially lit areas and under artificial structures may further increase the predation risk to hatchlings (Wilson et al. 2019).

An internal compass set while crawling down the beach, together with wave cues, are used to reliably guide hatchlings offshore (Lohmann & Lohmann 1992; Stapput & Wiltschko 2005). In the absence of wave cues, however, swimming hatchlings have been shown to orientate towards light cues (Lorne & Salmon 2007; Harewood & Horrocks 2008) and in some cases, wave cues were overridden by light cues (Thums et al. 2013, 2016; Wilson et al. 2018).

1.7.2 Environmental Outcomes and Management Objectives

The environmental outcomes of this ALMP, with respect to marine turtles, are:

- There will be no significant increase in hatchling marine turtle misorientation or disorientation at Bessieres, Ashburton, Thevenard, and Direction Islands; and
- There will be no significant increase in adult marine turtle misorientation, disorientation, or nesting habitat utilisation at Ashburton, Thevenard, Direction, and Bessieres Islands.

The management objectives of this ALMP, with respect to marine turtles, are to:

- Minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island (MS1204 Condition B3-1 (3)); and
- Minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate (MS1204 Condition B3-1 (4)).

1.7.3 Survey and Study Findings

The Project area has been subject to extensive surveying for marine turtles. **Table 5** presents the key ecological surveys enabling a detailed understanding of the existing marine turtle nesting population, and nesting and hatching behaviour in response to the baseline (pre-construction) lighting environment. The results of these studies have been integral in producing the outcome-based management trigger and threshold targets (**Section 2.1.1**), with the full justification developed in PENV 2023c (**Table 5**) and submitted to the Western Australian Environmental Protection Authority (**EPA**), Western Australian Department of Water and Environmental Regulation (**DWER)** and Western Australian Department of Biodiversity, Conservation and Attractions (**DBCA**) in July 2023.

1.7.4 Key Assumptions and Uncertainties

The following key assumptions and uncertainties apply to the baseline adult and hatchling orientation monitoring surveys, and subsequent development of outcome and objective-based provisions for marine turtles.

- An adult nesting turtle can only be misoriented when leaving their nesting pit and navigating back to the ocean, as opposed to crawling up the beach prior to nesting.
- All adult nesting activity captured occurred during night-time hours.
- Moon phase is not considered an influencing factor on track morphometrics used to describe adult turtle nesting behaviour.
- Due to concurrent construction activities associated with the Project, baseline hatchling orientation data collected from Ashburton Island was deemed to be unsuitable for analysis. In the absence of any other suitable data, hatchling orientation metrics captured at Thevenard Island were selected as a conservative proxy for Ashburton Island.
- No data was captured from Direction Island during baseline studies. In the absence of any other suitable data, hatchling orientation metrics captured at Thevenard Island were selected as a conservative proxy for Direction Island.

Further context around these assumptions is provided in PENV 2023a,b.

Table 5: Relevant Key Studies for Marine Turtles

Studies and Surveys	Survey Area	Survey/Study effort
Value: Marine fauna (marine turtles) Management Objective: Minimise the risk of artificial light impacts to adult and hatchling marine turtles – no changes to nesting habitat utilisation, and adult and hatchling orientation		
Key Studies		
Pendoley Environmental (2023a) Ashburton Infrastructure Project: Benchmark Hatchling Turtle Orientation Report **Appendix C**	Ashburton Island, Bessieres Island and Thevenard Island.	Field survey summary report detailing: • Baseline adult nesting behaviour at survey islands (orientation behaviour). • Baseline nesting habitat utilisation by adult turtles (density and pattern of nesting). • Classification of baseline nesting activity (false crawls, nesting attempts and successful nests). • Classification of nesting species. • Identification of trigger and threshold criteria to meet EPA's objective- and outcome-based management provisions.
Pendoley Environmental (2023b) Ashburton Infrastructure Project: Baseline Adult Turtle Nesting Behaviour & Habitat Utilisation Report **Appendix D**	Ashburton Island, Bessieres Island, Thevenard Island and Direction Island.	Field survey summary report detailing: • Baseline hatchling orientation behaviour at survey islands. • Artificial light environment during the survey. • Identification of trigger and threshold criteria to meet EPA's objective- and outcome-based management provisions.
Pendoley Environmental (2023c) Ashburton Infrastructure Project: Baseline Adult Turtle and Benchmark Hatchling Turtle Orientation: Trigger and Threshold Criteria Memo **Appendix E**	N/A	Short technical report detailing: • Rationale for the development of outcome-based management provisions. • Trigger and threshold criteria to determine compliance with the environmental outcomes. • Response actions to trigger and threshold exceedances. • Ongoing monitoring and reporting requirements.
Supporting Studies		
Pendoley Environmental (2021) Ashburton Infrastructure Project: Artificial Light Monitoring and Modelling **Appendix A in Appendix B**	Ashburton River Delta Beach, Onslow Back Beach, Bessieres Island, Ashburton Island and Thevenard Island	Detailed artificial light assessment including: • Description of existing artificial light environment visible from turtle nesting habitat on mainland and island beaches, informed by an artificial light monitoring survey. • Description of modelled artificial light environment from the same locations using proposed lighting design for the Landside, Nearshore, and Offshore Development Envelopes.

1.8 Seabirds and Migratory Shorebirds

The Pilbara coast and islands provide ecologically important feeding, roosting, and breeding habitat for many species of resident and migratory seabirds and shorebirds.

Seabird species are those which spend most of their lives at sea, are highly pelagic or coastal, and forage on the ocean (Commonwealth of Australia 2017b). The Pilbara coast and islands provide habitat for resident and migratory species of terns, noddies, cormorants and wedge-tailed shearwaters.

Shorebirds are wader species which inhabit the shorelines of coasts and inland water bodies for most of their lives and are particularly associated with wetland habitat (Commonwealth of Australia 2017b). The Pilbara coast and islands provides habitat for resident and migratory shorebirds. Resident species include terns, plovers, curlews, oystercatchers, osprey, and white-bellied sea-eagles. Migratory species pass through the Region, which is part of the East Asian-Australasian Flyway (Bamford et al. 2008) on their way to northern Australia from breeding grounds in the Northern Hemisphere or wintering grounds in New Guinea. Migratory species include plovers, sandpipers, stints, curlews, knots, and godwits.

Threatened species are, in broad terms, those species that have been identified as being in danger of becoming extinct (Commonwealth of Australia 2012). Migratory species are those species that are listed under:

- The Convention on the Conservation of Migratory Species of Wild Animals 1979 (**CMS** or **Bonn Convention**).
- The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (**JAMBA**).
- The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (**CAMBA**).
- The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007 (**ROKAMBA**). Any other international agreement, or instrument made under other international agreements approved by the environment minister.

1.8.1 Threatening Process: Artificial Light

1.8.1.1 Seabirds

Species with a nocturnal component of their life history, such as procellariforms, include the wedge-tailed shearwater, that breeds on nearby offshore islands. These species are at greater risk of negative impacts. The bulk of the literature concerning impacts of lighting upon procellariforms 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), with fewer investigating the impacts of light at sea. Reports of interaction between seabirds and artificial light at sea is generally anecdotal following significant interaction events (e.g. Black 2005), or by unsystematic monitoring by oil and gas operators (e.g. Day et al. 2015; Glass & Ryan 2013; Wiese et al. 2001; Ronconi et al. 2015). Deck lights and spotlights on fishing vessels have been recorded attracting numerous seabirds at night, particularly on nights with little moon light or low visibility (Black 2005; Merkel & Johansen 2011; Montevecchi 2006).

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 (Deppe et al. 2017). It has been shown that all seabirds are sensitive in the shorter, violet – blue region of the visible spectrum (380 nm – 440 nm; Machovsky-Capuska et al. 2011). Wedge-tailed shearwater (*Ardenna pacifica*) eye structure is characterised by a high proportion of cones sensitive to shorter wavelengths between 406 nm and 566 nm (Hart 2001). There would be no ecological advantage to an abundance of long-wavelength-sensitive photoreceptors in species foraging in clear blue oceanic waters, as the optimum wavelengths for through surface water vision are between 425 and 500 nm (Hart 2001). Diurnal seabirds are aquatic foragers, displaying diverse foraging strategies including surface seizing and dipping, suggesting an evolutionary adaptation to high sensitivity in the shorter wavelengths (Hart 2001). However, white lights have the greatest impact upon seabirds as they contain all wavelengths of light (Rich & Loncore 2006; Deppe et al. 2017). Bright white deck lights and spot-lights on fishing vessels attract numerous seabirds at night, particularly on nights with little moon light or low visibility (Black 2005; Merkel & Johansen 2011;

Montevecchi 2006). The intensity of light may be a more important cue than colour as a very bright light will attract seabirds, regardless of the colour (Raine et al. 2007).

In an overview of seabirds and migratory shorebirds of the north-west marine region (Commonwealth of Australia 2012), bright lighting was found to disorient flying birds and subsequently cause their death through collision with infrastructure or starvation due to disruptions in the ability to forage at sea (Wiese et al. 2001). Light pollution is a particular issue for wedge-tailed shearwaters due to their nocturnal habits and migratory shorebirds as they undertake their migratory flights at night (Geering et al. 2007). Gas flares and facility lights on petroleum production and processing plants are a significant source of artificial lighting that attract seabirds (Wiese et al. 2001) and could potentially attract migrating shorebirds. Nesting birds may be disoriented where lighting is situated adjacent to rookeries. This is evident for young fledglings, in particular wedge-tailed shearwaters, leaving breeding colonies for the first time (Nicholson 2002). Bright lights can also impact on migrating birds. Illumination at night from artificial lights can reduce the extent of foraging behaviour in shorebirds (Thomas et al. 2004), potentially reducing their abilities to replace used energy reserves (body fat) or to prepare for breeding or migration.

1.8.1.2 Migratory Shorebirds

Shorebirds feed during both the day and night and increase their feeding in the lead-up to migration (Santiago-Quesada et al. 2014; Lourenço et al. 2008). Two basic types of foraging strategies have been described: visual and tactile (touch-based) foraging. Some species, such as sandpipers, switch from visual foraging during the day, to tactile foraging at night, likely due to poor night vision (Lourenço et al. 2008). However, other species, such as plovers, are better adapted to night vision and employ visual foraging strategies during both day and night (Lourenço et al. 2008). Accordingly, artificial lighting has been shown to influence the nocturnal foraging behaviour in shorebirds, often resulting in improved foraging success by increasing the availability of more successful visual foraging (Santos et al. 2010; Dwyer et al. 2013). Conversely, artificial lighting may also increase risk of predation to shorebirds potentially resulting in selection of nocturnal roost sites with lower levels of light (Rogers et al. 2006). It has been shown that the density of dunlin (*Calidris alpina*) in suitable foraging areas declined with increasing distance to the nearest roost site (Dias et al. 2006). In the great knot (*C. tenuiros*) and red knot (*C. canutus*), nocturnal roost sites with low exposure to artificial lighting were selected (e.g. streetlights and traffic), (Rogers et al. 2006). This indicates that artificial illumination of nocturnal roost sites may reduce occupation of these roost sites and consequently influence the abundance of shorebirds in nearby foraging areas.

Although research into the role of vision in foraging has been undertaken, the sensitivity of shorebirds to different wavelengths is poorly understood. It is possible that artificial illumination at any spectral output will alter foraging or nocturnal roosting behaviours, particularly in visual foragers, but the degree of impact will likely depend on the intensity of the light (Longcore et al. 2018).

Red light has been shown to impact migration of passerines (taxonomic order comprising songbirds) via disruption of magnetic orientation in the laboratory (Wiltschko et al. 1993) and in the field (Poot et al. 2008). No disruption to orientation was observed under blue or green light (Wiltschko et al. 1993). Some species of shorebird, such as waders, undertake long-distance migrations, with studies indicating that some species possess a magnetic compass and suggest that magnetic cues are of primary directional importance (Sanderling; Gudmundsson & Sandberg 2000).

1.8.2 Management Objectives

The management objective of this ALMP, with respect to seabirds and migratory shorebirds, is to minimise artificial light impacts on listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds.

1.8.3 Survey and Study Findings

Conditions under MS 1204 with respect to artificial light impacts were only relevant to adult and hatchling marine turtles, with no specific conditions for seabirds and migratory shorebirds. Therefore, surveys undertaken for the Project were tailored to understand light impacts on marine turtles.

However, Condition 10 of 2021/9064 requires the Proponent to consider light impacts on migratory bird species (**Table 4**), and as such a desktop review and impact assessment was undertaken in a previous version (**Rev 6, Appendix A**) of this ALMP.

The desktop assessment was considered sufficient to meet the objectives of Condition 10, and as a result no further studies or surveys have been undertaken for seabirds or migratory shorebirds for the Project.

1.8.4 Key Assumptions and Uncertainties

As no prescribed monitoring has been undertaken for seabird and shorebird species, it is assumed that the objective-based management provisions nominated for seabirds and shorebirds will be sufficient in minimising the risk of artificial light impacts on MNES in the vicinity of the Project. The objective-based management targets are founded on the Best Practice Lighting Principles recommended by the NLPGW (Commonwealth of Australia 2023), and compliance will be verified via repeated audits of Project lighting.

1.9 ALMP Management Approach

This ALMP provides a hybrid of an objective and outcome-based approaches to manage significant residual impacts on marine fauna, specifically marine turtles, seabirds and migratory shorebirds, from Project-related artificial lighting. Outcome-based provisions are applied where an achievable and measurable outcome can be established (EPA 2021). Objective-based provisions are applied where the monitoring of an action or target is more effective or appropriate than a measurable outcome (EPA 2021). This hybrid management plan will ensure that potential direct and indirect impacts to marine fauna from artificial light are not greater than predicted. Management provisions have been prioritised using a risk-based approach informed by best management practice and industry standards, with the aim of ensuring the risks of secondary or indirect impacts are minimised, typically to the level of 'as low as reasonably practicable' (**ALARP**). Triggers for early response and adaptive management (**Section 6.1**) have been developed to further ensure the management objectives are achieved and performance is continually improved. Management actions (safeguards and controls) and performance targets have been assigned to ensure the associated objectives are achieved (**Section 2.1**).

Table 6 lists the key environmental factor and threatening process, management approach and rationale for the approach, that form the main scope of this ALMP.

Monitoring will be conducted to measure the environmental outcomes and management objectives to determine the effectiveness of management actions, notifying when trigger and threshold criteria are reached and/or flagging that response actions need to be implemented.

Table 6: Rationale for Provisions of Environmental Factors

Environmental Factor	Environmental Aspect	Management Provisions	Rationale for Provision
Marine Fauna	Artificial Light	Outcomes-based; and Objective-based.	Artificial light can alter the behaviour of listed marine fauna, specifically marine turtles, seabirds and shorebirds. Alteration of behaviour can result in reduced fitness of individuals, injury, or mortality, with the consequences exacerbated for individuals in early life stages (i.e. hatchling turtles or fledgling birds). Outcome-based and objective-based management provisions have been specified to minimise the impact of artificial light on the behaviour of light-sensitive marine fauna. • **Outcome-based Provisions:** Where specified by the EPA, trigger and threshold criteria have been developed for detecting light impacts on adult and hatchling turtle behaviour, with respective actions prescribed to avoid and otherwise minimise the detected impacts. Outcome-based provisions have only been determined for marine turtles as they are mentioned specifically by MS 1204 (**Table 4**). • **Objective-based Provisions**: Nominated objective-based provisions apply more generally to reducing the overall Project artificial light footprint, with the aim of minimising impacts to marine turtles, seabirds and shorebirds. They include implementing the Best Practice Lighting Principles as recommended by the National Light Pollution Guidelines for Wildlife (**Table 11**).

1.10 Risk Assessment

An assessment of the risk of potential impacts to MNES has been determined based on a risk management approach, modified from the Australian Standard for Risk Management (AS/NZS ISO 31000:2018).

Mineral Resources Limited, (**MinRes**, **The Proponent**) has adopted the mitigation sequence for environmental management, which involves avoiding, minimising, controlling, mitigating, and offsetting the significant residual impacts of mining activities on the environment.

The purpose of this ALMP is to:

- Identify environmental objectives and targets for the management of Marine MNES species and/or their habitats;
- Identify and assess risks and potential impacts to Marine MNES and their habitats where relevant to Project artificial lighting;
- Detail avoidance and mitigation measures; and
- Detail monitoring and reporting requirements and contingency actions if objectives and targets are not met.

A risk assessment was undertaken to assess the risk of construction and operation of the Project on MNES. Definitions for the categories used to determine the likelihood and consequence and the risk matrix used for the Proposal are provided in **Table 7**.

The following aspects were considered when determining the consequence of each potential impact:

- Type of impact (direct or indirect);
- Geographic extent, size, and scale;
- Duration, frequency, reversibility of the potential impact;
- Whether the potential impacts are from planned or unplanned events; and
- Sensitivity of the receptor/resource and the value of the receptor/resource.

1.10.1 Risk Analysis, Evaluation and Treatment

The potential impacts as described in **Section 1.5** have been assessed for MNES, including marine turtles, seabirds and shorebirds. The acceptability or otherwise of the assessed inherent risk level (that is, without any controls or management measures applied) and residual risk, following the application of management measures is presented in **Table 8**.

All risks identified as having a moderate or higher residual risk requiring detailed control measures are outlined within the of Project environmental risk assessment (**Table 9**). The full risk assessment conducted for MNES, and rationale for classification, is provided in **Appendix B** (Appendix A Page 24 to 33), including those scenarios where the residual risk rating was identified as low. A suite of management outcomes and measures have been developed to mitigate these risks. Specific management objectives and targets are presented in **Section 2**.

Table 7: Risk Matrix and Descriptors

		Consequence				
		Insignificant	Minor	Moderate	Major	Severe
Likelihood	Rare	Low	Low	Low	Moderate	Moderate
	Unlikely	Low	Low	Moderate	Moderate	High
	Possible	Low	Moderate	Moderate	High	High
	Likely	Moderate	Moderate	High	High	Extreme
	Almost Certain	Moderate	High	High	Extreme	Extreme

Likelihood	Frequency	Probability
Almost Certain	Expected to occur more or less continuously throughout a year (e.g. more than 250 days per year)	96 – 100 %
Likely	Expected to occur once or many times in a year (e.g. 1 to 250 days per year)	71 – 95 %
Possible	Expected to occur once or more in the period of 1 to 10 years	31 – 70 %
Unlikely	Expected to occur more than once in the period of 10 or more years	5 – 30 %
Rare	Expected to occur once or less over the Project life	0 – 5 %

Consequence	Description
Insignificant	Little to no impact on the overall ecosystem. Very small levels of impact on turtles, seabirds, or shorebirds and their habitats. Only occasional injury to, or mortality of, turtles.
Minor	Impacts are present, but not to the extent that the overall condition of turtle, seabird, and shorebird populations or their habitats are impaired in the long-term. Low levels of mortality of turtles and their habitats. Recovery would generally be measured in years for habitats.
Moderate	Turtle, seabird, and shorebird populations and their habitats are significantly affected, as outlined in the Significant Impact Guidelines (Commonwealth of Australia 2013). Medium levels of mortality of turtles and their habitats. Recovery at habitat level would take at least a decade, with recovery of turtles populations taking several decades.
Major	Significant impact on turtle, seabird or shorebird populations and their habitats, as outlined in the Significant Impact Guidelines (Commonwealth of Australia 2013), with high level of mortality. Recovery of habitats would take a few decades with populations taking several decades.
Severe	Turtle, seabird or shorebird habitat is irretrievably compromised. Mass mortality of turtles, seabirds or shorebirds, and local extinction of species. Recovery over several decades for habitat values and centuries for turtle, seabird or shorebird populations.

Table 8: Acceptability of Inherent Risk Level

Risk Level	Acceptability	Treatment
Extreme	Unacceptable	Risk will not be tolerated. Modification of activity required, and Project amended.
High	May be acceptable, with specific risk treatments	Risk may be tolerated with application of high reliability risk treatments. Environmental outcome / Closure objective required.
Moderate	Acceptable, with relevant risk treatments	Risk is tolerable with application of appropriate risk treatments. Environmental outcome / Closure objective required.
Low	Acceptable	Risk is acceptable, but still requires industry best practice environmental management.

Table 9: Assessment of Project Environmental Risks

Project Phase	Risk Pathway	Description of Impact	Avoidance and Mitigation Measures	Residual Risk		
				Likelihood	Consequence	Risk
Artificial lighting of vessels in anchorage, including: - Trans-shipment vessels - Ocean going vessels.	Artificial light causing misorientation or disorientation of hatchling turtles on Bessieres Island and Thevenard Island.	Resulting in the mortality of hatchlings due to exhaustion or predation.	• Reduce lumen output on vessels to as low as possible; • Reduce colour temperature to < 2700 K (from the 6500 K currently planned); • Shield all lights to prevent upward sky glow; and • Aim all lights so they are not directed towards Thevenard and Bessieres Islands.	Possible	Minor	Medium

2. ENVIRONMENTAL MANAGEMENT PLAN COMPONENTS

This section of the ALMP identifies the provisions that MinRes proposes to implement, to reduce construction and operational artificial lighting impacts on marine fauna. Management and monitoring provisions have been split into outcome-based (**Section 2.1.1**), where a specific measurable outcome incorporating threshold and trigger criteria is proposed, and objective-based (**Section 2.1.2**), relating to achievement of desired management targets/objectives.

2.1 Management Program

2.1.1 Outcome-based Provisions

Outcome-based provisions are performance based and are used where a potential impact on the environment is suited to object measurement and reporting. The outcome-based management provisions for marine turtles are provided in **Table 10**. Two outcome-based environmental criteria have been identified. For each of the criteria, trigger and threshold indicators, response actions, and corresponding monitoring and reporting requirements are described.

Table 10 includes a number of response actions to be implemented in situation where trigger and/or threshold criteria be exceeded to allow for the early intervention/implementation of management and/or contingency measures to prevent potential adverse impacts of artificial light on marine turtles. In addition to review and investigation activities, engineering / operational solutions to reduce problematic lighting (as identified by an independent audit) may include:

- Lowering emission intensity
- Altering colour temperature / spectral output;
- Installation additional shielding (cowling on individual lights or infrastructure solutions); and
- Implementing smart systems to reduce lighting use when not required.

An additional survey will be undertaken after implementation of any proposed actions to determine whether the actions have been successful. If engineering solutions fail, then intervention at impacted nesting habitat may be required and could include:

- Daily beach patrols during the nesting season to detect and relocate stranded/disoriented adult turtles; and
- Installation of temporary shielding on affected beaches during the hatching season to ensure emerging hatchling turtles reach the ocean.

Table 10: Marine Fauna: Marine Turtles – Outcome-based Management

EPA Factor	Marine Fauna				
EPA Objective	*To protect marine fauna so that biological diversity and ecological integrity are maintained.*				
Environmental Values	Marine Fauna – Marine Turtles				
Key Impacts	Increases in mortality rate of adult and hatchling turtles due to artificial light impacts				
Key Risks	• Misorientation or disorientation of adult turtles • Misorientation or disorientation of hatchling turtles • Changes in adult marine turtle nesting habitat utilisation				
Outcome	**Indicators (Trigger Criteria / Threshold Criteria)**	**Response Actions (Trigger level actions / • Threshold contingency actions)**	**Monitoring**	**Timing / Frequency of Monitoring**	**Reporting**
MS1204 **Condition B3-1(3)**: To minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island; and **Condition B3-1(4):** To minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate. **EPBC 2021/9064** **Condition 10:** The approval holder must implement the Artificial Light Impact Assessment and Management Plan (**ALMP**) for the life of the approval. By implementing the ALMP the approval holder must achieve the objectives of the ALMP to minimise artificial lighting impacts on listed marine fauna and listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds.					
There will be no significant increase (detectable difference) in adult marine turtle misorientation, disorientation, or nesting habitat utilisation at Ashburton, Thevenard, Direction or Bessieres Islands.	**Adult Nesting Behaviour: Length Ratio** Trigger criteria • Mean track length ratio at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.64 (± 2 standard deviations from the baseline mean). Threshold criteria • Mean track length ratio at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.97 (± 3 standard deviations from the baseline mean). **Adult Nesting Behaviour: Offset Angle (Down Track)** Trigger criteria • Mean offset angle of the 'down' track at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 60° (± 2 standard deviations from the baseline mean). Threshold criteria • The mean offset angle of the 'down' track ratio at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 80° (± 3 standard deviations from the baseline mean).	Trigger level action(s) (for length ratio or offset angle or sinuosity index): • If a single season of monitoring reports an exceedance in trigger criteria: Undertake an independent/external lighting audit that reviews all onshore/nearshore lighting, vessel movements, anchorage locations, and any other light-producing activities. The audit should recommend remedial actions for lighting where it appears to be excessive or causing significant impact. Remedial actions for problematic lighting (for onshore / nearshore infrastructure and TSVs) will be implemented prior to the next turtle seasons and may include: – changing the colour or wavelength – reducing the emission intensity – implementing additional shielding – implementing smart systems to reduce lighting use when it is not required. Remedial actions will be implemented prior to the next marine turtle nesting season.	Indicators: Length ratio, offset angle, or sinuosity index. Adult nesting behaviour monitoring will be conducted seasonally at Thevenard, Bessieres, Direction and Ashburton Islands (**Section 2.2.1**).	Adult turtle surveys will be undertaken over a 10-day period in the peak nesting season for flatback and green turtles. Monitoring will be undertaken each nesting season for five years during construction and post construction (operations). If threshold criteria are exceeded, additional seasons of monitoring may be required pending the outcome of a desktop review (as outlined in **Section 6**).	Annual reports on results of the monitoring survey, assessing against trigger and threshold criteria.

Outcome	Indicators (Trigger Criteria / Threshold Criteria)	Response Actions (Trigger level actions / • Threshold contingency actions)	Monitoring	Timing / Frequency of Monitoring	Reporting
	Adult Nesting Behaviour: Sinuosity Index Trigger criteria • Mean sinuosity index at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.15 (± 2 standard deviations from the baseline mean). Threshold criteria • Mean sinuosity index at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.20 (± 3 standard deviations from the baseline mean).	• If two consecutive seasons of monitoring report an exceedance in trigger criteria: Undertake review of artificial light monitoring, adult nesting behaviour, and habitat utilisation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions. Remedial actions will be implemented during the next marine turtle nesting season and may include intervention in adult nesting activities to prevent or reduce the impact to a level below the trigger criteria (e.g. daily beach patrols to detect and relocate stranded adult turtles). Threshold contingency action(s) (for length ratio or offset angle or sinuosity index): • If any season of monitoring reports an exceedance in threshold criteria: 1. Undertake an independent/external lighting audit that reviews all onshore/nearshore lighting, vessel movements, anchorage locations, and any other light-producing activities. The audit should recommend remedial actions for lighting where it appears to be excessive or causing significant impact. Remedial actions for problematic lighting (for onshore / nearshore infrastructure and TSVs) be implemented prior to the next marine turtle nesting season and may include: – changing the colour or wavelength – reducing the emission intensity – implementing additional shielding – implementing smart systems to reduce lighting use when it is not required. 2. Undertake a review of artificial light monitoring, adult nesting behaviour, and habitat utilisation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions. Remedial actions may include intervention in adult nesting activities to prevent or reduce the impact to a level below the trigger criteria (e.g. daily beach patrols to detect and relocate stranded adult turtles) and will be implemented during the next marine turtle nesting season.			

Outcome	Indicators (Trigger Criteria / Threshold Criteria)	Response Actions (Trigger level actions / • Threshold contingency actions)	Monitoring	Timing / Frequency of Monitoring	Reporting
There will be no significant increase in hatchling marine turtle misorientation or disorientation at Bessieres, Thevenard, Ashburton or Direction Islands.	**Hatchling Orientation: Spread Angle** Trigger criteria • Bessieres Island: The mean spread angle exceeds 51° and the lower bound (95 % highest posterior density interval) is below 51°. • Thevenard Island: The mean spread angle exceeds 57° and the lower bound (95 % highest posterior density interval) is below 57°. • Ashburton and Direction Islands: The mean spread angle exceeds 51° and the lower bound (95 % highest posterior density interval) is below 51°. Threshold criteria • Bessieres Island: The lower bound spread angle (95 % highest posterior density interval) exceeds 51°. • Thevenard Island: The lower bound spread angle (95 % highest posterior density interval) exceeds 57°. • Ashburton and Direction Islands: The lower bound spread angle (95 % highest posterior density interval) exceeds 51°. **Offset Angle** Trigger criteria • Bessieres Island: The mean offset angle exceeds 10.9° and the lower bound (95 % highest posterior density interval) is below 10.9°. • Thevenard Island: The mean offset angle exceeds 15.2° and the lower bound (95 % highest posterior density interval) is below 15.2°. • Ashburton and Direction Islands: The mean offset angle exceeds 10.9° and the lower bound (95 % highest posterior density interval) is below 10.9°. Threshold criteria • Bessieres Island: The lower bound offset angle (95 % highest posterior density interval) exceeds 10.9°. • Thevenard Island: The lower bound offset angle (95 % highest posterior density interval) exceeds 15.2°. • Ashburton and Direction Islands: The lower bound offset angle (95 % highest posterior density interval) exceeds 10.9°.	Trigger level action (for spread or offset angle at any monitoring location). If a single season of monitoring reports an exceedance in trigger criteria: Undertake an independent/external lighting audit that reviews all onshore/nearshore lighting, vessel movements, anchorage locations, and any other light-producing activities. The audit should recommend remedial actions for lighting where it appears to be excessive or causing significant impact. Remedial actions for problematic lighting (for onshore / nearshore infrastructure and TSVs) will be implemented prior to the next marine turtle hatching season and may include: – changing the colour or wavelength – reducing the emission intensity – implementing additional shielding – implementing smart systems to reduce lighting use when it is not required. • If two or more consecutive seasons of monitoring report an exceedance in trigger criteria: Undertake review of artificial light monitoring and hatchling orientation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions. Remedial actions will be implemented during the next marine turtle hatching season and may include intervention in hatchling emergence to prevent or reduce the impact to a level below the trigger criteria (e.g. installing temporary shielding on the beach during hatching season). Threshold criteria action (for spread or offset angle at any monitoring location) • If any season of monitoring reports an exceedance in threshold criteria: 1.Undertake an independent/external lighting audit that reviews all onshore/nearshore lighting, vessel movements, anchorage locations, and any other light-producing activities. The audit should recommend remedial actions for lighting where it appears to be excessive or causing significant impact. Remedial actions for problematic lighting (for onshore / nearshore infrastructure and TSVs) will be implemented during the next marine turtle hatching season and may include: – changing the colour or wavelength – reducing the emission intensity – implementing additional shielding – implementing smart systems to reduce lighting use when it is not required. 2. Undertake a review of artificial light monitoring and hatchling orientation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions. Remedial actions may include intervention in hatchling emergence to prevent or reduce the impact (e.g. installing temporary shielding on the beach during hatching season). Remedial actions will be implemented during the next marine turtle nesting season.	Indicators: Spread angle, offset angle Hatchling orientation monitoring will be conducted seasonally at Thevenard, Bessieres, Direction and Ashburton Islands (**Section 2.2.2**). Artificial light monitoring will be conducted seasonally at Thevenard, Bessieres, Direction and Ashburton Islands concurrently with hatchling orientation monitoring.	Hatchling surveys undertaken for a 14-day period over a new moon in the peak hatching season for flatback and green turtles. Artificial Light monitoring and hatchling surveys will be undertaken each hatchling season for five during construction and post construction (operations).If threshold criteria are exceeded, additional season of monitoring may be required pending the outcome of a desktop review (as outlined in per **Section 6.2**). Additional surveys may be required in event adequate samples are not collected (as outlined in **Section 6.3**).	The first post-construction season Annual Report will verify light model outputs, including onshore and offshore light sources. One annual report on results of the monitoring survey (including artificial light), assessing against trigger and threshold criteria.

2.1.2 Objective-based Provisions

The Purpose of the Marine Fauna - Objective-based Management Plan is to meet Condition C5 of MS 1204. **Table 11** outlines the rationale for the proposed outcomes-based management indicators, actions and monitoring for Marine Fauna. As there are no specific conditions under MS 1204 for seabirds and shorebirds, Condition 10 of EPBC:2021/9064 is also included in this management framework.

The Management Actions demonstrated in **Table 11** are the same as the Lighting Design Control Measures (**Section 5.2** of **Appendix B**) approved under 2021/9064, and as such the objective-based management provisions are applicable to both State and Commonwealth approvals.

Table 11: Marine Fauna - Objective- based Management

EPA Factor/s	Marine Fauna
EPA Objective/s	*To protect marine fauna so that biological diversity and ecological integrity are maintained.*
Environmental Values	Marine Fauna – Marine Turtles, Seabirds and Migratory Shorebirds
Key Impacts	Reduced fitness and mortality of marine turtles, seabirds and migratory shorebirds in response to artificial light pollution.
Key Risks	• Misorientation or disorientation of adult turtles • Misorientation or disorientation of hatchling turtles • Changes in adult marine turtle nesting habitat utilisation • Interactions between seabirds or shorebirds and artificial light sources, causing disorientation or grounding of fledglings. • Mortality or injury caused from seabird or shorebird collision with artificially lit infrastructure. • Starvation due to disruptions in the ability of seabirds and shorebirds to forage at sea and onshore.

Management Target	Management Action	Monitoring	Timing (Project Phase)	Timing / Frequency of Monitoring	Reporting	Contingency Action if Target(s) not Met
MS1204 **Condition B3-1(3):** To minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island; and **Condition B3-1(4):** To minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate. **EPBC 2021/9064** **Condition 10:** The approval holder must implement the Artificial Light Impact Assessment and Management Plan (**ALMP**) for the life of the approval. By implementing the ALMP the approval holder must achieve the objectives of the ALMP to minimise artificial lighting impacts on listed marine fauna and listed migratory bird species in accordance with the National Light Pollution Guidelines for Wildlife Including marine turtles, seabirds and migratory shorebirds.						
Use the minimum number and intensity of lights	A comparative assessment of lighting designs to identify the minimum number and intensity of lights required to meet lighting objectives.	• On-site audits of Project facility lighting to ensure compliance against the management target. • Implement the Bird Interaction Procedure (Appendix C of **Appendix B**) during wedge-tailed shearwater fledging window.	• Construction (for bird interaction monitoring). • Operations (for on-site audits and bird interaction monitoring).	• Regular inspections in construction period during wedge-tailed shearwater fledging window. • At least one annual internal audit at least six weeks prior to every marine turtle nesting season which begins in October. • One external audit every three years at least six weeks prior to the marine turtle nesting season. • Additional audits to be scheduled as necessary (e.g. following major weather events or major changes in Project facilities or buildings).	• Inspections and audits; • Fauna sighting and incident reporting; • Incident Classification and Reporting Procedure (MRL-OHM-PRO-0007); • Incident Report Form (MRLOHM-FRM-0002); • Compliance Assessment Report (**CAR**); and • Annual Compliance Report (**ACR**). One report following the external lighting audit every three years demonstrating compliance against the management target or where remedial actions are required.	Undertake remedial actions in line with recommendations from both annual internal audit reports and triennial external audit reports, such as replacing or modifying lighting fixtures where required, prior to the next marine turtle nesting season.

Management Target	Management Action	Monitoring	Timing (Project Phase)	Timing / Frequency of Monitoring	Reporting	Contingency Action if Target(s) not Met
Adapt lighting for colour, intensity and timing	• Lights situated seaward of the dune at the Port to utilise amber LED emitters (~585 nm 'true amber' emitters, 'phosphor-coated amber'). • Lights situated landward of the dune at the Port and above 10 m height, to utilise amber LED emitters (~585 nm 'true amber' emitters, 'phosphor-coated amber'). • Lights situated landward of the dune <10 m and where there is a need for good colour rendition, to utilise LEDs with a Correlated Colour Temperature (CCT) equal to or lower than 2700K. • All TSV lights to have a CCT lower than 2700K. • Red and green lights only used where required by navigation law. • If specific, intermittent tasks require a brighter white light (i.e. higher CCT), personnel are to use head torches. • Lighting design to identify lights that are not required to be continuously lit for TSVs and vessels under MinRes operational control. • Lights that are not required to be continuously lit to be motion activated, put on a timer, or can be manually switched off (including on TSV / OGVs). • Flashing/intermittent lights, or reflectors to be installed onshore instead of fixed beam to identify an entrance or delineate a pathway.	• On-site audits of Project facility lighting to ensure compliance against the management target. • Internal/external audits to be undertaken will include TSVs and other MinRes-controlled vessels to ensure TSVs are adhering to management actions. • Implement the Bird Interaction Procedure (Appendix C of **Appendix B**) during wedge-tailed shearwater fledging window.	Construction (for bird interaction monitoring) Operations (for on-site audits and bird interaction monitoring)	• Regular inspections in construction period during wedge-tailed shearwater fledging window. • At least one annual internal audit at least six weeks prior to every marine turtle nesting season which begins in October • Annual internal audits include TSVs and other MinRes-controlled vessels. • One external audit every three years at least six weeks prior to the marine turtle nesting season • Additional audits to be scheduled as necessary (e.g. following major weather events or major changes in Project facilities or buildings)	• Inspections and audits; • Fauna sighting and incident reporting; • Incident Classification and Reporting Procedure (MRL-OHM-PRO-0007); • Incident Report Form (MRLOHM-FRM-0002); • CAR; and • ACR. One report following the external lighting audit every three years demonstrating compliance against the management target or where remedial actions are required.	Undertake remedial actions in line with recommendations from both annual internal audit reports and triennial external audit reports, such as replacing or modifying lighting fixtures where required, prior to the next marine turtle nesting season.

Management Target	Management Action	Monitoring	Timing (Project Phase)	Timing / Frequency of Monitoring	Reporting	Contingency Action if Target(s) not Met
Light only the area intended	• All lights to be directed downwards using targeted asymmetrical distribution to illuminate only the specific areas of need, while minimising the reflectance at the Port, on TSVs and vessels under MinRes operational control. • All lights to be mounted at a height as low as possible while meeting lighting objectives at the Port, on TSVs and vessels under MinRes operational control. • The existing vegetation and dune profile in proximity to the Port to be maintained and enhanced where feasible. • Onshore Port lights to be directed away from turtle nesting habitat. For lights required to be directed in the direction of the habitat, lights should be placed so that buildings provide inherent shielding, where practicable. • OGV and TSV lights to be directed downwards and direct light spill onto the ocean surface avoided unless operationally required. • OGV and TSV lights should be aimed to prevent light being directly visible from nesting beaches. • Jetty and gantry design to prevent gaps in the floor which would result in light shining directly onto the ocean below the gantry and jetty, were compliant with technical and safety requirements. • Shielding of all lights to achieve an upward waste light output ratio (ULR) of 0 %. Shielding can be achieved by recessing the light fitting into roof structures, eaves or building ceilings, or the light housing which prevents horizontal light above a 45-degree angle at the Port, on TSVs and vessels under MinRes operational control. • All glass (windows/doors) of buildings to have a glass light transmissivity rating of 0.5 or less at the Port, on TSVs and vessels under MinRes operational control. • All glass (windows/doors) of buildings to have opaque (block-out) blinds/curtains/shutters fitted at the Port, on TSVs and vessels under MinRes operational control. • OGV and TSV windows fitted with opaque (block-out) blinds/curtains/shutters unless continuous visibility is required (e.g. on the bridge).	• On-site audits of Project facility lighting to ensure compliance against the management target. • Internal/external audits to be undertaken will include TSVs and other MinRes-controlled vessels to ensure TSVs are adhering to management actions. • Implement the Bird Interaction Procedure (Appendix C of **Appendix B**) during wedge-tailed shearwater fledging window.	Construction (for bird interaction monitoring) Operations (for on-site audits and bird interaction monitoring)	• Regular inspections in construction period during wedge-tailed shearwater fledging window. • At least one annual internal audit at least six weeks prior to every marine turtle nesting season which begins in October • Annual internal audits include TSVs and other MinRes-controlled vessels. • One external audit every three years at least six weeks prior to the marine turtle nesting season • Additional audits to be scheduled as necessary (e.g. following major weather events or major changes in Project facilities or buildings)	• Inspections and audits; • Fauna sighting and incident reporting; • Incident Classification and Reporting Procedure (MRL-OHM-PRO-0007); • Incident Report Form (MRLOHM-FRM-0002); • CAR; and • ACR. One report following the external lighting audit every three years demonstrating compliance against the management target or where remedial actions are required.	Undertake remedial actions in line with recommendations from both annual internal audit reports and triennial external audit reports, such as replacing or modifying lighting fixtures where required, prior to the next marine turtle nesting season.
Use of non-reflective, dark coloured surfaces	• Exterior finishes on all buildings to be matte and have a maximum reflective value of 30 %. • All other surfaces, including roads and conveyors within the port, to be matte and have a maximum reflective value of 30 %, unless not technically feasible or presents a health and safety risk.	On-site audits of Project facility lighting to ensure compliance against the management target.	Construction (for bird interaction monitoring) Operations (for on-site audits and bird interaction monitoring)	• Regular inspections in construction period during wedge-tailed shearwater fledging window. • At least one annual internal audit at least six weeks prior to every marine turtle nesting season which begins in October • One external audit every three years at least six weeks prior to the marine turtle nesting season • Additional audits to be scheduled as necessary (e.g. following major weather events or major changes in Project facilities or buildings)	• Inspections and audits; • Fauna sighting and incident reporting; • Incident Classification and Reporting Procedure (MRL-OHM-PRO-0007); • Incident Report Form (MRLOHM-FRM-0002); • CAR; and • ACR. One report following the external lighting audit every three years demonstrating compliance against the management target or where remedial actions are required.	Undertake remedial actions in line with recommendations from both annual internal audit reports and triennial external audit reports, such as replacing or modifying lighting fixtures where required, prior to the next marine turtle nesting season.

2.2 Monitoring Program

Monitoring of marine turtles will be conducted to meet the timing and outcomes outlined in **Table 10**. Adult and hatchling track metrics will be measured to determine compliance with the trigger and threshold criteria to determine if the AIP's artificial lighting is having an impact on marine turtle orientation behaviour, or nesting beach utilisation. **Section 2.2.1** and **Section 2.2.1** outline the metrics to be monitored for adult and hatchling turtles.

An adult turtle survey and a hatchling orientation survey will be undertaken each turtle nesting and hatchling season, over a five year period, during and post construction (i.e. during operations) at the same monitoring sites, and following the same methodology, as baseline artificial light surveys on adult turtles and hatchlings (**Section 1.7.3**, PENV 2023a,b.).

Artificial light monitoring (**Section 2.2.3**) will be undertaken concurrently with hatchling orientation monitoring (**Section 2.2.2**) for the specified timeframe (five seasons during construction and operations). By comparing with baseline data, annual monitoring results will be used to determine the influence of the operating AIP on the sea-finding ability of hatchling marine turtles and nesting adult turtles.

The Proponents commits to undertaking adult turtle and hatchling orientation surveys over a period of five years, during construction and commissioning (Year 1 and Year 2) and for a further 3 years during ramp up to 'steady state' operations (maintained in Years 3, 4 and 5). Monitoring during the first three years of steady state operations will ensure any changes to adult turtles and hatchlings behaviours, during sustained periods of most intense light emissions are identified.

Annual audits and the implementation of the adaptive management approach (**Section 6**), ensures any changes to the Projects 'steady state operations' will be identified and investigated to determine if environmental criteria or management objectives are being met, and where required suitable remedial control measure will be implemented.

Therefore, through the implementation of outcomes based (**Table 10**) and objective based (**Table 11**) management provisions, and through the application of an adaptive management approach whereby review and adjustment of management and mitigation targets will be undertaken to ensure desired outcomes or objectives can be achieved (**Section 6**), the Proponent can demonstrate that the environmental objectives as outlined in MS 1204 Conditions B3-1(3) and B3-1(4) for the life of the Proposal can be met.

Section 2.2.4 outlines the procedure to be implemented to provide the best possible outcomes for reducing light interactions with most migratory shorebird species from artificial light interaction at the AIP.

2.2.1 Adult Turtles

Locations proposed for monitoring include Ashburton Island (due to it being in closest proximity to the Port and the TSV navigation route), Direction Island, Thevenard Island, and Bessieres Island (due to its area of critical marine turtle habitat, multi-species use, and proximity to the anchorage area and TSV navigation route). Methodology for monitoring the orientation of adult turtles will include the measurement of their tracks pre- and post-nesting (i.e. the next day) via the use of aerial imagery captured by an Unmanned Aerial Vehicle (**UAV**). Analysis will involve the use of GIS to measure the following data parameters for each identified marine turtle track (all species) in the imagery within a designated monitoring area at each surveyed location:

- Track length ratio: The length of the nesting marine turtle's 'up' and 'down' track for each emergence on the beach will be measured and compared. To ensure consistency, the 'up' track will be measured from a delineated line on the beach (e.g. spring high tide line) to their nest site, and the length of the 'down' track will be measured from the nesting pit on the beach to the same delineated line. The hypothesis is that if the sea-finding behaviour of adult nesting turtles is influenced or impacted by artificial light, their 'down' track will be substantially longer than their 'up' track. Note that this ratio is only calculated for marine turtle emergences that featured no prior nesting attempts because the length of the 'up' track will be biased.
- Offset angle of the down track: The bearings from the nesting pit to the point the turtle's 'down' track intersects a 5 m distance buffer from the nesting pit, and from the nesting pit directly to the ocean, will be measured. The offset angle between the two bearings will then be calculated. The hypothesis is that if the initial sea-finding behaviour of a nesting turtle i.e. within the first 5 m after departing the nesting pit, is influenced by artificial light, the offset angle between the bearing of the 'down' track and the direct bearing to the ocean will increase due to misorientation.

- Sinuosity Index: The sinuosity index is a measure of how much the 'down' track deviates from a straight line and is calculated by dividing the length of the 'down' track (as per the length ratio described above) by the straight-line distance between the nesting pit and the point the 'down' track intersects a delineated tide line on the beach. A sinuosity index of 1 indicates a perfectly straight line, while a value >1 indicates a more sinuous track. The hypothesis is that if the sea-finding behaviour of an adult nesting turtle during the entirety of their crawl to the ocean is influenced or impacted by artificial light, the turtle may crawl in a more circuitous fashion resulting in a sinuosity index substantially greater than 1.

The survey length should be a minimum of 10 days. Note that no consideration will be given to the lunar phase at the time of monitoring on the basis that there is no evidence that suggests the vulnerability of adult turtles to the influence of artificial light differs across a lunar phase (unlike the case for hatchling turtles).

2.2.2 Hatchling Turtles

Locations selected for monitoring include Ashburton Island (due to it being in closest proximity to the Port and the TSV navigation route), Thevenard Island, and Bessieres Island (due to its area of critical marine turtle habitat, multi-species use, and proximity to the anchorage area and TSV navigation route), and Direction Island.

Methodology for monitoring the orientation of hatchlings will include the measurement of their tracks post-hatching (i.e. the next day) to assess two metrics; spread angle and offset angle (**Figure 2**) as follows:

- Spread angle: This describes track dispersion from the emergence point, capturing the spread of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean finding bearings and may indicate disruption to natural hatchling sea finding ability.
- Offset angle: This describes the degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e. less deviation from the most direct route) and a larger value demonstrates greater deviation from the most direct route, which may indicate disruption to natural hatchling sea finding ability.

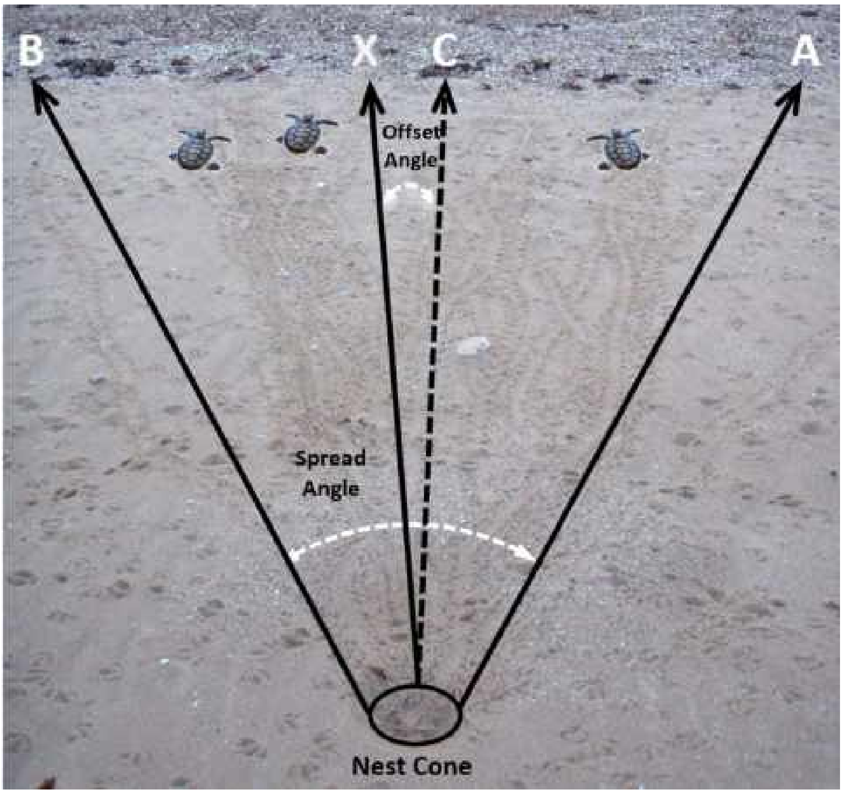


Figure 2: Hatchling Orientation Indices

A nest fan will be recorded if five or more hatchling tracks are sighted from a hatched clutch, indicated by a localise depression in the sand which marks the point of emergence. A sighting compass will be used to measure the bearing of the outermost tracks of the nest fan and the bearing of the most direct route to the ocean. Bearings will be measured from either the point where the track crosses the high tide line, or five metres from the clutch emergence point (whichever distance is shortest). The survey length should be a minimum of 14 days and be focused around a new moon period during the nesting season. Hatchling orientation metrics can alternatively be collected by the use of in-situ controlled release of hatchlings within an arena at night.

2.2.3 Artificial Light Monitoring

Artificial light monitoring will be undertaken concurrently with hatchling orientation monitoring **(Section 2.2.2**) for the specified timeframe (annually for a period of 5 years post construction). Light monitoring locations include Thevenard Island, Bessieres Island, Ashburton Island and Direction Island in accordance with the methodology outlined in Section 2, of Appendix A: Ashburton Infrastructure Project: Artificial Light Monitoring and Modelling Technical Report in **Appendix B**.

Artificial light data will be gathered at each survey location using ky42™ light monitoring cameras deployed at all survey locations on each survey day and will be programmed to automatically begin taking photos in 15-minute intervals between sunset and sunrise. Images were downloaded from the cameras every second day.

All suitable images will be processed using specialised software to determine "whole-of-sky" and "horizon" sky brightness levels. Whole-of-sky (WOS) is the mean value of sky glow in the entire image, and horizon is the mean value of sky glow within the 60° – 90° outer band. All images will be quantified in units of visual magnitudes per arc second^2 (V mag), a common unit used to measure astronomical sky brightness that represents light intensity on an inverse logarithmic scale.

Comparison of annual artificial light monitoring data will be compared against benchmark artificial light data to determine any increase in brightness (%) for WOS and Horizon, Sky Brightness Metric (Pendoley 2021, Appendix A of **Appendix B)**.

2.2.4 Seabird and Migratory Shorebirds

Based on the results of the impact assessment (i.e., low residual impacts, **Section 4.4 in Appendix B**), construction and operational monitoring of seabirds and shorebirds has been proposed for the AIP.

Bird interactions will be recorded when encountered during construction and operations, and MinRes will keep a register of the species and outcome of each interaction, such as the location of the interaction, and if the interaction resulted in mortality of the individual.

If bird interaction records indicate that certain species are more vulnerable, or certain areas of the AIP experience higher frequency of interactions with birds, identification of 'problem lights' will be made using the results of the artificial light monitoring and auditing.

Bird interactions should be handled in accordance with the Bird Interaction Procedure developed for the Project in Appendix C of the ALMP V6 (**Appendix B**).

3. ENVIRONMENTAL REPORTING

3.1 Incident Reporting

All employees of MinRes and Contractors shall immediately report all environmental incidents and observations as a non-conformance, whether these are reportable or non-reportable incidents (i.e., performance indicators are not met, or management actions are not followed) to the Contractor site supervisor, who will investigate the incident with both the Contractor Project Manager (Contractor PM) and MinRes Registered, Project and Construction Managers (MinRes PM).

Reportable incidences include live adult turtle strandings, and where audits determine management actions required in response to exceedances in adult/hatchling turtle indices have not been implemented. Incidents are to be reported to Contractor PM and / or the MinRes PM, whereby the MinRes General Manager Environment (or delegate) will notify the relevant regulatory agencies including DBCA, DWER and DCCEEW.

Events that either cause or have the potential to cause harm or contamination of the environment will be recorded and investigated as stipulated in the Incident Classification and Reporting Procedure (MINRES-OHM-PRO-0007). The MinRes Incident Report Form (MINRES-OHM-FRM-0002) shall be used to report all incidents occurring on the Project to the MinRes system. In addition, Projects may also be required to, either by contract or by client requirements, to complete and submit a client report form. Projects are required to maintain a register of all incidents in INX, which include:

- Initial Incidents are logged in INX within 24 hours;
- All relevant documents and photos are uploaded with the report; and
- Incidents are monitored, updated and closed out within the required timeframes.

Incidents are classified with a potential consequence ranking between 1 (minor) and 5 (major). For incidents with a potential consequence ranking of 3 or greater, a Formal Root Cause ICAM Investigation shall be undertaken in accordance with the standard ICAM methodology and shall be led by a trained and competent ICAM facilitator.

Corrective and preventative actions arising from an incident investigation shall be recorded within the incident record on INX for monitoring to closeout. For high potential events, a review of all corrective actions associated with high potential events will be followed up within three (3) months of the incident date to ensure the risks have been effectively controlled.

All regulatory reporting for the AIP shall be undertaken by the Client, the Registered Manager, or a person having control of a workplace or delegate.

3.2 Non-Compliance Reporting

It should be noted that for the purposes of this ALMP, failure to achieve an environmental outcome, or the exceedance of a threshold criteria, regardless of whether threshold contingency measures have been or are being implemented, represents a non-compliance with MS1204 and EPBC 2021/9064 conditions (Condition clauses C4-2 and C5-5; Condition 24, 25, 33, 34 and 35, **Table 4**).

In the event of a non-compliance under MS1204, MinRes will (in accordance with Condition clause D1-1):

- Report the non-compliance to the CEO within seven (7) days;
- Implement contingency measures;
- Investigate the cause;
- Investigate environmental impacts;
- Advise rectification measures to be implemented;
- Advise any other measures to be implemented to ensure no further impact; and
- Provide a report to the CEO within twenty-one (21) days of being aware of the potential non-compliance, detailing the measures outlined above.

In the event of a non-compliance under EPBC:2021/9064, MinRes will (in accordance with Condition 33, 34 and 35):

- Report the non-compliance to the DCCEEW electronically within five (5) days
- Specify in the electronic non-compliance notification:
  - Any condition or commitment made in a Management Plan(s) which has been or may have been breached.
  - A short description of the incident and/or potential non-compliance and/or actual noncompliance.
  - The location (including co-ordinates), date, and time of the incident and/or non-compliance.
- Implement contingency measures;
- Investigate the cause;
- Investigate environmental impacts;
- Advise rectification measures to be implemented;
- Advise any other measures to be implemented to ensure no further impact; and
- Provide a report to the DCCEEW within twenty-one (21) of becoming aware of any incident and/or potential non-compliance and/or actual noncompliance, the details of that incident and/or potential non-compliance and/or actual non- compliance with the conditions or commitments made in a Management Plan(s). The approval holder must specify:
  - Any corrective action or investigation which the approval holder has already taken;
  - The potential impacts of the incident and/or non-compliance and/or non-compliance; and
  - The method and timing of any corrective action that will be undertaken by the approval holder.

Contingency measures proposed as part of the adaptive management framework are provided for in **Table 11** of **Section 2.1**.

3.3 Annual Compliance Reporting

Annual Compliance Reporting will be undertaken for the Project in line with regulatory requirements and relevant guidance documentation including the Annual Compliance Assessment Report (**CAR**) and Annual Compliance Report (**ACR**). The annual reports will document monitoring outcomes and compliance with approval conditions imposed on the Project as well as requirements stipulated in this ALMP and as required under MS 1204 Condition D2-1 and Condition D2-4.

- MinRes will publish environmental performance reports and research findings, from monitoring programs that address knowledge gaps regarding the imitation measure implemented to reduce impacts of artificial light generation on marine turtles, seabirds and migratory shorebirds as required under:

- MS 1204 Condition C3-2, C4-1 and C5-2 annual within the CAR; and
- EPBC 2021/9064 Conditions 26, 27, 28, 29, 30 and 31 within the ACR.

The reporting period for the MS 1204 CAR's is 3 July to 2 July as per Condition D2 and will be submitted (electronically) to the CEO of the DWER by 2 October of the corresponding reporting year to meet the requirements of Condition D2-3.
The reporting period for the ACR under EPBC:2021/9064 is 12 December to 11 December as per Condition 29 requirements and will be submitted (electronically) to the Minister by 8 March (i.e. 60 business days following the 11 December) to meet the requirements of Condition 32.

4. ROLES AND RESPONSIBILITIES

All our people are responsible for ensuring they comply with the company's environmental management requirements and that any action or inaction on their part does not result in harm to the environment. Delegation of responsibilities may occur to ensure that environmental management activities are co-ordinated at an appropriate level, however, accountability remains with the person designated those responsibilities. MinRes also expects this general principle of line management accountability to apply to all its Contractors. Key roles and responsibilities relevant to the Project include the below.

Table 12: Roles and Responsibilities Relevant to the Project

Title	Responsibilities
Managing Director, Chief Operating Officer, Executive General Managers.	The Executive General Manager (Project Services) and/or Project Director will be responsible for: • Providing the necessary resources to effectively implement this ALMP; • Endorsing and supporting the Environmental Policy, this ALMP; • Taking strategic actions to continuously improve the ALMP; and • Reviewing the ALMP performance and implementation of corrective actions in the event of breaches of associated MS1204 and EPBC:2021/9064 conditions that may lead to serious impacts on local communities or affect the reputation of the Project.
General Manager Environment	Responsibility for: • Reviewing the ALMP in alignment with the defined review schedule; • Communicating the requirements of the ALMP to site personnel; • Ensuring Environment inductions are undertaken in accordance with the ALMP; • Managing environmental monitoring programs as required by this ALMP; • Identify and implement corrective and preventative actions after incidents and share lessons learned within the relevant personnel; and • Reviewing and monitoring corrective and preventative actions resulting from audits, incidents, and non-conformances.
Site Environmental Personnel	Responsible for environmental management and control of all activities relating to the execution of the works including work undertaken by subcontractors; • Assisting in the development and delivery of environmental training for site personnel and subcontractors; • Supporting the Environment Manager with environmental incident investigations and any other relevant tasks; • Providing environmental advice to other site personnel; • Coordinate monitoring, inspections, and audits in accordance with this ALMP.
Contractor / Construction Managers	The Contractor / Construction Manager/s will be responsible for: • Overall accountability for auditing and compliance assessment to ensure objectives and targets are achieved; and • Comply with all legal requirements and the requirements of the ALMP.
All Personnel	• Must receive induction prior to commencement of work on site; • Report incidents to their Construction Contractor supervisor or MinRes Project Manager; • Attend environmental inductions and any other training required; and • Participate in toolbox meetings and suggest improvements to management measures as required.

5. SYSTEM REQUIREMENTS

5.1 Management System

MinRes implements an Environmental Management System (**EMS**) to manage impacts associated with mining operations, identify and manage compliance, and address risks.

The purpose of the ALMP is to support the AIP's Framework Environmental Management Plan (**FEMP**). The FEMP outlines the programme for MinRes to effectively manage environmental factors in all its construction and operational activities on the haul road and to meet its legal obligations. As well as managing the risk of unintended or unnecessary environmental impact, this plan also seeks to reduce or eliminate the business risk associated with poor environmental outcomes at its operations.

The EMS is aligned with the international standard for EMS - ISO 14001:2015. The EMS shall be continuously updated and amended to ensure:

- MinRes's objectives and targets are defined;
- Legal obligations are understood and adhered to;
- MinRes's environmental management activities are consistent; and
- **A commitment to driving environmental management is demonstrated.**

Figure 3 outlines the main features of the EMS. Environmental improvement is driven using the Plan-Do-Check-Act (**PDCA**) model.

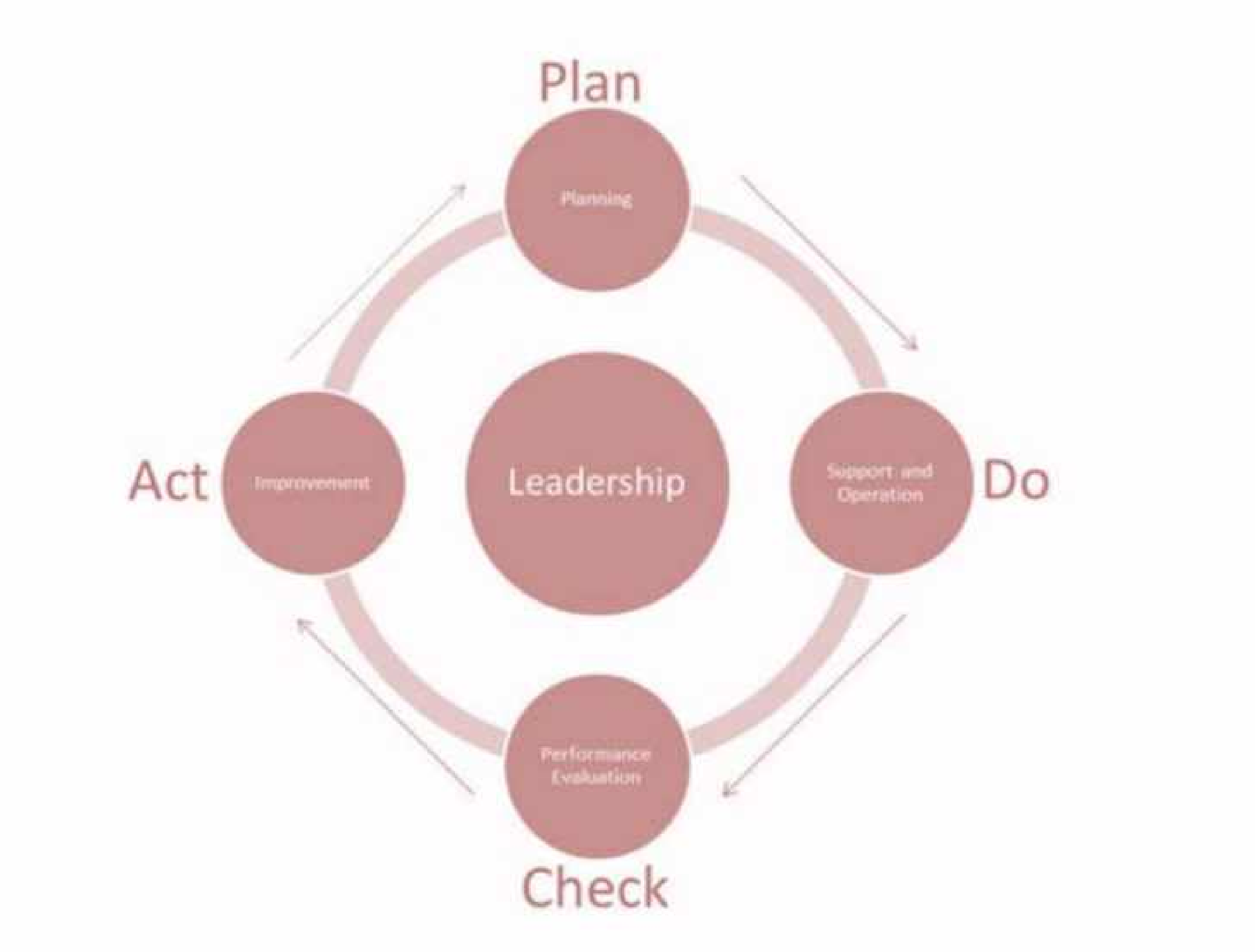


Figure 3: Environmental Improvement Plan-Do-Check-Act (PDCA) Model

5.2 Competence, Training and Awareness

MinRes will ensure that all personnel have the awareness, understanding, competence and skills appropriate to their role and responsibilities. General guidance on training and awareness requirements is given as follows:

Table 13: Training and Awareness Requirements

Title	Responsibilities
Managing Director, Chief Operating Officer, Executive General Managers	• Awareness of environmental legislation; • Understanding of national and international trends in the approach to environmental issues relevant to MinRes businesses; and • Understanding of MinRes' approach to environmental management, as outlined in this ALMP.
General Manager Environment	• Awareness of environmental legislation; • Understanding of national and international trends in the approach to environmental issues relevant to MinRes businesses; • Knowledge of EMS and principles of ISO 14001; and • Understanding of MinRes' approach to environmental management, as outlined in this ALMP.
Manager Environment	• Detailed knowledge of EMS and principles of ISO 14001; • Detailed understanding of MinRes' approach to managing environmental aspects relevant to site. Ability to undertake environmental audits; and • Ability to conduct incident investigations using Incident Cause Analysis Method (**ICAM**).
Registered, Project and Construction Managers	• Awareness of environmental legislation, particular licences, permits and approvals applicable to site; • Understanding of MinRes' approach to managing environmental aspects relevant to site; and • Understanding of MinRes' approach to environmental management, as outlined in this ALMP.
Superintendents and Supervisors	• Awareness of environmental legislation, particular licences, permits and approvals applicable to site; • Detailed understanding of MinRes’ approach to managing environmental aspects relevant to site; and • Ability to conduct incident investigations using ICAM.
Environmental Advisors	• Working knowledge of EMS and principles of ISO 14001; • Detailed understanding of MinRes’ approach to managing environmental aspects relevant to site. Ability to undertake environmental audits; • Ability to conduct incident investigations using ICAM; and • Specialist training (e.g. land rehabilitation techniques, fauna handling, water sampling and testing) appropriate to site.
Our People	• Awareness of MinRes’ approach to environmental management; • Awareness of environmental aspects relevant to site and their management; and • Specialist training (e.g. spill management) appropriate to site.

As a minimum, training comprises the corporate and site inductions, both of which contain an environmental component. Other training and awareness can be delivered through toolbox meetings, presentations, and refreshers.

An annual program of environmental training requirements must be developed and implemented.

All training records for the Business shall be maintained in the MinRes’ INX Safety System application. Contractors shall maintain their own records, and where requested, shall make these available to MinRes and Business Units.

Training records shall be made accessible to the individual and relevant departments such as Human Resources and Environment as appropriate.

As a minimum, training records should include details on who has been trained, what the training course covered, what competencies or qualifications were achieved or obtained, the identification of the provider and training duration.

6. ADAPTIVE MANAGEMENT AND REVIEW

The Proponent will utilise an adaptive management approach to ensure that implementation of mitigation measures, monitoring and assessment of trigger and threshold criteria are successful in ensuring that the environmental objectives and outcomes are being met. An adaptive management approach will also allow the Proponent to provide continuous improvements in response to learnings or changes in regulatory and corporate requirements.

The management approach will be based upon information gathered from:

- Evaluation of marine turtles, seabirds and migratory shorebirds monitoring data;
- Reviewing new information about artificial lighting technologies and equipment;
- Reviewing new information about artificial lighting impacts on marine turtles, seabirds and migratory shorebirds;
- Incident reports; and
- Changes to operations.

Adaptive management will involve:

- Implementing additional mitigation measures and/or corrective actions (as outlined in **Table 10** and **Table 11**);
- Monitoring and evaluation against management targets (including early response triggers) and environmental criteria (including triggers and thresholds) (as outlined in **Table 10** and **Table 11**); and
- Systematically adapting management and mitigation measures and monitoring to ensure the environmental outcomes or objectives are met.

If environmental criteria/management objectives are not being met, review and adjustment of management and mitigation targets will be undertaken to ensure desired outcomes or objectives can be achieved. If new information becomes available, it will be reviewed and where appropriate, incorporated into this ALMP.

Examples of adaptive management throughout operations include:

- The introduction of alternative monitoring initiatives to better understand parts of an ecosystem responding differently to that expected;
- The identification of more effective trigger criteria or early response triggers in light of more comprehensive monitoring information;
- Changes to management actions and targets in response to monitoring data; and
- Changes in technology.

6.1 Early Response Indicators, Criteria and Actions

MinRes propose to implement early response indicators as part of the adaptive management approach. Early response indicators provide information on changes that are precursors to an environmental impact. They also support improved understanding and identification of trends in environmental systems.

Early response actions have been established for both outcome-based and objective-based provisions and are provided in **Table 10** and **Table 11** in **Section 2.**

6.2 Review and Changes to an EMP

6.2.1 EP Act EMP

The confirmed ALMP will be reviewed after the first 12 months of implementation, and then on an annual basis thereafter, to ensure that the plan takes into consideration amendments to construction or operations, monitoring and inspection results and environmental audits. During this review, management targets and trigger/threshold level actions will also be reviewed to ensure they meet EPA's environmental objectives for Marine Fauna and that any improvements or adaptive management implemented is incorporated.

Other occasions when the ALMP will be reviewed include:

- Upon significant changes to the Project activities or upon significant changes to key environmental values identified in this ALMP;
- Following non-compliances;
- If one or more management targets or performance indicators are not being met and adaptive management is required; and
- Upon regulatory approval of the Project from other regulatory bodies such as DWER.

If revised, a copy of the latest ALMP will be provided to the Chief Executive Officer of DWER for approval prior to implementation. MinRes will provide a table summarising the changes to the ALMP following the example template (EPA, 2021). The summary table of changes will clearly indicate location and reason/s for changes. A tracked change version of the revised ALMP will be provided where possible and for all minor, non-structural changes to the document. All changes to an EMP post-assessment must be provided separate to compliance reports and submitted to registrar@dwer.wa.gov.au.

The most recently approved version of the plan will be implemented until either a new version has been approved by DWER or DWER advises that the ALMP no is no longer required to be implemented.

All contractors shall be supplied a copy of any revisions to the ALMP that may affect their scope of works.

6.2.2 EPBC Act EMP Requirements

This ALMP will be reviewed periodically during Project implementation. Other occasions when the ALMP will be reviewed include:

- Upon significant changes to the Project activities or upon significant changes to key environmental values identified in this ALMP;
- Following non-compliances or environmental incidents with a potential consequence ranking of 3 or greater;
- If one or more management targets or performance indicators are not being met and adaptive management is required; and
- Upon regulatory approval of the Project from regulatory bodies such as DWER or DCCEEW.

As per Condition 40 of EPBC:2021/9064, the Proponent may, at any time, apply to the Commonwealth Minister for a variation the ALMP approved by the Minister, or as subsequently revised in accordance with EPBC:2021/9064 Conditions, by submitting an application in accordance with the requirements of section 143A of the EPBC Act. If the Minister approves a revised action management plan (**RAMP**) then, from the date specified, the approval holder must implement the RAMP in place of the previous action management plan.

The revised ALMP will meet the environmental objectives of each of the ALMP outlined in Condition 10 of EPBC:2021/9064 and reflect any monitoring data is provided in accordance with Condition 47.

The Proponent will notify the DCCEEW in writing that the approved action management plan has been revised (as per Condition 46 and 47) and provide DCCEEW with:

- An electronic copy of the RAMP;
- Where possible, provide an electronic copy of the RAMP marked up with track changes to show the differences between the approved action management plan and the RAMP;
- An explanation of the differences between the approved action management plan and the RAMP;
- The reasons the approval holder considers that taking the action in accordance with the RAMP would not be likely to have a new or increased impact;
- Written notice of the date on which the approval holder will implement the RAMP (RAMP implementation date), being at least 20 business days after the date of providing notice of the revision of the action management plan, or a date agreed to in writing with the Department.

Subject to Condition 43 of EPBC:2021/9064, MinRes will implement the RAMP from the RAMP implementation date.

As per Condition 17 of EPBC:2021/9064, at least three (3) months prior to each fifth anniversary of this approval decision(12 December 2022), MinRes will engage an independent suitably qualified expert review each of this operational ALMP to advise if the triggers and thresholds are still effective and meet industry standards, whether further mitigation measures need to be applied and whether the management actions have been implemented.

In the event the independent suitably qualified expert recommends revisions to one or more operational management plans, MinRes will revise the ALMP in accordance with the recommendations of the independent suitably qualified expert. The revised ALMP will be submitted to the DCCEEW for Minister approval within six (6) months of the five-year anniversary of this approval decision. MinRes will must implement each approved revised ALMP.

Any amendments prepared for inclusion in this ALMP, shall be signed as authorised by the relevant manager and shall comply with statutory requirements. All employees and relevant contractors shall be supplied a copy of any revisions that may affect their scope of works.

6.3 Management of Change

In the event that there is a change in equipment, or materials used for construction, procedures, processes or roles and responsibilities during the construction and operational phases of the AIP, relevant to artificial lighting, the following should be written in a Management of Change report document:

- Reasons for change – Why is it needed and what are beneficial outcomes of the change?
- Determine the scope – Who will the change impact? What policies and processes will it impact?
- Who is responsible for the change?
- How will this change be executed to employees, contractor(s) and other stakeholders?

The management of changes should be approved by senior management prior to the execution of the change.

6.4 Environmental Inspections

MinRes will undertake annual environmental inspections including bird interactions recorded as per the requirements in **Section 2.2.4.** Inspections will be recorded when bird interactions are encountered during construction and operations, and the Proponent will keep a register of the species and outcome of each interaction, such as the location of the interaction, and if the interaction resulted in mortality of the individual.

6.5 Auditing

An artificial light audit will be undertaken at the frequency nominated in **Table 11** to ensure:

- Compliance with control measures (at the Port, TSVs and vessels under MinRes operational control);
- Identification of, and measures taken to reduce, impacts of problem lights; and
- Identification of any new information regarding potential impact pathways between artificial light associated with the project and biological receptors, and any adaptive management measures that could further reduce potential impacts.

As outlined in the NLPGW, audits should be undertaken by personnel qualified in environmental auditing and considered in consultation with an appropriately qualified biologist or ecologist. Additional audits will be scheduled as necessary, for example, following major weather events or major changes in Proposal facilities or buildings.

7. STAKEHOLDER CONSULTATION

The Proponent recognises the value of building positive relationships with key stakeholders and the communities in which we are active. The Proponent seeks to build sustainable partnerships with business partners, governments, non-government organisations, host communities and other stakeholders to support mutually beneficial outcomes.

MinRes is committed to ongoing stakeholder engagement and communication through all stages of the Project. Key stakeholders for the Project are outlined in **Table 14**.

Through this variety of engagement forums, MinRes has been able to identify the required studies and investigations and importantly, key social and environmental effects and associated mitigation and management strategies required to support this Project.

Table 14: Key Stakeholders

Stakeholder Sector	Organisation
Australian Government Agencies	Commonwealth Department of Climate Change, Energy, the Environment and Water (**DCCEEW**)
State Government Agencies & Members of Parliament	Conservation Council WA
	Department of Biodiversity, Conservation and Attractions (**DBCA**)
	Department of Jobs, Tourism, Science and Innovation (**JTSI**)
	Department of Planning, Lands and Heritage (**DPLH**)
	Department of the Premier and Cabinet (**Ministers for Water and Environment**)
	Department of Primary Industries and Regional Development
	Department of Transport (**DoT**)
	Department of Water and Environmental Regulation (**DWER**)
	Department of Water and Environmental Regulation – Environmental Protection Authority Services (**DWER – EPAS**)
	Development WA (**DevWA**)
	Environmental Protection Authority (**EPA**)
	Pilbara Port Authority (**PPA**)
Local Government	Shire of Ashburton
Traditional Owners	Buurabalayji Thalanyji Aboriginal Corporation (**Thalanyji**)
Private Industry	Australian Premium Iron Management (**APIM**)
	Chamber of Minerals and Energy (**CME**)
	Chevron Australia Pty Ltd
	KUFPEC Australia (Julimar) Pty Ltd Kyushu Electric Wheatstone Pty Ltd
	Finder No 3 Pty Ltd
	Mackeral Islands Pty Ltd
	Mineral Edge Pty Ltd
	Mobil Resources Company Pty Ltd
	Onslow Chamber of Commerce and Industry (**OCCI**)
	Onslow Marine Support Base
	Onslow Salt

Stakeholder Sector	Organisation
	North West Solar Salt
	Wheatstone Pty Ltd
	Pilbara Development Commission
	Sapuraomv Upstream (Western Australia) Pty Ltd
	Santos Offshore Pty Ltd
	Strike Resources
	Shell Australia Pty Ltd
	Regional Development Australia
	WA Fishing Industry Council (**WAFIC**)
Community	Bird Life Western Australia
	Onslow Community
	Onslow School
	Onslow Police

7.1 Consultation Undertaken

The Proponent has a number of established systems and procedures in place to consult, inform and communicate with stakeholders, particularly landowners and occupiers of private or public land, and the local community including native title holders and indigenous groups.

The Proponent has a tailored consultation management database to support stakeholder consultation across its projects. The database is a platform from which all activities, discussions and communications are captured, monitored and tracked for reference as the project advances.

As new stakeholders become identified, their details are added to the system to ensure consultation is thorough and inclusive, and appropriately actioned.

The stakeholder consultation database will track actions against delivery and resolution of issues, commitments or grievances identified. Under this approach, accountability is assigned to appropriate points of contact internally at MinRes who are responsible for addressing any action outlined under the consultation record. This generates traceability and ensures the Proponent remains responsive to the requests of their stakeholders. The Proponent is also able to track trends that may occur with stakeholder issues, enabling the company to proactively identify issues and work towards a solution with affected parties.

Other stakeholder engagement activities specific to the proposed preliminary and investigative works have included:

- Briefings and presentations with key regulatory authorities and potentially affected parties to provide information on the planned studies and request feedback;
- Face to face meetings, telephone calls and written correspondence with potentially affected stakeholders to provide up AIP and obtain additional feedback; and

MinRes' has established a Community Reference Group (**CRG**) to provide a more formal, structured update to the community on a monthly basis and will ensure regular and ongoing consultation is maintained.

7.2 Outcomes of Consultation

Over the course of September 2021 to February 2022, the Proponent has discussed the AIP. These have guided the development of the ALMP including measures to minimise environmental impacts and ensure stakeholder concerns and suggestions are incorporated.

This consultation has increased stakeholder confidence and understanding of the AIP, building on existing relationships established as part of the Proponents' larger work in the Onslow region.

Through these engagement forums, the Proponent has identified key social and environmental effects and associated mitigation and management strategies required to develop the ALMP The key stakeholder consultation and engagement activities undertaken to date by the Proponent are summarised in **Table 15.**

Table 15: Stakeholder Consultation for the AIP relevant to the ALMP

Stakeholder	Date and Consultation Activities	Key Issues and Topics Raised	Outcomes
Regulators			
DCCEEW (previously DAWE)	Consultation has taken place from August 2021, mainly through online and face-to-face meetings. Engagement has included initial pre-referral, various ongoing technical consultations followed, and agreed schedules developed Higher level meetings also provided strategic context in relation to the Proposal. Engagement took place in January 2022 to cover activity such as Minor & Preliminary Works.	Project scope and overview, baseline surveys, MNES terrestrial, MNES marine, avoidance and mitigate, predicted outcomes, expected time frames, process and approvals. Clarification on Controlled Action Decision for EPBC Referral 2021-9064 Notification of lodgement of EPBC Referral 2021-9064 Processing of EPBC2021-9064 via Gateway Receipt of Referral EPBC2021-9064, published online for comment. Minor & Preliminary Works Pre - Referral Meeting for the Ashburton Infrastructure Project - Sea Dumping Permit AIP DAWE Meeting - Independent EPBC assessment	MinRes provided update on the LOA expected timeframes. DAWE confirmed receipt of Sea Dumping Application. MinRes confirmed to cc DAWE into any correspondence with the EPA to progress with an accredited assessment to enable DAWE to make an official decision. MinRes briefed DAWE on MinRes' request for dredging as "early works" after application is lodged. Ongoing engagement.
JTSI	Updates provided as necessary to various stakeholders within JTSI since introducing the project in July 2020 and maintaining updates ongoing, mainly via face-to-face meetings.	Project introduction. Access locations for the Ashburton North Strategic Industrial Area (**ANSIA**) and interaction with other Proponents. General discussion about GIA and MinRes works.	No issues raised.
Pilbara Ports Authority	Regular and ongoing consultation has taken place between MinRes and PPA since July 2020. Weekly meetings between MinRes and PPA have been implemented at times throughout this period.	Project introduction. Port location options and road options. Approval's process and requirements. Proposed layouts for port lease area including site access path and loadout options. Landside layout and berth study. Dredging and sea dumping approvals. Request for further information relating to NVCP application, potential water sources, potential for background dust monitoring, and early works potential for bulk earthworks Port Landside layout Port Development Application EPP Stage 1 lot design kick off between PPA, MinRes and BGER. Commercial agreements to be drafted between MinRes and PPA, e.g. Infrastructure Agreement, Lease Agreement and licensing" MinRes activity in Onslow. MinRes presented to the PPA Technical Advisory Committee to give an overview of the project as well as detail regarding the port development, dredging requirements and environmental impacts and mitigation. Review Construction Application assessment (Earthworks and Landside), including outstanding Technical Queries. MinRes Environmental Management Plan Discussion. Succeeded meeting on required revision of CEMP to support CA process. Construction Application assessment (Earthworks and Landside), including outstanding Technical Queries AIP Dredging approvals update. Construction Application assessment (Earthworks and Landside), including outstanding Technical Queries Early works consultation meeting. Dredging maintenance contingency Mobilisation – MinRes targeting 6th June for establishment of facilities and 20th June for earthworks commencement. Dilapidation survey and baseline environmental audit.	MinRes provided project definition document. MinRes provided further information relating to NVCP application, potential water sources, potential for background dust monitoring, and early works potential for bulk earthworks. Ongoing refinement of footprint to meet PPA access requirements and tie in with PPA stage 1 lot development. Ongoing resolution of technical queries. Ongoing weekly meetings between MinRes and PPA.

Stakeholder	Date and Consultation Activities	Key Issues and Topics Raised	Outcomes
DWER	Project was introduced via consultation in July 2020 and since then there have been regular engagements between MinRes and DWER through to March 2022 and ongoing.	Proposal to the EPA, including the scope of the Proposal, required approvals and associated timeframe. Impacts associated with road, port and transshipping construction and operations. Presentation of the scope of the s38 referral and the additional survey effort being undertaken. Proposal and approvals pathway. Presentation of Preliminary Impact Assessment for the Proposal including the identification of Key Factors, level of assessment and additional technical studies underway (baseline and modelling). Approval targets and timeframes and supporting documents for the referral. Minor and Preliminary Works Ashburton Hub Water Strategy, short term construction water requirements, long term operational water requirements RIWI Act Assessments	MinRes to continue engagement as the Proposal develops and scope is finalised. MinRes to progress one s38 referral document. MinRes focused s41A (3) application on lower impact areas and reducing the linear extent. Prioritised degraded areas and factor this into a supporting impact assessment. Provided DWER water strategy presentation Attached cover letter to 26D applications - detailing link to MinRes water strategy' MinRes supplied a table of priorities, defined by when we are targeting an approval date. MinRes supplied investigative works letter recently submitted to the EPA. Ongoing engagement required.
EPA	Ongoing and regular consultation has occurred between MinRes and EPA since July 2020 to date with engagement ongoing, significantly the engagements have been face-to-face meetings and at times involving other agencies such as DWER and DMIRS.	Project introduction, approval strategy and timeframes for approvals. Ashburton Project referrals under S.38 of the EP Act, proposed timings. Proposal to the EPA, including the scope of the Proposal at present, required approvals and associated timeframe. Impacts associated with road, port and transshipping construction and operations. Presentation of the scope of the s38 referral and the additional survey effort being undertaken. Presentation of Preliminary Impact Assessment for the Proposal including the identification of Key Factors, level of assessment and additional technical studies underway (baseline and modelling). Approval targets and timeframes and supporting documents for the referral. Presentation of the Proposal to the EPA Board including avoidance, mitigation and management measures incorporated into Proposal design and forward work plan. Minor and Preliminary Works Update on Ashburton was provided as part of a general joint meeting with DMIRS & DWER on MinRes activities.	MinRes continued engagement as the Proposal developed and scope was finalised. MinRes progressed one s38 referral document. MinRes have considered concerns raised by the EPA MinRes progressed request for s41A(3) Minor Preliminary Works. MinRes provided EPA with email correspondence notifying DAWE of independent assessment. MinRes provided EPA with Preliminary Works Application. Ongoing engagement.
DPLH	MinRes has engaged as necessary with DPLH throughout 2021, with ongoing consultation on various outstanding issues continuing.	Project introduction. S18 resubmission for Bungaroo south. Crossing of the De Grey Mullewa Stock Route. Seabed at Area C approval to deposition of spoils. Water bores and turkeys' nests.	Further engagement, as necessary. DPLH has no objection to MinRes carrying out deposition of spoils within Area C, subject to MinRes undertaking further consultation with Department of Transport and MinRes obtaining environmental approval to carry out the dumping of materials at Area C.
Department of Transport	Only minimal and necessary engagement has been undertaken with the Department of Transport from 2020 and continues to date.	Project introduction. Present update on driver assist/automation project in discuss vehicle automation exemptions and permits. Seabed at Area C approval to deposition of spoils. Dredging and sea disposal activities Port landside construction Water bores and turkeys' nests.	MinRes provided project brief for automated vehicle trial. Continue to meet regularly for project updates Further engagement when and if necessary.
Development WA	Initial engagement with Development WA began in July 2020 and since then ongoing engagement has been undertaken on a regular basis. .	Proposal location and roads within the Port of Ashburton. Submission of ANSIA Proposal and road alignment options. DevWA raised issues around Heritage clearance, and established survey work is still required. Discussion regarding Chevron Lease Area within the ANSIA. Meeting held with Development WA and JTSI to discuss the development of the MinRes Haul Road within the ANSIA area.	Further engagement to be undertaken when necessary.

Stakeholder	Date and Consultation Activities	Key Issues and Topics Raised	Outcomes
Traditional Owners			
Thalanyji	Extensive and ongoing engagement has been undertaken between MinRes and Thalanyji since 2020. Engagement has included business development and employment opportunities as well as updates on the project and heritage work.	Introductory meeting, presentation of the proposal and discussed the background of the Thalanyji. Proposal updates and request to negotiate an access agreement. Proposal update and upcoming heritage surveys. Proposal update and its relationship to the ANSIA. Business development opportunities. Land opportunities. Globhill-KBSS Joint Venture and introduction to MinRes capabilities Business development and employment days in Perth and Onslow. LV workshop business potential for the Proposal. Hydraulic business potential for the Proposal. Proposal overview. Extensive discussions in regard to Lot 300. Facilitated meeting with WA Limestone and BTAC regarding sea wall construction at Onslow Heritage meetings to discuss Lot 300 and Warrida Road. Early Works Consultation update.	MinRes to provide further schedule updates. MinRes to continue engagement regarding business development and employment opportunities. MinRes to support 2022 NAIDOC week initiatives to further commit to working relationship with Thalanyji.
Local Government Agency			
Shire of Ashburton	Extensive engagement has been undertaken with the Shire of Ashburton since 2020 through to 2022 mainly via face-to-face engagement. Engagement is ongoing to ensure Shire is kept up to date on any activity and current issues.	Introductory consultation. Meeting with Shire Officers regarding the Proposal. Proposal and the availability of dredge spoil material. MinRes in attendance of the Onslow Waste Management Facility opening. Discussion around Proposal timing and request from the community to be kept up to date. Presentation of the Proposal and opportunity to express concerns from the Shire. Community consultation opportunities. Proposal received from the Shire with potentials for community investment. Part-time appointment of an MinRes employee in Onslow, Discussions in regard to development on Lot 300 Realignment of Peedamulla Road Access to the Onslow standpipe Attended Shire meetings with Council when voting taking place on development of Lot 300 Project updates provided. Community investment opportunities for the town of Onslow and surrounding areas MinRes proposal to develop a new haul road for transport of iron ore from Kens Bore to Port. Seeking Shire agreement to realign section of Peedamulla Road for safe separation of public traffic from MinRes' proposed haul road. Presented Yarri MP and MCP update. Overview and update on overall Onslow Iron project from Ken's Bore minesite through to the offshore transhipping operation Overview of measures taken during design phase to minimise community and environmental impacts for the life of the project including dust management, low impact marine structures with minimal dredging and disturbance, traffic management Overview of previously approved mining activity and land uses on Yarri Overview of proposed land uses on Yarri lease during construction phase Overview of permanent Road Train Maintenance Facilities on the Yarri mining lease Overview of MinRes Mine Closure and rehabilitation process and dedicated MinRes mine closure/rehab resources Discussion on options at end of mine life for key infrastructure such as roads	MinRes to continue engagement. MinRes to continue to deliver community consultation. Provide ongoing project updates MinRes to provide detailed haul road alignment when available. MinRes confirmed there would be no concave pits or open excavations at the conclusion of the mining activities on the Yarri lease. MinRes confirmed that Truck Maintenance Facility would contain any retail or other public facilities

Stakeholder	Date and Consultation Activities	Key Issues and Topics Raised	Outcomes
Onslow Community			
Community Members	Throughout 2021 and 2022 MinRes has increased community engagement and consultation. MinRes has implemented an Onslow Community Consultation Group with members of the community to further engagement. This group meets every three months. One-on-one consultation has been undertaken with community members on request to discuss any topics or issues.	Presented proposal with community members, including local business owners who requested that packages of work (e.g., transport opportunities) are open for tender as the Proposal develops Discussion around the Proposal including environmental impacts, closure plans and contributions from the proposal to the Onslow community. Ashburton project and Lot 300 development. MinRes activity in town and what MinRes' presence will look like. MinRes held a community forum in Onslow where approximately 100 residents attended. Topics presented on were - MinRes overview, Ashburton project overview, Lot 300, town planning, environmental impact, design concepts, community investment. Sought interest from community members about joining the MinRes Community Consultation Group. Implemented Community Consultation Group and defined structure going forward. Community investment discussions and opportunities of what areas of the community requires investment or assistance. Environmental approvals Haul road construction Dust management MinRes housing to be built. Haulage road and impact on public	Engagement with the community has been more focused and strengthened since the employment of MinRes' local Community Engagement Officer on the ground in Onslow. Launched MinRes Community Grants Program through feedback from the community. MinRes to continue to engage via: MinRes Community Consultation Group Meetings One-on-one meetings with community members Community presentations to provide project and whole of community updates MinRes reiterate information to ease any concerns such as traffic impacts, dust management etc.
Private Industry – Mining and Tourism			
Chamber of Minerals and Energy	Initial engagement made with CME in August 2020 and since then only minor engagement when needed.	Detailed introduction of project and required approvals. Presentation of the proposal and discussion of key environmental and community factors. Importance of heritage consultation. Progress of the Ashburton project and more detail on approvals.	Ongoing engagement when necessary and appropriate.
Onslow Salt	Various engagements with Onslow Salt over 2021 and 2022 to provide relevant updates and respond to concerns raised.	General project overview and interaction with Onslow Salt at the Port of Ashburton. Presentation of proposal overview, discussion of environmental mitigation and management options, modelling to date and road alignment. Comments on dust and shipping congestion raised. MinRes responded to various concerns raised by Onslow Salt.	MinRes to supply further environmental mitigation measures information. MinRes to continue to provide updates when relevant and respond to any issues or concerns raised by Onslow Salt.
Chevron	Engagement with Chevron began in August 2021 and has been proactive and ongoing since. Various engagements in regard to project activity as well as community investment in Onslow.	Removal or potential use of infrastructure. Access requirements to Chevron leases cut-off by our Haul Road. Collaborative approach to community engagement to better understand and assist the Onslow community. Early works consultation meeting.	A positive ongoing relationship through providing updates and working together to support community investment. Increased engagement with Chevron since having MinRes Community Engagement Officer employed locally.
Onslow Chamber of Commerce and Industry	Since 2021 MinRes has undertaken face-to-face engagements and attended meetings with the OCCI to provide updates and strengthen relationships.	Opportunities for MinRes to start considering involvement through the Chamber through attendance at events and meetings. Provide updates on MinRes activity Community investment opportunities Attended OCCI COVID meetings with local businesses and representatives.	Positive relationship and feedback from the OCCI and its members.
Exmouth Sales	Minor engagement regarding building opportunities. No required engagement since.	Discussions regarding building opportunities.	No further engagement required currently.
Mackerel Islands Pty Ltd	Various engagements September 2021 have been undertaken	Informal presentation of the proposal and discussion of potential operational requirements and tourism opportunities. Project updates. Lot 300. Mackerel Islands and MinRes can develop a partnership in future.	MinRes to continue engagement and coordinate updates when necessary.

Stakeholder	Date and Consultation Activities	Key Issues and Topics Raised	Outcomes
WA Fishing Industry Council	MinRes has provided relevant updates to WAFIC since September 2021 to ensure they are briefed on any activity that affects their industry.	Proposal including environmental impacts, closure plans and contributions from the proposal to the Onslow community. Project updates. Discussion on Jetty, Dredging, Sea dumping and Off Shore anchorages were the focus Early Works Consultation.	MinRes to continue engagement and provide updates when necessary.
RecFish West	MinRes has consulted with the Operations Team at RecFish West to provide update to ensure adequate consultation and proactive engagement.	Whole of project overview Port development and dredge program	Positive feedback Ongoing engagement when necessary

8. REFERENCES

Bamford, M., Watkin, D., Bancroft, W., Tishler, G. & Wahl, J. (2008) *Migratory Shorebirds of the East Asian-Australasian Flyway: Population Estimates and Internationally Important Sites*. Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT.

Black, A. (2005) Light induced seabird mortality on vessels operating in the Southern Ocean: incidents and mitigation measures. *Antarctic Science,* 17 (1), 67–68.

Cabrera-cruz, S.A., Smolinsky, J.A. & Buler, J.J. (2018) Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world. *Nature Scientific Reports*, 8:e3261.

Commonwealth of Australia (2012). *Marine bioregional plan for the North-west Marine Region prepared under the Environment Protection and Biodiversity Conservation Act 1999*. Department of Sustainability, Environment, Water, Population and Communities.

Commonwealth of Australia (2013) *Matters of National Environmental Significance Significant Impact Guidelines 1.1 Environmental Protection and Biodiversity Conservation Act 1999*: Canberra, Australia. 39p.

Commonwealth of Australia (2014) *Environmental Management Plan Guidelines*. Department of the Environment.

Commonwealth of Australia (2015) *Wildlife Conservation Plan for Migratory Shorebirds*. Department of the Environment.

Commonwealth of Australia (2017a) *Recovery Plan for Marine Turtles in Australia 2017 - 2017*. Department of the Environment and Energy.

Commonwealth of Australia (2017b) *Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species*. Department of the Environment and Energy.

Commonwealth of Australia (2022) *Wildlife Conservation Plan for Seabirds. Department of Biodiversity, Conservation and Attractions*, NSW Government, Government of South Australia, Queensland Government.

Commonwealth of Australia (2023) *National Light Pollution Guidelines for Wildlife*. Department of Climate Change, Energy, the Environment and Water.

Department of Climate Change, Energy, the Environment and Water (DCCEEW) (2023) *Protected Matters Search Tool*. Available: https://pmst.awe.gov.au/.

Day, R.H., Rose, J.R., Prichard, A.K. & Streever, B. (2015) Effects of Gas Flaring on the Behavior of Night-Migrating Birds at an Artificial Oil-Production Island, Arctic Alaska. *Arctic*, 68, 367–379.

Deppe, L., Rowley, O., Rowe, L.K., Shi, N., Mcarthur, N., Gooday, O. & Goldstein S.J. (2017) Investigation of fallout events in Hutton's shearwaters (Puffinus huttoni) associated with artificial lighting. *Notornis*, 64(4), 181-191.

Dias, M.P., Granadeiro, J.P., Lecoq, M., Santos, C.D. & Palmeirim, J.M. (2006) Distance to high-tide roosts constrains the use of foraging areas by dunlins: Implications for the management of estuarine wetlands. *Biological Conservation*, 131, 446-452.

Environmental Protection Authority (EPA) (2010) *No.5 Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts.* Available at: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EAG%205%20Lights%20Turtle%2011110.pdf

Environmental Protection Authority (EPA) (2016) *Environmental Factor Guideline: Marine Fauna.* Available at https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Marine-Fauna-131216_2.pdf.

Environmental Protection Authority (EPA) (2021) *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans*, 29 October 2021 EPA, Western Australia.

Environmental Protection Authority (EPA) (2021) *Interim Guidance – Environmental outcomes and outcomes-based conditions*, October 2021 EPA, Western Australia.

Environmental Protection Authority (EPA) (2023) *Ministerial Statement 1204,* July 2023 EPA, Western Australia.

Fritsches, K.A. (2012) Australian Loggerhead sea turtle hatchlings do not avoid yellow. *Marine and Freshwater Behaviour and Physiology*, 45(2), 79-89.

Geering, A., Agnew, A. & Harding, S. (2007) *Shorebirds of Australia*, CSIRO Australia.

Glass, J.P. & Ryan, P.G. (2013) Reduced seabird night strikes and mortality in the Tristan rock lobster fishery. *African Journal of Marine Science,* 35, 589 – 592.

Gyuris, E. (1994) The rate of predation by fishes on hatchlings of the green turtle (Chelonia mydas). *Coral Reefs*, 13, 137-144.

Harewood, A. & Horrocks, J.A. (2008) Impacts of coastal development on hawksbill hatchling survival and swimming success during the initial offshore migration. *Biological Conservation*, 141, 394-401.

Hodge, W., Limpus, C.J. & Smissen, P. (2007) *Queensland turtle conservation project: Hummock Hill Island nesting turtle study* December 2006 conservation technical and data report.

Hu, Z., Hu, H. & Huang, Y. (2018) Association between nighttime artificial light pollution and sea turtle nest density along Florida coast: A geospatial study using VIIRS remote sensing data. *Environmental Pollution*, 239, 30-42.

Kamrowski, R.L., Limpus, C., Pendoley, K. & Hamann, M. (2014) Influence of industrial light pollution on the sea-finding behaviour of flatback turtle hatchlings. *Wildlife Research* 41 (5), 421-434.

Le corre, M., Ollivier, A., Ribes, S. & Jouventin, P. (2002) Light-induced mortality of petrels: a 4-year study from Réunion Island (Indian Ocean). *Biological Conservation*, 105, 93-102.

Levenson, D.H., Eckert, S.A., Crognale, M.A., Deegan, J.F. & Jacobs, G.H. (2004) Photopic spectral sensitivity of green and loggerhead sea turtles. *Copeia*, 2, 908-914.

Lohmann, C.M.F. & Lohmann, K.J. (1992) Geomagnetic orientation by sea turtle hatchlings. In: *Proceedings of the 12th International Symposium on Sea Turtle Biology and Conservation* (eds. J.I. Richardson & T.H. Richardson), Jekyll Island.

Lohmann, K.J., Witherington B.E., Lohmann C.M.F. & Salmon M. (1997) Orientation, navigation, and natal beach homing in sea turtles, in *The Biology of Sea Turtles*. Volume I, P.L. Lutz and J.A. Musick, Editors., CRC Press: Washington D.C. p. 107-135.

Longcore, T., Rodriguez, A., Witherington, B., Penniman, J. F., Herf, L., and Herf, M. (2018). Rapid assessment of lamp spectrum to quantify ecological effects of light at night. J. Exp. Zool. A Ecol. Integr. Physiol. 329, 511–521.

Lorne, J.K. & Salmon, M. (2007) Effects of Exposure to Artificial Lighting on Orientation of Hatchling Sea Turtles on the Beach and in the Ocean. *Endangered Species Research*, 3, 23-30.

Lourenço, P.M., Silva, A., Santos, C.D., MIRANDA, A.C., GRANADEIRO, J.P. & PALMEIRIM, J.M. (2008) The energetic importance of night foraging for waders wintering in a temperate estuary. *Acta Oecologica,* 34, 122-139.

Merkel, F.R. & Johansen, K.L (2011) Light-induced bird strikes on vessels in Southwest Greenland. M*arine Pollution Bulletin*, 62, 2330-2336.

Montevecchi, W.A. (2006). Influences of artificial light on marine birds. In: Rich, C., Longcore, T. (Eds.), *Ecological Consequences of Artificial Night Lighting*. Island Press, Washington, D.C., USA, pp. 94e113.

Mrosovsky, N. (1972) The water finding ability of sea turtles. *Brain Behaviour and Evolution,* 5, 202-225.

Mrosovsky, N. & Shettleworth, S.J. (1968) Wavelength preferences and brightness cues in the water finding behaviour of sea turtles. *Behaviour*, 32, 211-257.

Nicholson, L.W. (2002) *Breeding strategies and community structure in an assemblage of tropical seabirds on the Lowendal Islands, Western Australia*. PhD dissertation, Murdoch University, Perth, WA.

Pendoley, K.L., (2005) *Sea Turtles and Industrial Activity on the North West Shelf,* Western Australia. Ph.D thesis, Murdoch University, Perth.

Pendoley, K.L. & Kamrowski, R.L. (2015) Influence of horizon elevation on the sea-finding behaviour of hatchling flatback turtles exposed to artificial light-glow. *Marine Ecology Progress Serie*s, 529, 279-288.

Pendoley Environmental (PENV) (2021) *Ashburton Infrastructure Project: Artificial Light Monitoring and Modelling. Report* prepared by Pendoley Environmental for Mineral Resources Ltd. October 2021.

Pendoley Environmental (PENV) (2023a) *Ashburton Infrastructure Project: Benchmark Hatchling Turtle Orientation Report*. Report prepared by Pendoley Environmental for Mineral Resources Ltd. June 2023.

Pendoley Environmental (PENV) (2023b) *Ashburton Infrastructure Project: Baseline Adult Turtle Nesting Behaviour & Habitat Utilisation Report*. Report prepared by Pendoley Environmental for Minteral Resources Ltd. June 2023.

Pendoley Environmental (PENV) (2023c) *Ashburton Infrastructure Project: Baseline Adult Turtle and Benchmark Hatchling Turtle Orientation: Trigger and Threshold Criteria Memo*. Report prepared by Pendoley Environmental for Mineral Resources Ltd. June 2023.

Pilcher, N.J., Enderby, S., Stringell, T. & Bateman, L. (2000) Nearshore turtle hatchling distribution and predation. In N. Pilcher & G. Ismail (Eds.), Sea turtles of the Indo-Pacific: research management and conservation. *Proceedings of the Second ASEAN Symposium and Workshop on Sea Turtle Biology and Conservation*. (pp. 151-166) London: ASEAN Academic Press.

Poot, H., Ens, B.J., De vries, H., Donners, M.A.H., Wernand, M.R. & Marquenie, J.M. (2008) Green light for nocturnally migrating birds. *Ecology and Society*, 13, 47-47.

Raine, H., Borg, J.J., Raine, A., Bairner, S. & Borg Cardona, M. (2007) Light Pollution and Its Effect on Yelkouan Shearwaters in Malta; Causes and Solutions. *BirdLife Malta: Malta: Life Project Yelkouan Shearwater.*

Reed, J.R., Sincock, J.L. & Hailman, J.P. (1985) Light attraction in endangered procellariform birds: Reduction by shielding upward radiation. Auk 102:377-383.RICH, C. & LONGCORE T, eds. (2006) *Ecological consequences of artificial night lighting*. Island press: Washington DC. 480.

Rodriguez, A., García, D., Rodríguez, B., Cardona, E.P.L. & Pons, P. (2015a) Artificial lights and seabirds: Is light pollution a threat for the threatened Balearic petrels? J*ournal of Ornithology*, 156, 893-902.

Rodríguez, A., Rodríguez, B. & Negro, J.J. (2015b) GPS tracking for mapping seabird mortality induced by light pollution. Scientific Reports, 5, 10670.

Rogers, D.I., Piersma, T. & Hassell, C.J. (2006) Roost availability may constrain shorebird distribution: Exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation,* 133(2), 225-235.

Ronconi, R.A., Allard, K.A. & Taylor, P.D. (2015) Bird interactions with offshore oil and gas platforms: review of impacts and monitoring techniques. *Journal of Environmental Management,* 147, 34-45.

Salmon, M. (2003) Artificial night lighting and sea turtles. *Biologist*, 2003 (50), 163-168.

Santiago-quesada, F., Estrella, S.M., Sanchez-guzman, J.M. & Masero, J.A. (2014) Why water birds forage at night: a test using black-tailed godwits *Limosa limosa* during migratory periods. *Journal of Avian Biology*, 45(4), 406-409.

Santos, C.D., Miranda, A.C., Granadeiro, J.P., Lourenço, P.M., Saraiva, S. & Palmeirim, J.M. (2010) Effects of artificial illumination on the nocturnal foraging of waders. *Acta Oecologica*, 36, 166-172.

Stapput, K. & Wiltschko, W. (2005) The sea-finding behaviour of hatchling olive ridley sea turtles, Lepidochelys olivacea, at the beach of San Miguel (Costa Rica). *Naturwissenschaften*, 92(5), 250-253.

Thomas, R.J., Kelly, D.J. & Goodship, N.M. (2004) Eye design in birds and visual restraints on behaviour. *Ornitologia Neotropica*l, 15, 243-250.

Thums, M., Whiting, S.D, Reisser, J.W., Pendoley, K.L., Pattiaratchi C.B., Harcourt, R.G., Mcmahon, C.R. & Meekan, M.G. (2013) Tracking sea turtle hatchlings—A pilot study using acoustic telemetry. *Journal of Experimental Marine Biology and Ecology*, 440, 156-163.

Truscott, Z., Booth, D.T. & Limpus, C.J. (2017) The effect of on-shore light pollution on sea-turtle hatchlings commencing their off-shore swim. *Wildlife Research*, 44(2), 127-134.

Wang, J.H, Boles, L.C., Higgins, B. & Logmann, K.J. (2007) Behavioural responses of sea turtles to lightsticks used in longline fisheries. *Animal Conservation*, 10, 176-182.

Wiese, F.K., Montevecchi, W.A., Davoren, G.K., Huettmann, F., Diamond, A.W. & Linke. J. (2001) Seabirds at risk around offshore oil platforms in the North-west Atlantic. *Marine Pollution Bulletin*, 42, 1285–1290.

Wilson, P., Thums, M., Pattiaratchi, C., Meekan, M., Pendoley, K., Fisher, R. & Whiting, S. (2018) Artificial light disrupts the nearshore dispersal of neonate flatback turtles Natator depressus. *Marine Ecology Progress Series*, 600, 179-192.

Wilson, P., Thums, M., Pattiaratchi, C., Whiting, S., Pendoley, K., Ferreira, L.C. & Meekan, M. (2019) High predation of marine turtle hatchlings near a coastal jetty. *Biological Conservation*, 236, 571-579.

Wiltschko, W., Munro, U., Ford, H., & Wiltschko, R. (1993) Red light disrupts magnetic orientation of migratory birds. *Nature*, 364, 525-527.

Witherington, B.E. & Bjorndal, K.A. (1991) Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles Caretta. *Biological Conservation*, 55(2), 139-149.

Witherington, B.E. (1992a) Behavioural responses of nesting sea turtles to artificial lighting. *Herpetologica*, 48, 31-39.

Witherington, B.E. (1992b) *Sea-finding behaviour and the use of photic orientation cues by hatchling sea turtles*. PhD thesis, University of Florida, Gainesville.

Witherington, B. & Martin, R.E. (2003) Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. *Florida Fish and Wildlife Conservation Commission FMRI Technical Report TR-2*: Jensen Beach, Florida. p. 84

MINERAL RESOURCES

APPENDIX A
PROTECTED MATTERS SEARCH TOOL (2023)

Australian Government

Department of Agriculture, Water and the Environment

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.

LGA SHIRE OF ASHBURTON, WA

Report created: 29/03/21 13:17:16

[redacted]

[redacted]

Summary

Matters of National Environment 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 - see http://environment.gov.au/protection/environment-assessments

World Heritage Properties:	1
National Heritage Places:	1
Wetlands of International Significance:	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	1
Threatened Ecological Communities:	None
Threatened Species:	42
Migratory Species:	49

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. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits-and-application-forms

Commonwealth Lands:	2
Commonwealth Heritage Places:	None
Listed Marine Species:	87
Whales and Other Cetaceans:	15
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	1

Extra Information

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

State and Territory Reserves:	26
Regional Forest Agreements:	None
Invasive Species:	17
Nationally Important Wetlands:	7

Details

Matters of National Environmental Significance

World Heritage Properties		[Resource Information]
Name	State	Status
The Ningaloo Coast	WA	Declared property

National Heritage Properties		[Resource Information]
Name	State	Status
Natural		
The Ningaloo Coast	WA	Listed place

Commonwealth Marine Area [Resource Information]

Approval is required for a proposed activity that is located within the Commonwealth Marine Area which has, will have, or is likely to have a significant impact on the environment. Approval may be required for a proposed action taken outside the Commonwealth Marine Area but which has, may have or is likely to have a significant impact on the environment in the Commonwealth Marine Area.

Name
EEZ and Territorial Sea

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
Falco hypoleucos		
Grey Falcon [929]	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
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Malurus leucopterus edouardi		
White-winged Fairy-wren (Barrow Island), Barrow Island Black-and-white Fairy-wren [26194]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pezoporus occidentalis		
Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis		
Australian Fairy Tern [82950]	Vulnerable	Breeding known to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed	Vulnerable	Species or species

Name	Status	Type of Presence
Albatross [64459]		habitat may occur within area
FISH		
Milyeringa veritas		
Blind Gudgeon [66676]	Vulnerable	Species or species habitat may occur within area
Ophisternon candidum		
Blind Cave Eel [66678]	Vulnerable	Species or species habitat known to occur within area
MAMMALS		
Balaenoptera borealis		
Sei Whale [34]	Vulnerable	Species or species habitat likely to occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Balaenoptera physalus		
Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Bettongia lesueur Barrow and Boodie Islands subspecies		
Boodie, Burrowing Bettong (Barrow and Boodie Islands) [88021]	Vulnerable	Species or species habitat known to occur within area
Dasyurus hallucatus		
Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] [331]	Endangered	Species or species habitat known to occur within area
Eubalaena australis		
Southern Right Whale [40]	Endangered	Species or species habitat may occur within area
Isoodon auratus barrowensis		
Golden Bandicoot (Barrow Island) [66666]	Vulnerable	Species or species habitat known to occur within area
Lagorchestes conspicillatus conspicillatus		
Spectacled Hare-wallaby (Barrow Island) [66661]	Vulnerable	Species or species habitat known to occur within area
Macroderma gigas		
Ghost Bat [174]	Vulnerable	Breeding known 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
Osphranter robustus isabellinus		
Barrow Island Wallaroo, Barrow Island Euro [89262]	Vulnerable	Species or species habitat likely to occur within area
Petrogale lateralis lateralis		
Black-flanked Rock-wallaby, Moororong, Black-footed Rock Wallaby [66647]	Endangered	Species or species habitat known to occur within area
Rhinonicteris aurantia (Pilbara form)		
Pilbara Leaf-nosed Bat [82790]	Vulnerable	Roosting known to occur within area
PLANTS		
Pityrodia augustensis		
Mt Augustus Foxglove [4962]	Vulnerable	Species or species habitat likely to occur within area
Thryptomene wittweri		
Mountain Thryptomene [16645]	Vulnerable	Species or species habitat likely to occur within area

Name	Status	Type of Presence
REPTILES		
Aipysurus apraefrontalis Short-nosed Seasnake [1115]	Critically Endangered	Species or species habitat known to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Breeding known to occur within area
Ctenotus zastictus Hamelin Ctenotus [25570]	Vulnerable	Species or species habitat known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Liasis olivaceus barroni Olive Python (Pilbara subspecies) [66699]	Vulnerable	Species or species habitat known to occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur within area
SHARKS		
Carcharias taurus (west coast population) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat known to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area
Pristis clavata Dwarf Sawfish, Queensland Sawfish [68447]	Vulnerable	Species or species habitat known to occur within area
Pristis zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

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
Ardenna carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat may occur within area
Ardenna pacifica Wedge-tailed Shearwater [84292]		Breeding known to occur within area
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area

Name	Threatened	Type of Presence
Fregata ariel Lesser Frigatebird, Least Frigatebird [1012]		Species or species habitat likely to occur within area
Hydroprogne caspia Caspian Tern [808]		Breeding known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Onychoprion anaethetus Bridled Tern [82845]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Migratory Marine Species		
Anoxypristis cuspidata Narrow Sawfish, Knifetooth Sawfish [68448]		Species or species habitat likely to occur within area
Balaena glacialis australis Southern Right Whale [75529]	Endangered*	Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	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
Balaenoptera physalus Fin Whale [37]	Vulnerable	Species or species habitat likely to occur within area
Carcharhinus longimanus Oceanic Whitetip Shark [84108]		Species or species habitat likely to occur within area
Carcharodon carcharias White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat likely to occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding 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	Foraging, feeding or related behaviour known to occur within area
Dugong dugon Dugong [28]		Breeding known to occur within area
Eretmochelys imbricata Hawksbill Turtle [1766]	Vulnerable	Breeding known to occur within area
Manta alfredi Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Manta birostris Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat known to 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
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 zijsron Green Sawfish, Dindagubba, Narrowsnout Sawfish [68442]	Vulnerable	Species or species habitat known to occur within area
Rhincodon typus Whale Shark [66680]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		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
Migratory Terrestrial Species		
Hirundo rustica Barn Swallow [662]		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 may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat 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 likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Limosa lapponica Bar-tailed Godwit [844]		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
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Thalasseus bergii Crested Tern [83000]		Breeding known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [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 - TOM PRICE 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
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat 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 likely to occur within area

Name	Threatened	Type of Presence
Calonectris leucomelas Streaked Shearwater [1077]		Species or species habitat likely to occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may 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 likely to occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Hirundo rustica Barn Swallow [662]		Species or species habitat may occur within area
Larus novaehollandiae Silver Gull [810]		Breeding known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may 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 may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Breeding known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat may occur within area
Puffinus pacificus Wedge-tailed Shearwater [1027]		Breeding known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna anaethetus Bridled Tern [814]		Breeding known to occur within area
Sterna bengalensis Lesser Crested Tern [815]		Breeding known to occur

Name	Threatened	Type of Presence
		within area
Sterna bergii Crested Tern [816]		Breeding known to occur within area
Sterna caspia Caspian Tern [59467]		Breeding known to occur within area
Sterna dougallii Roseate Tern [817]		Breeding known to occur within area
Sterna fuscata Sooty Tern [794]		Breeding known to occur within area
Sterna nereis Fairy Tern [796]		Breeding known to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area
Fish		
Acentronura larsonae Helen's Pygmy Pipehorse [66186]		Species or species habitat may occur within area
Bulbonaricus brauni Braun's Pughead Pipefish, Pug-headed Pipefish [66189]		Species or species habitat may occur within area
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 latispinosus Muiron Island Pipefish [66196]		Species or species habitat may occur within area
Choeroichthys suillus Pig-snouted Pipefish [66198]		Species or species habitat may occur within area
Doryrhamphus dactyliophorus Banded Pipefish, Ringed Pipefish [66210]		Species or species habitat may occur within area
Doryrhamphus janssi Cleaner Pipefish, Janss' Pipefish [66212]		Species or species habitat may occur within area
Doryrhamphus multiannulatus Many-banded Pipefish [66717]		Species or species habitat may occur within area
Doryrhamphus negrosensis Flagtail Pipefish, Masthead Island Pipefish [66213]		Species or species habitat may occur within area
Festucalex scalaris Ladder Pipefish [66216]		Species or species habitat may occur within area
Filicampus tigris Tiger Pipefish [66217]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
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 angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		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 habitat may occur within area
Hippocampus planifrons Flat-face Seahorse [66238]		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
Phoxocampus belcheri Black Rock Pipefish [66719]		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,		Species or species

Name	Threatened	Type of Presence
Straight Stick Pipefish [66281]		habitat may occur within area
Mammals		
Dugong dugon Dugong [28]		Breeding 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 known 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
Astrotia stokesii Stokes' Seasnake [1122]		Species or species habitat may occur within area
Caretta caretta Loggerhead Turtle [1763]	Endangered	Breeding 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	Foraging, feeding or related behaviour known 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 known to occur within area
Hydrophis czeblukovi Fine-spined Seasnake [59233]		Species or species habitat may occur within area
Hydrophis elegans Elegant Seasnake [1104]		Species or species habitat may occur within area
Hydrophis ornatus Spotted Seasnake, Ornate Reef Seasnake [1111]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Breeding known to occur

Name	Threatened	Type of Presence
		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		
Balaenoptera acutorostrata Minke Whale [33]		Species or species habitat may occur within area
Balaenoptera borealis Sei Whale [34]	Vulnerable	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
Balaenoptera physalus Fin Whale [37]	Vulnerable	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
Eubalaena australis Southern Right Whale [40]	Endangered	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
Orcinus orca Killer Whale, Orca [46]		Species or species habitat may occur within area
Sousa chinensis Indo-Pacific Humpback Dolphin [50]		Species or species habitat likely 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

Australian Marine Parks

[Resource Information]

Name	Label
Montebello	Multiple Use Zone (IUCN VI)

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Airlie Island	WA
Barlee Range	WA
Barrow Island	WA
Bessieres Island	WA
Boodie, Double Middle Islands	WA
Burnside And Simpson Island	WA
Cane River	WA
Cane River (Mount Minnie and Nanutarra)	WA
Giralia	WA
Gnandaroo Island	WA
Karijini	WA
Little Rocky Island	WA
Locker Island	WA
Lowendal Islands	WA
Millstream Chichester	WA
Mungaroona Range	WA
Round Island	WA
Serrurier Island	WA
Tent Island	WA
Unnamed WA40322	WA
Unnamed WA41696	WA
Unnamed WA44665	WA
Victor Island	WA
Wanna	WA
Whalebone Island	WA
Y Island	WA

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,

Name	Status	Type of Presence
Birds		
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer montanus		
Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Mammals		
Camelus dromedarius		
Dromedary, Camel [7]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Equus asinus Donkey, Ass [4]		Species or species habitat likely to occur within area
Equus caballus Horse [5]		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
Oryctolagus cuniculus Rabbit, European Rabbit [128]		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
Vulpes vulpes Red Fox, Fox [18]		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
Cylindropuntia spp. Prickly Pears [85131]		Species or species habitat likely to occur within area
Parkinsonia aculeata Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]		Species or species habitat likely to occur within area
Prosopis spp. Mesquite, Algaroba [68407]		Species or species habitat likely to occur within area
Reptiles		
Ramphotyphlops braminus Flowerpot Blind Snake, Brahminy Blind Snake, Cacing Besi [1258]		Species or species habitat may occur within area

Nationally Important Wetlands [Resource Information]

Name	State
Exmouth Gulf East	WA
Fortescue Marshes	WA
Karijini (Hamersley Range) Gorges	WA
Kookhabinna Gorge	WA
Millstream Pools	WA
Mt. Bruce coolibah-lignum flats	WA
Yadjiyugga Claypan	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 oigations 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.

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 Environment 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
-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.

Department of Agriculture Water and the Environment
GPO Box 858
Canberra City ACT 2601 Australia
+61 2 6274 1111

APPENDIX B

ARTIFICIAL LIGHT IMPACT AND ASSESSMENT AND MANAGEMENT PLAN (ALMP), REVISION 6, J88001

Independent Peer Review

Client	Mineral Resources Limited
Author	Pendoley Environmental Pty Ltd
Title	Ashburton Iron Infrastructure Project: Artificial Light Assessment and Management Plan
Version	Rev 0
Report Date	30/09/21
Reviewer	Dr Bruce Hegge, Teal Solutions Pty Ltd
Review Date	24/08/21

Section	Review Comment	Response	MRL Close
Project Description and Scope	MRL to review to ensure consistent description of the project, project infrastructure elements and Development Envelope(s) across all technical reports.	Updated as per final PDD provided by MRL for consistency across all technical report.	Adequately addressed
Scope and subsequent report sections	Ensure naming and sequence of five steps for environmental impact assessment for effects of artificial light on wildlife match Commonwealth (2020)	The only variation is the order of Steps 1 and 2. These are independent steps and therefore their specific order does not matter. We prefer to describe the wildlife (receptor) first and then the project lighting (stressor/threat). I don't believe we need to justify this change in order because it does not affect any of the outcomes of the assessment.	Accepted.
1.1.1 Regional Overview	Include figures showing critical habitat areas and Biologically Important Areas	We don't have access to the boundary files.	Not addressed in final report, however information captured in O2 Marine Fauna Report and Impact Assessments.
1.2 Seabirds and Migratory Shorebirds	Clarify and tighten text to clearly define the various categories of birds considered here. Presently the categories include: seabird, waterbird, shorebird, marine bird, migratory shorebird, migratory wader, migratory waterbird. Expand tables/text to include State listed species.	Section has been updated to response to this comment.	Adequately addressed
1.2 Seabirds and Migratory Shorebirds	Check capitalisation of common names of birds for consistency with standard ornithological practice	Comment from Lisa: Many journals no longer use capital letters for common names for birds (eg. Records of the WA Museum). In this report the standard practice is to not capitalise common names.	Adequately addressed
3.3 Marine Turtles and 3.4	Consider moving background text (in the various sections herein) regarding species/life state sensitivities to separate	Updated to separate sections	Adequately addressed

Section	Review Comment	Response	MRL Close
Seabirds and Shorebirds	subsection (perhaps Section 1) so that these sections focusses on impacts from the proposed AIP project.		
5.2 Marine Turtle Monitoring	More specific details on proposed monitoring, e.g. location, timing, duration, frequency.	Updated	Adequately addressed

MINERAL RESOURCES LIMITED (MRL)

ASHBURTON INFRASTRUCTURE PROJECT: ARTIFICIAL LIGHT IMPACT ASSESSMENT AND MANAGEMENT PLAN

Prepared by

Pendoley Environmental Pty Ltd

For

Mineral Resources Limited (MRL)

26 October 2022

PENDOLEY ENVIRONMENTAL

PENDOLEY ENVIRONMENTAL

DOCUMENT CONTROL INFORMATION

TITLE: Ashburton Infrastructure Project: Artificial Light Impact Assessment and Management Plan

Disclaimer and Limitation

This report has been prepared on behalf of and for the use of Mineral Resources Limited. Pendoley Environmental Pty Ltd. Takes no responsibility for the completeness or form of any subsequent copies of this Document. Copying of this Document without the permission of Mineral Resources Limited is not permitted.

Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		17/05/2021	M. Wohling / A. Mitchell / L. Nicholson
Rev IA	Internal Review	17/05/2021	25/05/2021	K. Pendoley
Rev IB	Technical Review	25/05/2021	11/06/2021	P. Whittock
Rev A	Client review	11/06/2021	12/08/2021	S. Osborne
Rev B	Second Draft	12/08/2021	24/08/2021	A. Mitchell, K. Pendoley, L. Nicholson
Rev 0	Final report issued	30/09/2021	01/10/2021	A. Mitchell
Rev 1	Address further comments	28/03/2022	09/04/2022	A. Mitchell, P. Whittock, L. Nicholson
Rev 2	Addition of Bird Interaction Procedure	06/07/2022	15/07/2022	A. Mitchell
Rev 3	Address Further Comments	15/07/2022	20/07/2022	A. Mitchell
Rev 4	Address Further Comments	30/09/2022	03/10/2022	A. Mitchell
Rev 5	Address Further Comments	20/10/2022	21/10/2022	A. Mitchell
Rev 6	Address Further Comments	26/10/2022	26/10/2022	P. Whittock

PENDOLEY ENVIRONMENTAL

Printed:	26 October 2022
Last saved:	26 October 2022 03:02 PM
File name:	http://intranet/CorporateServices/ProjectServices/ProjectDevelopment/WPSTP/07 Environment/10 Enviro Man Plans/12 Marine MPs/AIP ALMP/ALMP Rev6_Clean.docx
Author:	Kellie Pendoley/Paul Whittock/Marc Wohling/Adam Mitchell/Lisa Nicholson
Project manager:	Adam Mitchell
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Ashburton Infrastructure Project: Artificial Light Impact Assessment
Client	Mineral Resources Limited
Client representative:	Sarah Osborne
Report number:	J88001
Cover photo:	Ashburton region (looking west). Credit: A. Slater

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Project Description

Mineral Resources Limited (MRL) intends to develop the Ashburton Infrastructure Project (AIP; the Project). The Project involves the mining of the Bungaroo South Deposit and associated infrastructure would consist of a dedicated private haul road approximately 150 km long from the mine area to the Ashburton North Strategic Industrial Area (ANSIA), a stockyard and port infrastructure (landside and nearshore facilities) within the existing Port of Ashburton, and offshore anchorage areas. MRL expects the project will deliver about 20 - 40 million tonnes per annum (Mtpa) of iron ore for export over about 30 - 40 years as a Direct Shipping Ore. The project is located entirely within the Shire of Ashburton in the West Pilbara region of Western Australia (**Figure 1**).

The Project's proposed facilities (Port Landside, Nearshore and Offshore Development Envelopes) are situated approximately 11 km from the town of Onslow. At the Landside and Nearshore Development Envelopes, MRL will establish a port operation within the Pilbara Port Authority (PPA) controlled area including a storage shed, covered conveyor, and a new jetty with a ship loader. Landside and nearshore facilities will include:

- A ship loading facility;
- Berth pocket;
- Modularised jetty and wharf;
- Ship loader installed on the wharf for loading ore via conveyors into Trans-Shipment Vessels (TSV); and
- Small desalinisation plant.

Offshore shipping activities will involve the operation of TSV's which will utilise an existing shipping channel to access an anchorage area (Offshore Development Envelope) for out-loading of iron ore from the TSV's to an Ocean-Going Vessel (OGV) located to the north-west of Thevenard Island in ~30 - 50 m water depth.

1.2 Scope

In February 2021, MRL engaged Pendoley Environment (PENV) to undertake an Artificial Light Impact Assessment (ALIA) and Artificial Light Management Plan (ALMP) for the Project. Project related facilities and operations considered within the scope of the assessment (and form the 'Project Area'), include the landside and nearshore facilities, the TSV's while transiting along a navigation route between the Port and the anchorage area (Offshore Development Envelope), and the OGV(s) when at the anchorage area (see **Figure 1** for the Project Area boundary).

Our approach was to include the five steps outlined within the *National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds* (the guidelines) (Commonwealth of Australia 2020) for assessing the potential effects of artificial light on wildlife:

- **Step 1: Describe the wildlife:** Includes a description of marine turtle, seabird, and migratory shorebird species occurring <20 km of the Project Area. This distance is recommended by the guidelines and is based on two case studies where observable impacts of artificial light to marine turtle hatching orientation were recorded 15 km from a Liquified Natural Gas (LNG) facility (Kamrowski et al. 2014) and 18 km from an aluminium refinery (Hodge et al. 2007).
- **Step 2: Describe the Project Area lighting:** Includes a description of facilities and light sources associated with the project area and the existing light environment.
- **Step 3: Risk assessment:** Using the description of wildlife and light within the Project Area (described in Steps 1 and 2), assess the risk of impact of artificial light to marine turtles, seabirds, and migratory shorebird species (with consideration of proposed mitigation and light management). In addition to the guidelines, this step also considered the *WA EPA Environmental Factor Guideline: Marine Fauna* (EPA 2016) and *WA Environmental Protection Authority Environmental Assessment Guideline No. 5 Protecting Marine Turtles from Light Impacts* (EPA 2010).
- **Step 4: Artificial light management plan:** Outlines the application of best practice lighting design principles and mitigation measures to eliminate or minimise Project Area related lighting impacts to marine turtle, seabird, and migratory shorebird species identified in Step 4.
- **Step 5: Biological and artificial light monitoring and auditing**: Outlines the approach for monitoring marine turtle, seabird, and migratory shorebird behaviour and artificial light, and the auditing of Project Area light to ensure compliance with the ALMP described in Step 4.

Note that the guidelines include the requirement for continuous review of the impact assessment and ALMP as further information from wildlife or artificial light monitoring, modelling, or audits become available. The review should incorporate any change to the project that may affect its lighting design within the Project Area and provide recommendations for continual improvement.

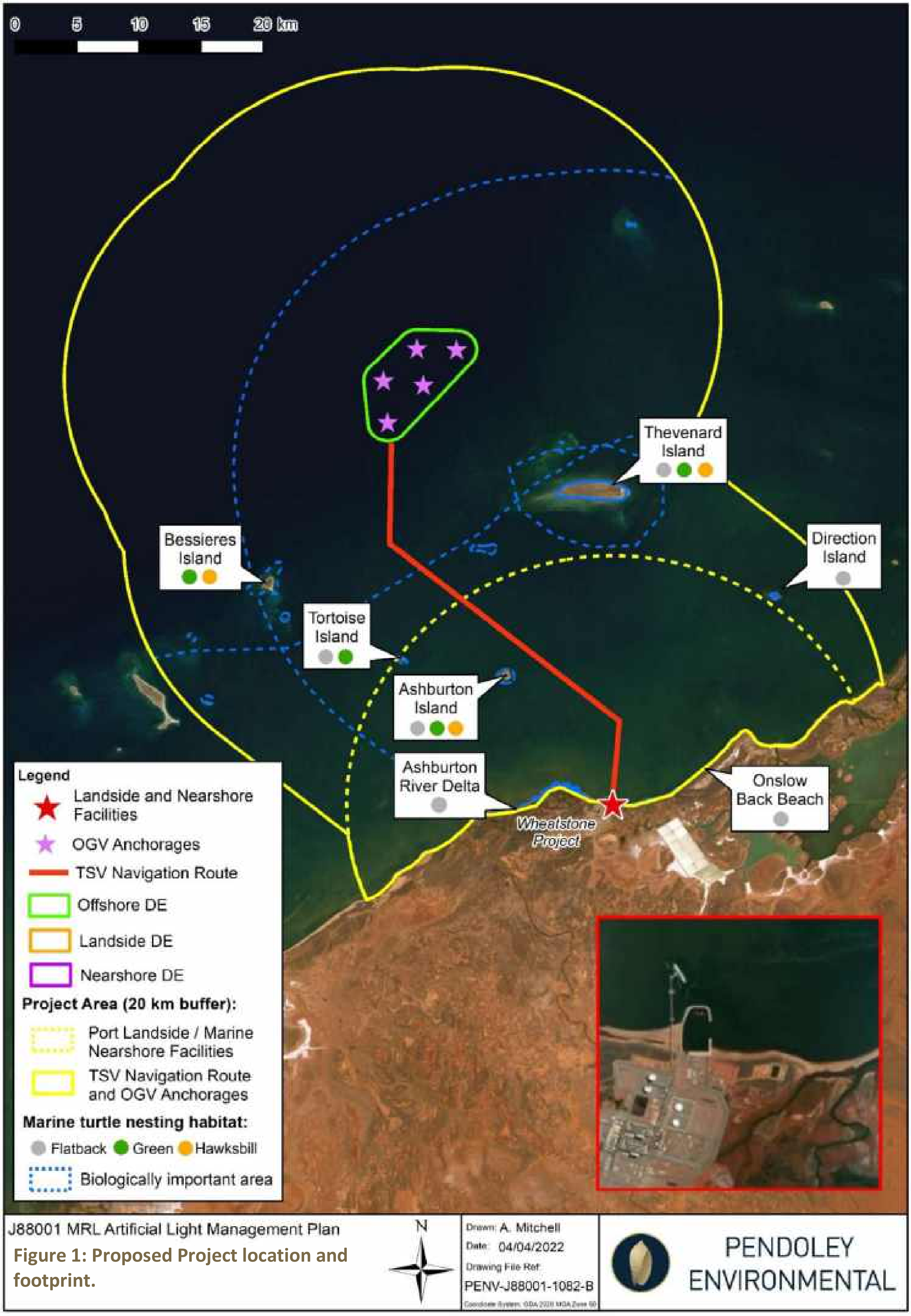


Figure 1: Proposed Project location and footprint.

2 STEP 1: DESCRIBE THE WILDLIFE

2.1 Marine Turtles

2.1.1 Approach

The following resources were used to describe marine turtle presence within 20 km of the Project Area:

- Protected Matters Search Tool (PMST);
- Species Profile and Threats (SPRAT) Database;
- Recovery Plan for Marine Turtles in Australia 2017 – 2027 (Commonwealth of Australia 2017);
- National Conservation Values Atlas (NCVA); and
- Marine bioregional plan for the North-west Marine Region (Marine Bioregional Plan; Commonwealth of Australia 2012b).

2.1.2 Regional Overview

Six of the world's seven species of marine turtles are known to occur in Australian waters and are protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and State *Biodiversity Conservation Act 2016*. The marine turtle species include flatback (*Natator depressus*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacea*), loggerhead (*Caretta caretta*), and olive ridley (*Lepidochelys olivacea*) (Commonwealth of Australia 2017).

The PMST identified that breeding of flatback, green, hawksbill, loggerhead, and leatherback turtles is likely to occur in the Project Area. Furthermore, the Marine Bioregional Plan indicates the region provides important nesting areas for green, hawksbill, loggerhead, and flatback turtles (Commonwealth of Australia 2012b). Note that based on the SPRAT database, leatherback turtle nesting in Western Australia is unknown or unconfirmed (Prince 1994).

Marine turtles in Australia belong to discrete genetic stocks, within each species, which are defined by the presence of regional breeding aggregations. Marine turtle breeding aggregations that overlap with the Project Area include the Flatback – Pilbara (F-Pil), Green North West Shelf (G-NWS), and Hawksbill – Western Australia (H-WA) genetic stocks (Commonwealth of Australia 2017). The *Recovery Plan for Marine Turtles in Australia 2017 – 2027* (recovery plan; Commonwealth of Australia 2017) provides information for each stock (including details of important nesting areas) and is summarised below:

- Flatback turtles: The population trend of the F-Pil genetic stock is currently unknown. Important nesting areas within the Project Area include Thevenard Island (minor).
- Green turtles: The population trend for the G-NWS stock is reported as stable. Important nesting areas within the Project Area include Thevenard Island (minor).

- Hawksbill turtles: The population trend for the H-WA stock is also unknown. The recovery plan does not define any important nesting areas within the Project Area.
- Light pollution was assessed as a high-risk threat to all three genetic stocks (G-NWS;F-Pil; H-WA).

The recovery plan also defines areas of onshore nesting and offshore inter-nesting (the period of time between successive nesting events) habitat considered critical for the survival of the species. Critical habitat for nesting and inter-nesting that overlaps with the Project Area includes areas for flatback (Thevenard Island), green (Thevenard Island), and hawksbill (Cape Preston to mouth of Exmouth Gulf) turtles (Commonwealth of Australia 2017).

Biologically Important Areas (BIA) are spatially defined areas where aggregations of individuals of a species are known to display biologically important behaviour such as breeding (nesting and inter-nesting), foraging, resting, or migration (available within the NCVA held by the Department of Agriculture, Water and Environment (DAWE)). BIAs that overlap with the Project Area have been defined for the following marine turtle species (refer to **Figure 1**):

- Flatback turtle onshore nesting habitat on Thevenard Island.
- Flatback turtle offshore inter-nesting habitat around Thevenard Island.
- Hawksbill turtle onshore nesting habitat on Thevenard Island.
- Hawksbill turtle offshore inter-nesting habitat around Thevenard Island.

There are no discrete genetic stocks, breeding aggregations, defined areas of critical habitat, or BIAs for leatherback, loggerhead, or olive ridley turtles that overlap with the Project Area and therefore these species have not been considered further within the impact assessment.

2.1.3 Adult: Nesting

2.1.3.1 Flatback Turtles

Flatback turtles are known to utilise nesting habitat within the Project Area (Fossette et al. 2021; Pendoley et al. 2016; Pendoley Environmental 2009a, 2009b; Chevron Australia 2010a). These areas include Ashburton, Direction, Thevenard, and Tortoise islands, and on the mainland, notably at Ashburton River Delta (**Figure 1**).

Based on an aerial survey of the Pilbara region in 2016 (extending from Exmouth Gulf in the west to Cape Keraudren in the east), Ashburton, Direction, and Thevenard Islands recorded ‘very high’ overnight track count of 50 – 249 tracks per night, and Ashburton River Delta recorded a ‘high’ overnight track count of 10 – 49 tracks per night (Fossette et al. 2021). Furthermore, out of these areas, Thevenard Island recorded the highest percentage (5.0 %) of all flatback tracks identified during the survey with the nesting activity situated on the south-east side of the island (notably the island is also used by the Department of Biodiversity, Conservation, and Attractions as a designated index beach for flatback turtle monitoring within Pilbara region).

The occurrence and level of nesting activity identified by Fossette et al. (2021) is supported by the findings of a summary of marine turtle nesting activity recorded during field surveys by Pendoley

Environmental in the Pilbara region between 1992 and 2012 (Pendoley et al. 2016) and baseline environmental surveys conducted as part of Chevron Australia's Wheatstone Project (Chevron Australia 2010a). The Pendoley et al. (2016) summary also reported the presence of flatback turtle nesting activity on Tortoise Island (though no actual overnight track count was reported) (**Figure 1**).

With the exception of Ashburton River Delta, very low-level nesting activity may also occur at mainland locations within the Project Area. This includes Onslow Back beach (approximately 5 km east of the Port) which recorded two flatback turtle nests in 2008/09 (Pendoley Environmental 2009b) and has been known to record up to five nests over a two-week period (P. Whittock pers. comms.). Note that Fossette et al. (2021) did not record any flatback nesting activity at mainland nesting habitat to the east of Beadon Creek in Onslow and west of Ashburton River Delta.

2.1.3.2 Green turtle

Green turtles are not considered to utilise the mainland beaches within the Project Area for nesting purposes (Pendoley et al. 2016). Within the Project Area, green turtles have been recorded as utilising the offshore islands of Ashburton, Bessieres, Thevenard, and Tortoise for nesting purposes (Fossette et al. 2021; Pendoley et al. 2016; Pendoley Environmental 2009a; Chevron Australia 2010a) (**Figure 1**).

At Thevenard Island, 20 – 32 overnight green turtle tracks were recorded in December 2016 (onground survey; Fossette et al. 2021) and 13 tracks per km per night in December 2009 (Pendoley Environmental 2009a; Chevron Australia 2010a). The distribution of green turtle nesting activity on Thevenard Island is situated on the west side of the island. At Bessieres Island, 24.2 tracks per km per night were recorded (Pendoley Environmental 2009a) which corresponded to between 11 – 100 overnight tracks reported in Pendoley et al. (2016). At Tortoise and Ashburton Islands, a lower track count was reported compared to the other islands (Pendoley et al. 2016).

2.1.3.3 Hawksbill turtle

Hawksbill turtles are not considered to utilise the mainland beaches within the Project Area for nesting purposes (Pendoley et al. 2016). Within the Project Area, hawksbill turtles have been recorded as utilising the offshore islands of Ashburton, Bessieres, and Thevenard for nesting purposes (Pendoley et al. 2016; Chevron Australia 2010a) (**Figure 1**).

At Bessieres Island, one record of hawksbill turtle nesting was recorded as part of the baseline surveys for the Wheatstone Project (Chevron Australia 2010a). Pendoley et al. (2016) also recorded the presence of hawksbill nesting activity at the island (though no actual overnight track count was reported). Elsewhere, Thevenard Island recorded 1 – 10 overnight tracks and the presence of hawksbill activity was also reported for Ashburton Island (Pendoley et al. 2016).

2.1.3.4 Regional Importance of Nesting Sites

To understand the regional importance of nesting sites for each species within the Project Area (**Figure 1**), the combined estimated annual nester abundance for each nesting site was compared with the overall estimated annual nester abundance for the genetic stock (sub-population) (see **Table 1**). Flatback turtles recorded the highest percentage of the overall estimated annual nester abundance for the genetic stock within the Project Area (10.1 %). For context, a regionally significant flatback turtle nesting site at Barrow Island is estimated to contribute 25 % of the overall estimated annual nester abundance for the genetic stock (~2000 annual nesters).

Table 1: Estimated annual abundance at each nesting site and percentage of each species genetic stock population within the Project Area. Estimated annual abundance is derived using subject matter expertise and knowledge of nesting sites.

Marine Turtle Nesting Site	Estimated Annual Nester Abundance of each Species		
	Flatback	Green	Hawksbill
Ashburton River Delta	250	NA	NA
Ashburton Island	100	25	10
Bessieres Island	NA	200	10
Direction Island	25	NA	NA
Onslow Back Beach	15	NA	NA
Thevenard Island	400	1,000	50
Tortoise Island	25	25	NA
Total	815	1,250	70
Genetic Stock	F-Pil	G-NWS	H-WA
Estimated Annual Nester Abundance within Genetic Stock	8,000	25,000	4,000
% of Genetic Stock Population within Project Area	10.1 %	5.0 %	1.8 %

2.1.4 Adult: Inter-nesting

Between successive nesting events, marine turtles will utilise offshore habitat for a period of approximately 14 days (known as the inter-nesting period). During this period, they will often aggregate in large groups in areas situated close to their nesting habitat (Whittock et al. 2014). The movement and behaviour of marine turtles during this period is revealed via the use of satellite tracking units deployed on individual turtles.

Within the Project Area, satellite tracking units have been deployed on nesting flatback turtles at Ashburton (n = 6) and Thevenard Island (n = 6) (Whittock et al. 2014, 2016; Chevron Australia 2010a).

Flatback turtles at Ashburton Island remained primarily within close proximity of the nesting habitat and on occasion travelled up to 40 km away from the nesting habitat in a north-east direction before returning to nest (Chevron Australia 2010a). They spent most of their time within areas that had a mean water depth of 5.9 m, with the deepest depth recorded as 16 m (Whittock et al. 2016a). Suitable inter-nesting habitat for flatback turtles at Ashburton Island was defined as water <16 m depth, up to 11.7 km from the coastline (Whittock et al. 2016b).

At Thevenard Island, flatback turtles travelled a mean distance of 78.6 km during each inter-nesting period, moving up to 25.7 km away from the nesting habitat in the direction of the mainland before returning to nest (Whittock et al. 2014). The majority of their time was spent within 10 km of the nesting habitat in water with a mean depth of 9.9 m (Whittock et al. 2016a). Suitable inter-nesting habitat for flatback turtles at Thevenard Island was defined as water <44 m deep within 23 km of the coastline (Whittock et al. 2016b).

No satellite tracking units have been deployed on nesting green or hawksbill turtles at nesting habitat within the Project Area. Based on other published studies, green and hawksbill turtles will typically remain in nearshore shallow waters during their inter-nesting period (<25 m depth) (Hays et al. 2002; Pendoley 2005). During their inter-nesting period, green and hawksbill turtles were found to remain within 10 km from their nesting site on Barrow Island and Varanus Island, respectively (Pendoley 2005).

2.1.5 Adult and Juvenile: Migration

Following the completion of breeding, adult flatback and green turtles are known to undertake a post-nesting migration from the nesting habitat in the Pilbara region to foraging grounds situated further north in the Kimberley region of Western Australia (Whittock et al. 2016a; Pendoley et al. 2014; Ferreira et al. 2020). Their movements during this period are primarily within shallow water <50 m depth and have been shown as extending across the Project Area (Ferreira et al. 2020; Chevron Australia 2010a).

There is no known available information on the migration of juvenile marine turtles within the Project Area.

2.1.6 Adult and Juvenile: Foraging

There are no BIAs defined for foraging activities within the Project Area. Areas suitable for foraging within the Project Area include shallow reef that surround the offshore islands, and mangrove habitat close to the mainland within the Ashburton Delta system.

For flatback turtles, Whittock et al. (2016a) describes a foraging area situated 20 km to the west of Thevenard Island and may extend with the Project Area boundary. Baseline foraging surveys undertaken in July/August 2009 for the Wheatstone Project recorded 69 green turtles and two flatback turtles within the offshore area, with the highest density of sightings occurring within reef habitat (12.6 turtles per km^2) (Chevron Australia 2010a). There is no information on foraging activities of adult hawksbill turtles or juvenile marine turtles of any species.

2.1.7 Hatchling: Behaviour

2.1.7.1 Onshore

Following emergence from their nest, hatchlings 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 on the beach towards a lower brighter horizon (as occurs over the ocean) and away from a tall dark horizon (dunes) (Limpus & Kamrowski 2013; Pendoley & Kamrowski 2015; Salmon et al. 1992). The orientation angles of the tracks of hatchlings on the beach can be measured to determine the spread of their tracks as an indication of their disorientation, and the offset of their direction of travel in relation to the direction of the ocean as an indication of their misorientation.

Prior to the construction of the Wheatstone Project, the orientation angles of hatchling tracks from 18 hatched nests (flatback: n = 13; green: n = 5) were recorded in 2009/10 (Chevron Australia 2010a). Of these 18 nests, 13 were recorded at nesting habitat within the Project Area (Ashburton Island: flatback: n = 6; Bessieres Island: flatback: n = 1; green: n = 5; and Onslow Back beach: flatback: n = 1).

The mean fan angle was larger for flatback turtle hatchlings (66.7°, range = 20 – 108°) compared to green turtle hatchlings (37.6°, range 14 – 62°) indicating a broader natural spread of their tracks when orienting to the ocean.

There are no known orientation angles of hawksbill hatchling tracks from nesting habitat within the Project Area.

2.1.7.2 Offshore

Following the completion of their initial swimming/frenzy period to an offshore area situated away from their nesting habitat (Wyneken & Salmon 1992), marine turtle hatchlings are considered to be subject to the influence of tidal currents for their subsequent dispersal over large geographical areas of the ocean. Limited observations on hatchling behaviour as they leave the beach suggests that they will search out and use floating weed to rest on after several hours of swimming (Clusella-Trullas et al. 2006). This, together with the overriding influence of tides and currents (stronger than 0.5 knot) on swimming speeds, will carry the hatchlings to some common convergent zones where they will use floating rafts of seaweed for shelter and foraging (Musick & Limpus 1997).

Flatback turtle hatchlings have been tracked in the Project Area in the nearshore waters off Thevenard Island (Wilson et al. 2018; Wilson et al. 2019). Hatchlings tracked on the north-western shoreline of the island dispersed offshore at speeds of 0.5 $m.s^{-1}$ and their trajectories were displaced by ocean currents which ran parallel (east–west) to the coast (Wilson et al. 2018). However, when an artificial light was present, hatchlings were able to swim against low velocity currents (up to 0.3 $m.s^{-1}$) to get towards (and stay near) the light source located on a boat in the nearshore (Wilson et al. 2018). Hatchling speed (0.5 $m.s^{-1}$) was found to be faster than maximum current speed (0.3 $m.s^{-1}$), meaning they could move in any direction as their speed was greater than the speed of the nearshore current. On the north-western side of the island, hatchlings mostly moved directly offshore or to the northwest, rather than towards the east. When the tide was ebbing (flowing towards the southwest), movement towards the northwest was more pronounced as the currents carried them in this direction (Wilson et al. 2018). When the tide was flooding (moving towards the east), hatchlings dispersed more towards the north (Wilson et al. 2018). Hatchlings have also been tracked on the south-eastern side of the island near the jetty (Wilson et al. 2019). Hatchlings mostly moved towards the southwest (n = 7) with the exception of two individuals that moved towards the east. This study was conducted on the ebbing tide when currents flowed to the southwest at speeds of 0.13 ± 0.03 $m.s^{-1}$ and was the likely cause for the hatchlings travel direction.

There are no other known tracking studies involving green or hawksbill hatchling turtles at nesting habitat within the Project Area.

2.2 Seabirds and Migratory Shorebirds

2.2.1 Background

The Pilbara coast and islands provide ecologically important feeding, roosting, and breeding habitat for many species of resident and migratory seabirds and shorebirds.

Seabird species are those which spend most of their lives at sea, are highly pelagic or coastal, and forage on the ocean (Commonwealth of Australia 2017). The Pilbara coast and islands provide habitat for resident and migratory species of terns, noddies, cormorants and wedge-tailed shearwaters.

Shorebirds are wader species which inhabit the shorelines of coasts and inland water bodies for most of their lives and are particularly associated with wetland habitat (Commonwealth of Australia 2017). The Pilbara coast and islands provides habitat for resident and migratory shorebirds. Resident species include terns, plovers, curlews, oystercatchers, osprey, and white-bellied sea-eagles. Migratory species pass through the Region, which is part of the East Asian-Australasian Flyway (Bamford et al. 2008) on their way to northern Australia from breeding grounds in the Northern Hemisphere or wintering grounds in New Guinea. Migratory species include plovers, sandpipers, stints, curlews, knots, and godwits.

Threatened species are, in broad terms, those species that have been identified as being in danger of becoming extinct (Commonwealth of Australia 2012). Species may be listed in the following categories:

- Conservation dependent;
- Vulnerable;
- Endangered;
- Critically endangered;
- Extinct in the wild; or
- Extinct.

Migratory species are those species that are listed under:

- The Convention on the Conservation of Migratory Species of Wild Animals 1979 (CMS or Bonn Convention).
- The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment 1974 (JAMBA).
- The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment 1986 (CAMBA).
- The Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds 2007 (ROKAMBA).
- Any other international agreement, or instrument made under other international agreements approved by the environment minister.

Birds that are considered in scope as part of the ALIA are restricted to those listed under Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* legislation. An EPBC Protected Matters Report for the project region (Shire of Ashburton) was generated using the Matters of National Environmental Significance (MNES) search tool, in conjunction with a search for scheduled species in the Wildlife Conservation (Specially Protected Fauna) Notice 2018 in Schedule 5 of the *WA*

Biodiversity Conservation Act (2016) (BC Act). The search results for 37 seabird and shorebird species, and their status, are shown in **Table 2**.

Table 2: The EPBC status and results from an MNES search for the presence of listed seabird and shorebird species occurring in the Project Area. There are 21 seabird species - * beside their common name, and 16 shorebird species.

Scientific Name	Common Name	Presence	Presence type	Threatened Category	Migratory Category	Marine
Actitis hypoleucos	Common Sandpiper	Known	Species or species habitat known to occur within area		Migratory Wetlands Species	Listed
Anous stolidus	Common Noddy *	May	Species or species habitat may occur within area		Migratory Marine Birds	Listed
Apus pacificus	Fork-tailed Swift	Likely	Species or species habitat likely to occur within area		Migratory Marine Birds	Listed - overfly marine area
Ardenna carneipes	Flesh-footed Shearwater, Fleshy-footed Shearwater*	May	Species or species habitat may occur within area		Migratory Marine Birds	Listed (as Puffinus carneipes)
Ardenna pacifica	Wedge-tailed Shearwater*	Known	Breeding known to occur within area		Migratory Marine Birds	Listed (as Puffinus pacificus)
Bubulcus ibis	Cattle Egret	May	Species or species habitat may occur within area			Listed - overfly marine area (as Ardea ibis)
Calidris acuminata	Sharp-tailed Sandpiper	Known	Species or species habitat known to occur within area		Migratory Wetlands Species	Listed
Calidris canutus	Red Knot, Knot	May	Species or species habitat may occur within area	Endangered	Migratory Wetlands Species	Listed - overfly marine area
Calidris ferruginea	Curlew Sandpiper	Known	Species or species habitat known to occur within area	Critically Endangered	Migratory Wetlands Species	Listed - overfly marine area
Calidris melanotos	Pectoral Sandpiper	Likely	Species or species habitat likely to occur within area		Migratory Wetlands Species	Listed - overfly marine area
Calonectris leucomelas	Streaked Shearwater*	Likely	Species or species habitat likely to occur within area		Migratory Marine Birds	Listed
Charadrius leschenaultii	Greater Sand Plover, Large Sand Plover	Known	Species or species habitat known to occur within area	Vulnerable	Migratory Wetlands Species	Listed

Scientific Name	Common Name	Presence	Presence type	Threatened Category	Migratory Category	Marine
Charadrius veredus	Oriental Plover, Oriental Dotterel	May	Species or species habitat may occur within area		Migratory Wetlands Species	Listed - overfly marine area
Chroicocephalus novaehollandiae	Silver Gull*	Known	Breeding known to occur within area			Listed
Fregata ariel	Lesser Frigatebird, Least Frigatebird*	Likely	Species or species habitat likely to occur within area		Migratory Marine Birds	Listed
Glareola maldivarum	Oriental Pratincole	May	Species or species habitat may occur within area		Migratory Wetlands Species	Listed - overfly marine area
Haliaeetus leucogaster	White-bellied Sea-Eagle*	Known	Species or species habitat known to occur within area			Listed
Hydroprogne caspia	Caspian Tern*	Known	Breeding known to occur within area		Migratory Marine Birds	Listed
Larus pacificus	Pacific Gull*	Known	Breeding known to occur within area			Listed
Limnodromus semipalmatus	Asian Dowitcher	May	Species or species habitat may occur within area		Migratory Wetlands Species	Listed - overfly marine area
Limosa lapponica	Bar-tailed Godwit	Known	Species or species habitat known to occur within area		Migratory Wetlands Species	Listed
Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit, Russkoye Bar-tailed Godwit	Known	Species or species habitat known to occur within area	Critically Endangered		
Macronectes giganteus	Southern Giant-Petrel, Southern Giant Petrel*	May	Species or species habitat may occur within area	Endangered	Migratory Marine Birds	Listed
Numenius madagascariensis	Eastern Curlew, Far Eastern Curlew	Known	Species or species habitat known to occur within area	Critically Endangered	Migratory Wetlands Species	Listed
Onychoprion anaethetus	Bridled Tern*	Known	Breeding known to occur within area		Migratory Marine Birds	Listed
Onychoprion fuscatus	Sooty Tern*	Known	Breeding known to occur within area			Listed
Pandion haliaetus	Osprey*	Known	Breeding known to occur within area		Migratory Wetlands Species	Listed
Phaethon lepturus	White-tailed Tropicbird*	May	Species or species habitat may occur within area		Migratory Marine Birds	Listed

Scientific Name	Common Name	Presence	Presence type	Threatened Category	Migratory Category	Marine
Rostratula australis	Australian Painted Snipe	May	Species or species habitat may occur within area	Endangered		Listed - overfly marine area
Sterna dougallii	Roseate Tern*	Likely	Breeding likely to occur within area		Migratory Marine Birds	Listed
Sternula albifrons	Little Tern*	May	Species or species habitat may occur within area		Migratory Marine Birds	Listed
Sternula nereis	Fairy Tern*	Known	Breeding known to occur within area	Vulnerable		Listed
Thalassarche carteri	Indian Yellow-nosed Albatross*	May	Species or species habitat may occur within area	Vulnerable	Migratory Marine Birds	Listed
Thalasseus bengalensis	Lesser Crested Tern*	Known	Breeding known to occur within area			Listed
Thalasseus bergii	Greater Crested Tern*	Known	Breeding known to occur within area		Migratory Wetlands Species	Listed
Thalassarche impavida	Campbell/black browed albatross*	May	Species or species habitat may occur	Vulnerable	Migratory Marine Birds	Listed
Tringa nebularia	Common Greenshank, Greenshank	Likely	Species or species habitat likely to occur within area		Migratory Wetlands Species	Listed - overfly marine area

Migratory seabird and shorebird species with an EPBC Act 1999 listing, for whom the Project Area overlaps with a BIA, are provided in **Table 3** (derived from Commonwealth of Australia 2012b).

Table 3: EPBC listed marine seabird species and shorebird species with Biologically Important Areas within the Project Area.

Species	Purpose	Category	EPBC Act status
Wedge-tailed shearwater (*Ardenna pacifica*)	Breeding	Seabird	Migratory, marine
Fairy tern (*Sternula nereis nereis*)	Breeding		Vulnerable, marine
Little tern (*Sternula albifrons sinensis*)	Breeding		Migratory, marine
Roseate tern (*Sterna dougallii*)	Breeding		Migratory, marine
Bar-tailed godwit (*Limosa lapponica*)	Habitat	Shorebird	Migratory, marine
Common greenshank (*Tringa nebularia*)	Habitat		Migratory, marine
Greater sand plover (*Charadrius leschenaultii*)	Habitat		Migratory, marine
Grey-tailed tattler (*Heteroscelus brevipes*)	Habitat		Migratory, marine
Ruddy turnstone (*Arenaria interpres interpres)*	Habitat		Migratory, marine
Sanderling (*Calidris alba*)	Habitat		Migratory, marine

2.2.2 Seabirds

Terns are the most common seabird species in the Pilbara coastal region (Johnstone, Burbidge, & Darnell 2013). These are usually seen in small groups and occasionally larger flocks. Along the coastal salt flats and mangroves south-west of the Project Area, Humphreys et al. (2005) recorded roosting groups of silver gulls *Chroicocephalus novaehollandiae,* gull-billed terns *Gelochelidon nilotica*, caspian terns *Hydroprogne caspia*, lesser crested terns *Thalasseus bengalensis*, crested terns *Thalasseus bergii*, common terns *Sterna hirundo*, little terns *Sternula albifrons*, fairy terns *Sternula nereis*, bridled terns *Onychoprion anaethetus*, and whiskered terns *Chlidonias hybrida.* These species have also been recorded in the gulf region waters and islands adjacent to the Project Area (Surman & Nicholson, 2015; Johnstone et al. 2013). Based on previous research in the Project Area and adjacent waters, 30 seabird species have been recorded (**Table 2 and Table 4**).

Table 4: Seabird species that have been recorded in, or adjacent to, the Project Area by other researchers. Five of these species are not EPBC listed for the Project area, so do not occur in Table 2.

Scientific Name	Common Name	Activity	EPBC Listed in Table 3	Reference
Ardenna pacifica	Wedge-tailed Shearwater	Breeding, foraging,	Yes	Johnstone et al., 2013; Surman & Nicholson, 2015
Calonectris leucomelas	Streaked Shearwater	Foraging	No	Dunlop et al., 1995
Chlidonias hybrida	Whiskered Terns	Breeding, foraging, roosting	No	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Chroicocephalus novaehollandiae	Silver Gull	Breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Gelochelidon nilotica	Gull-billed Tern	Foraging, roosting	No	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Haliaeetus leucogaster	White-bellied Sea Eagle	Breeding, foraging, roosting	Yes	Johnstone et al., 2013; Surman & Nicholson, 2015
Hydroprogne caspia	Caspian Tern	Breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Oceanites oceanicus	Wilson's Storm Petrel	Foraging	No	Dunlop et. al. 1995; Johnstone et al., 2013; Surman & Nicholson, 2015
Oceanodroma matsudairae	Matsudeira Storm Petrel	Foraging	No	Dunlop et al., 1995

Scientific Name	Common Name	Activity	EPBC Listed in Table 3	Reference
Onychoprion anaethetus	Bridled Tern	Breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Pandion haliaetus	Osprey	Breeding, foraging, roosting	No	Dunlop et. al. 1995; Johnstone et al., 2013; Surman & Nicholson, 2015
Pelagodroma marina	White-faced Storm Petrel	Foraging	No	Johnstone et al., 2013; Surman & Nicholson, 2015
Phalacrocorax varius	Pied Cormorant	Breeding, foraging, roosting	No	Johnstone et al., 2013; Surman & Nicholson, 2015
Pseudobulweria rostrata	Tahiti Petrel	Foraging	No	Dunlop et al., 1995
Puffinus huttoni	Hutton's Shearwater	Foraging	No	Dunlop et al., 1995
Sterna hirundo	Common Tern	Foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Sternula albifrons	Little Tern	Possible breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Sternula nereis	Fairy Tern	Breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Thalasseus bengalensis	Lesser Crested Tern	Breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015
Thalasseus bergii	Crested Tern	Breeding, foraging, roosting	Yes	Humphreys et al., 2005; Johnstone et al., 2013; Surman & Nicholson, 2015

Based on previous records from aerial and vessel-based surveys of the distribution and abundance of seabirds at sea on the North-west Shelf (Dunlop et al. 1995; Dunlop et al. 1988; Surman 2002, 2005, pers. obs.; Surman & Nicholson 2015; Nicholson 1996 – 2000 pers. obs.), seabird fauna of the waters adjacent to the Exmouth Sub-basin would be expected to include predominantly tropical and sub-tropical species such as the wedge-tailed shearwater, crested tern and bridled tern, as well as boobies, frigatebirds, cormorants, and tropicbirds. In addition, species known to migrate to the area from the Pacific Ocean include streaked shearwaters *Calonectris leucomelas*, Tahiti petrels *Pseudobulweria* *rostrata*, Hutton's shearwaters *Puffinus huttoni* and matsudaira's storm-petrels *Hydrobates matsudaira* (Dunlop et. al. 1995). White-faced storm petrels *Pelagodroma marina* and Wilson's storm petrels *Oceanites oceanicus* have also been recorded (Dunlop et. al. 1995). Significant numbers of wedge-tailed shearwaters have been recorded over-wintering in this region (Surman & Nicholson, 2015) and may be birds which breed on the North-west Shelf during the summer months, or birds from colonies further south at the Houtman Abrolhos.

Within the Project Area, significant seabird breeding colonies have been recorded at Bessieres Island. Many of the recorded seabird species were site-faithful (nesting at the same location each year) and included the wedge-tailed shearwater, bridled tern, silver gull, and osprey. Wedge-tailed shearwater breeding locations have also been recorded on Bessieres Island (Surman & Nicholson, 2015).

Six species of non-migratory seabird species breed in the region during the autumn-winter period, these include the crested tern, lesser crested tern, fairy tern, Caspian tern, roseate tern and pied cormorant (Surman & Nicholson. 2015; Nicholson 2002). Commencement of breeding during this period may range from March (for crested terns) to July (fairy terns). All of these species have been recorded roosting on suitable coastal beaches in the region (Surman & Nicholson 2015; Humphreys et al. 2005).

Four species of seabirds breed on the offshore islands of this region during the summer period; the wedge-tailed shearwater, bridled tern, silver gull and little tern (Surman & Nicholson, 2015). The breeding population is dominated by two migratory seabirds, the burrow nesting wedge-tailed shearwater and the surface nesting bridled tern. The non-breeding component of resident seabirds also feed close to shore, in conjunction with roosting on suitable beaches or sand bars. By biomass, there are significantly more birds breeding and feeding in the region during summer. The wedge-tailed shearwater has not been recorded roosting on suitable coastal beaches of the region, as has occurred with the other three summer breeding species, as it forages in pelagic waters away from landfall, only returning and departing from burrows within the colony in the darkness of dusk and dawn (Nicholson 2002).

2.2.3 Resident Shorebirds

Resident shorebirds species live, feed and breed on the Pilbara coast and islands all year round. They typically nest solitarily during the austral spring and include the pied oystercatcher *Haematopus longirostris*, sooty oystercatcher *H. fuliginosus*, red-capped plover *Charadrius ruficapillus* and eastern reef egret *Egreta sacra* and beach-stone curlew *Esacus magnirostris* (Surman & Nicholson, 2015). Sooty and pied oystercatchers occur in this region in internationally significant numbers (Johnstone et al. 2013).

2.2.4 Migratory Shorebirds

Habitat adjacent to the Project Area is contained within the East Asian-Australasian flyway geographic region that supports groups of migratory waterbirds throughout their annual cycle (Bamford et al. 2008). Avifaunal visitors to the Pilbara region make up 56 % of all recorded bird species.

Migratory waders are the largest guild of shoreline users in the North-west Marine Region. For example, over 20,000 migratory waders have been recorded on Barrow Island (Bamford and Bamford

2005). Many arrive from breeding areas in the Northern Hemisphere between August and October and return north between March and April (Bamford et al. 2008), however some non-breeding adults and juveniles overwinter in the region.

Twenty-eight migratory shorebird species that were recorded in the coastal salt flats south-west of the Project Area by Humphreys et al. (2005) are listed as migratory species under the EPBC Act 1999. Twenty of these species were migrants from breeding grounds in the northern hemisphere. The Pilbara region has been ranked of international importance for the grey-tailed tattler *Tringa brevipes*, greater sand plover *Charadrius leschenaultii*, bar-tailed godwit *Limosa lapponica*, ruddy turnstone *Arenaria interpres,* and sanderling *Calidris alba* (Humphreys et al. 2005; Bamford et al. 2008) (**Table 2**). Sixteen migratory wader species listed as present in the area (MNES data search) are given in **Table 2.**

Thirty species of resident and migratory shore bird species have been recorded during surveys adjacent to the Project Area, and these are given in **Table 5.** The migratory species that are included in **Table 3** are shown. An additional 9 shorebird species were listed as present in the area in **Table 2**, which gives a total of 39 shorebird species having been recorded as present in the region adjacent to the Project Area.

Table 5: Shorebird species recorded adjacent to the Project Area (Surman & Nicholson, 2015; Bamford et al. 2008, 2009; Humphreys et al. 2005).

Scientific Name	Common Name	EPBC Listed in Table 3
Actitis hypoleucos	Common Sandpiper	Yes
Anas gracilus	Grey Teal	No
Anas superciliosa	Pacific Black Duck	No
Ardea alba modesta)	Eastern Great Egret	No
Ardea pacifica	White-necked Heron	No
Arenaria interpres	Ruddy Turnstone	Yes
Aythya australis	Hardhead	No
Calidris alba	Sanderling	Yes
Calidris ruficollis	Red-necked Stint	Yes
Charadrius leschenaultii	Greater Sand Plover	Yes
Charadrius mongolus	Lesser Sand Plover	Yes
Chenonetta jubata	Australian Wood Duck	No
Circus approximans	Swamp Harrier	No
Cygnus atratus	Black Swan	No
Dendrocygna eytoni	Plumed Whistling-Duck	No
Egretta novaehollandiae	White-faced Heron	No
Fulica atra	Eurasian Coot	No
Himantopus himantopus	Black-winged (Pied) Stilt	No
Limosa lapponica	Bar-tailed Godwit	Yes
Malacorhynchus membranaceus	Pink-eared Duck	No
Microcarbo melanoleucos	Little Pied Cormorant	No
Pandion haliaetus	Eastern Osprey	No
Pelecanus conspicillatus	Australian Pelican	No

Scientific Name	Common Name	EPBC Listed in Table 3
Threskiornis spinicollis	Straw-necked Ibis	No
Tringa nebularia	Common Greenshank	Yes
Haematopus longirostris	Pied Oystercatcher	No
Haematopus fuliginosus	Sooty Oystercatcher	No
Charadrius ruficapillus	Red-capped Plover	No
Egreta sacra	Eastern Reef Egret	No
Esacus magnirostris	Beach-stone Curlew	No

Sites are recognised as being important for migratory shorebirds when they regularly support large numbers. The most widely used criteria are those of the Ramsar convention that recognise sites as important if they support:

- 20,000 waterbirds;
- 1 % of a species population; or
- 0.25 % of a migratory species population on passage.

In 2005 a detailed, baseline field survey of shorebirds took place in the mangrove dominated coastal zone of the eastern Exmouth Gulf, Western Australia (Humphreys et al. 2005). Except for the common tern (*Sterna hirundo*) the counts for shorebird species from both surveys were all well below any criterion of international significance. Higher numbers of migratory shorebirds were recorded in the Project Area and surrounds during the austral summer (Bamford et al. 2008). Thirty-five shorebird species have been recorded along the coastal gulf area south-west of the MRL project site (Humphreys et al. 2005). The families that represented the main species were the sandpipers (*Scolopacidae*; 14 species), herons (*Ardeidae*: six species) and plovers (*Charadriidae*; six species). The most abundant species in the study area were the grey-tailed tattler, red-necked stint (*Calidris ruficollis*), bar-tailed godwit and the greater sand plover (*Charadrius leschenaultia*).

3 STEP 2: DESCRIBE THE PROJECT AREA LIGHTING

3.1 Appearance of Light

Light may appear as either a direct light source from an unshielded lamp with direct line of sight to the observer or through sky glow. Where direct light falls upon a surface, this area of light is referred to as light spill.

Sky glow is the diffuse glow caused by light that is screened from view but through reflection and refraction, creates a glow in the atmosphere. Scattering of light by dust, salt and other atmospheric aerosols increases the visibility of light as sky glow, while the presence of clouds reflecting light back to earth can substantially illuminate the landscape (Kyba et al. 2011). White-blue light scatters more easily and further in the atmosphere compared to yellow-orange light (Kyba et al. 2011). Therefore, the distance at which direct light and sky glow may be visible from the source is dependent on the number, intensity and types of lights, and how such lights are orientated or shielded, in addition to environmental conditions such as topography, vegetation, and cloud cover.

3.2 Description of Project Lighting

Project facility and vessel lighting considered in this assessment include:

- Landside Development Envelope
  - Storage and loading infrastructure
  - Desalination plant
  - Power station
  - Administration buildings
  - Sewage treatment facility
- Nearshore Development Envelope
  - Dedicated berth
  - Jetty wharf
  - Ship loader, including 2 Transhipment Vessels (TSV's)
- Offshore Development Envelope
  - 2 Ocean Going Vessels (OGV's) (at anchorages A and B)
  - 2 TSV's unloading at one OGV (anchorage A)

The landside and nearshore facilities have a total of 248 LED luminaires resulting in a total lumen output of 2,427,500 lumens. All lighting is either 4000K LED or Amber LED (peak emission at 612 nm) with no direct upward light spill. OGV lighting consists of wide range of luminaires including 3500K tungsten halogen, High Pressure Sodium (HPS), 4000K incandescent and 4000K fluorescent lights, with little in-built light spill mitigation. In total, each OGV has 82 lights for a total of 1,061,840 lumens each (therefore, a total of 2,123,680 lumens at the anchorage area).

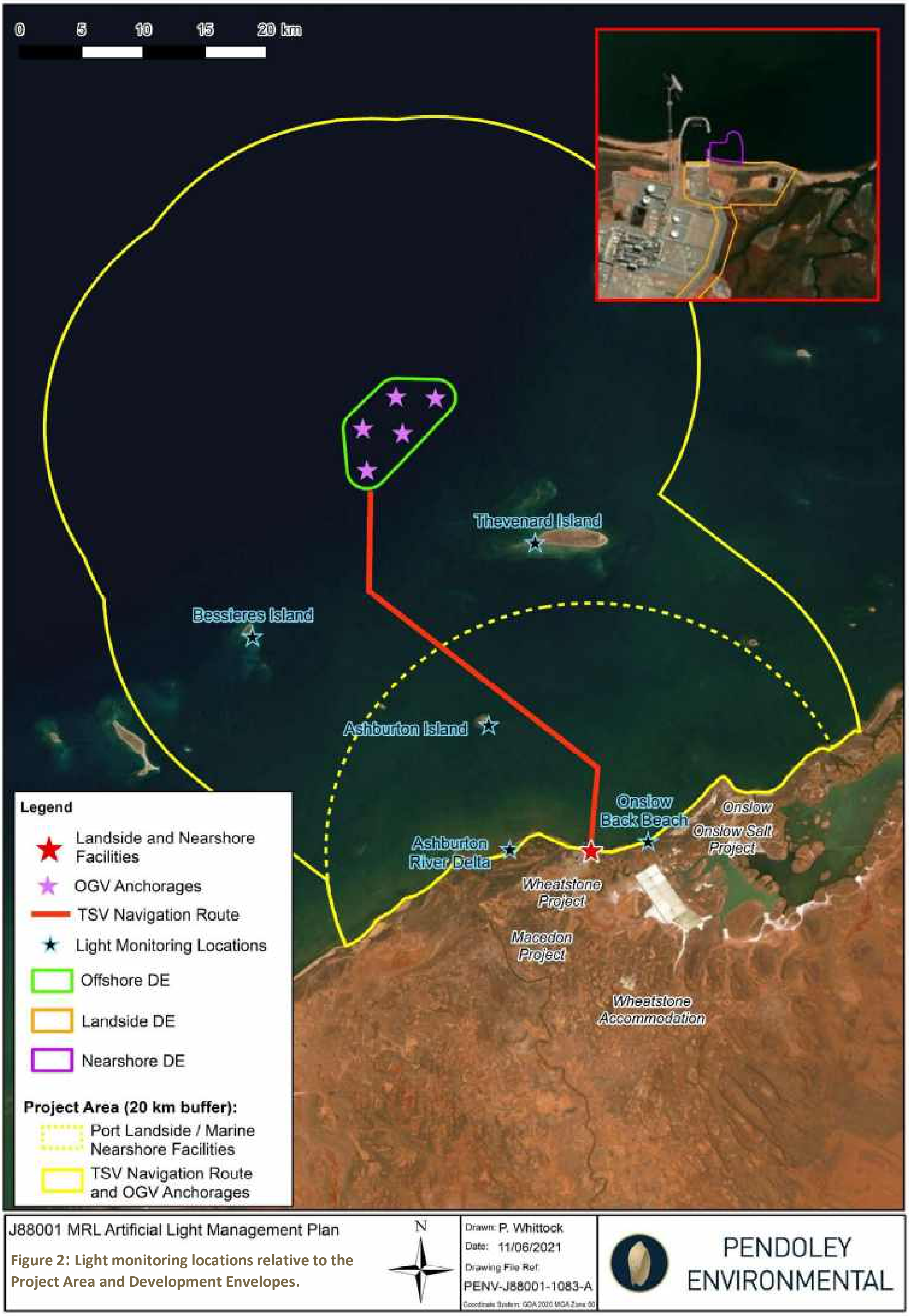
TSV Lighting consists primarily of 5000K LED's with a similar number of 4000K LED's. Each TSV has a total of 34 luminaires emitting 622,814 lumens. As the modelling considers 2 TSV's at the loading jetty and 2 TSV's at the anchorage area, 1,245,628 lumens representing the TSV's is therefore included in each area. A summary of lights included within the assessment is provided in **Appendix B**.

3.2.1 Shipping Activities

MRL plans to utilise the nearshore portion of the existing PPA shipping channel. The TSV will utilise the existing PPA channel until deep water is reached and then navigate to the anchorage area (**Figure 2**). Specifically, shipping activities will involve:

- Four TSV's (with one tugboat attached to each) continuously operating 24 hours a day.
- A maximum of two OGV anchorages in use at any time, with at least one OGV likely to be present at any time.

Each TSV will take approximately three hours each way to transit to/from the Port and the OGV anchorage area (not including loading time). The TSV will take approximately seven hours to transfer its load to the OGV at the anchorage area. Note that transiting TSV's are not included within the modelled data.



J88001 MRL Artificial Light Management Plan

Figure 2: Light monitoring locations relative to the Project Area and Development Envelopes.

3.3 Summary of Benchmark Light Monitoring and Modelling Outputs

3.3.1 Benchmark Light Monitoring

Two mainland and three offshore island sites were monitored to determine the existing lighting environment within the Project Area (see **Appendix A**, **Figures A5 – A9**). The images clearly show a substantial source of directly visible light and sky glow originating from the Wheatstone development located immediately adjacent to the MRL project footprint. The light from the Wheatstone development is visible from every location surveyed, including the offshore locations at Thevenard and Bessieres Islands. Sky glow from the Onslow area, including the township and the Onslow Salt facilities, was also visible from every survey location except the Ashburton River Delta where the orientation of Onslow relative to the Wheatstone development results in the two light sources merging into each other.

3.3.2 Light Modelling

The benchmark light modelling results are presented in **Appendix A, Figures A10 – A14**. The direct visibility and sky glow from lights associated with the proposed project were modelled separately from each of the five monitoring sites using the ILLUMINA model. The benchmark survey results were then merged with the modelled output to provide a final image of the existing and the proposed light sources. The images were then interpreted to give a prediction on the visibility of direct light and sky glow from each of the survey locations. These predictions are summarised below.

The modelling of project-related light from representative islands in the Project Area showed the MRL landside and nearshore facility lighting is visible on the horizon and merges with the Wheatstone project site when viewed from the benchmark monitoring sites on Bessieres, Thevenard, and Ashburton Islands (**Figures A10** – **12**). The visibility of these facilities is a function of distance with the greatest direct and sky glow intensities observed from Ashburton Island compared to the similarly reduced intensities visible from Thevenard and Bessieres Islands. The cumulative increase in direct visibility of light and sky glow over the existing light from the Wheatstone facilities is not detectable in the model results from these offshore island locations.

The model results for the Ashburton River Delta site (**Figure A14**) confirm the shielding of light by the vegetated dune that backs this beach and shows a relatively small cumulative increase in sky glow intensity and areal extent above the dune produced by the existing Wheatstone development. When viewed from Onslow Back Beach (**Figure A13**), the landside and nearshore facility lighting is directly visible and merge with the lights from the existing Wheatstone development, extending the area of visibility across the horizon. There is also a cumulative increase in sky glow intensity and aerial extent above the Wheatstone and MRL facilities when viewed from this location. The modelled glow from the offshore anchorage area (situated 35 km away) is very dim and spread low across the offshore horizon, and once merged with ambient sky glow in the benchmark image, it is undetectable from these mainland locations.

While no vessel lights are directly visible from the anchorage location at any of the offshore islands surveyed, the sky glow is very visible, particularly from Thevenard and Bessieres Islands which are situated ~10 km from the offshore anchorage area.

While model results show sky glow is visible from Ashburton Island, when the benchmark results are accounted for, sky glow from the OGV's is completely shielded by dunes and vegetation on the island.

4 STEP 3: RISK ASSESSMENT

4.1 Methods

The potential impacts of lighting associated with the Project Area during both construction and operational phase are assessed utilising an impact assessment matrix. The impact assessment process is modified from the Great Barrier Reef Marine Park Authority Environmental Assessment and Management Risk Management Framework (GBRMPA 2009). The impact assessment process is described in **Table 6** with descriptions of the likelihood and consequence provided in **Table 7** and **Table** 8, respectively. In this section we assess the impacts before (inherent) and after (residual) mitigation measures outlined in the ALMP (see **Section 5**) are applied.

The assessment is conducted on the MRL project lighting only and does not assess other existing lighting in the area (**Section 3.2**). While the inherent risk of cumulative lighting can be assessed it is not possible to assess the residual risk of cumulative lighting because the proponent has no control over the lighting operated by other projects. Recommendations for management and mitigation of lighting can only be made for Project lighting and not for Wheatstone, Onslow Salt, or Onslow township lighting. The following risk assessment is therefore restricted to the MRL project and does not account for cumulative impact from third party lighting.

Table 6: Impact assessment matrix.

Likelihood (see **Table 4** for definition)		**Consequence** (see **Table 5** for definition)				
		Insignificant 1	*Minor* 2	*Moderate* 3	*Major* 4	*Catastrophic* 5
Almost certain *(96 – 100 %)*	5	**Medium** 5	**High** 10	**High** 15	**Extreme** 20	**Extreme** 25
Likely *(71 – 95 %)*	4	**Medium** 4	**Medium** 8	**High** 12	**High** 16	**Extreme** 20
Possible *(31 – 70 %)*	3	**Low** 3	**Medium** 6	**Medium** 9	**High** 12	**High** 15
Unlikely *(5 – 30 %)*	2	**Low** 2	**Low** 4	**Medium** 6	**Medium** 8	**High** 10
Rare *(0 – 5 %)*	1	**Low** 1	**Low** 2	**Low** 3	**Medium** 4	**Medium** 5

Table 7: Definition of likelihood.

Description	**Frequency**	**Probability**
Almost certain	Expected to occur more or less continuously throughout a year (e.g. more than 250 days per year)	96 – 100 %
Likely	Expected to occur once or many times in a year (e.g. 1 to 250 days per year)	71 – 95 %
Possible	Expected to occur once or more in the period of 1 to 10 years	31 – 70 %
Unlikely	Expected to occur more than once in the period of 10 or more years	5 – 30 %
Rare	Expected to occur once or less over project life	0 – 5 %

Table 8: Definition of consequence.

Description	Definition
Insignificant	Little to no impact on the overall ecosystem. Very small levels of impact on turtles, seabirds, or shorebirds and their habitats. Only occasional injury to, or mortality of, turtles.
Minor	Impacts are present, but not to the extent that the overall condition of turtle, seabird, and shorebird populations or their habitats are impaired in the long term. Low levels of mortality of turtles and their habitats. Recovery would generally be measured in years for habitats.
Moderate	Turtles, seabirds, and shorebirds populations and their habitats are significantly affected, as outlined in the Significant Impact Guidelines (Commonwealth of Australia 2013). Recovery at habitat level would take at least a decade, with recovery of turtle populations taking several decades.
Major	Significant impact on turtle, seabird, or shorebird populations and their habitats, as outlined in the Significant Impact Guidelines (Commonwealth of Australia 2013), with high level of mortality. Recovery of habitats would take a few decades with populations taking several decades.
Catastrophic	Turtle, seabird, or shorebird habitat is irretrievably compromised. Mass mortality of turtles, seabirds, or shorebirds, and local extinction of species. Recovery over several decades for habitat values and centuries for turtle, seabird, or shorebird populations.

4.2 Significant Impact Criteria

The EPBC Act Significant Impact Guidelines (Commonwealth of Australia 2013) provide criteria under which an action can be assessed. An action is likely to have a significant impact on an endangered or vulnerable species if there is a real chance or possibility that it will:

- Lead to a long-term decrease in the size of a population (endangered) or important population (vulnerable).
- Reduce the area of occupancy of the species (endangered) or important population (vulnerable).
- Fragment an existing population (endangered) or important population (vulnerable) into two or more populations.
- Adversely affect habitat critical to the survival of a species.
- Disrupt the breeding cycle of a population (endangered) or important population (vulnerable).
- Modify, destroy, remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline.
- Result in invasive species that are harmful to an endangered or vulnerable species becoming established in the endangered or vulnerable species' habitat.
- Introduce disease that may cause the species to decline.
- Interfere (endangered) or substantially interfere (vulnerable) with the recovery of the species.

The potential for significant impacts are assessed based on the outcomes of the impact assessment. The ALMP is adaptive and will incorporate new information from environmental monitoring surveys, annual audits, and any changes to project scope and scale. The following outcomes from the impact assessment will be modified and updated as required.

4.3 Marine Turtles

Adverse effects of artificial light on marine turtle behaviour are well recognised by a substantial body of research (see Withington & 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.

In general, artificial light most disruptive to marine turtles are those rich in short wavelength blue and green light (400 – 550 nm) (Fritsches 2012; Pendoley 2005; Witherington 1992a). The attractiveness to light differs by species (Horch et al. 2008; Pendoley 2005; Wang et al. 2007; Witherington & Bjorndal 1991a, 1991b), however, green, flatback, and loggerhead turtles all show increased sensitivity to wavelengths <600 nm (Fritsches 2012; Pendoley 2005; Levenson et al. 2004). Furthermore, green and flatback turtles show stronger preference for blue light <500 nm (Fritsches 2012; Pendoley 2005). Thus, cooler, whiter lights are more likely to attract turtles in comparison to warmer, amber lights.

Although longer wavelengths of light are less attractive than shorter wavelengths, long wavelength light can still disrupt the ability of hatchlings to locate the sea (Robertson et al. 2016; Pendoley 2005; Pendoley & Kamrowski 2015), and if bright enough can elicit a similar response to shorter wavelength light (Mrosovsky 1972; Mrosovsky & Shettleworth 1968; Pendoley & Kamrowski 2015; Cabrera-Cruz et al. 2018). Hence, the disruptive effect of light on hatchlings is also strongly correlated with intensity. However, red light (~650 – 700 nm) must be almost 600 times more intense than blue light before green turtle hatchlings show an equal preference for the two colours (Mrosovsky 1972).

In the absence of competing light sources, there is potential for artificial light to result in behavioural impacts to marine turtles, should the intensity be great enough, even if spectral output of light sources are outside the peak sensitivity of marine turtles (i.e. >600 nm).

4.3.1 Adult: Nesting

4.3.1.1 Background

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 & 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).

It has been postulated that neophytes (females breeding for the first time) are more vulnerable to nesting disruption by artificial light compared to experienced females that had nested at a given beach prior to the introduction of light sources (Limpus pers. comm.). Anecdotal outcomes of long-term marine turtle monitoring programs across Australia suggest that (assumed) neophyte turtles favour nesting on dark beaches unaffected by onshore light pollution, whereas experienced nesters continue to use light affected beaches. Over time this could result in changes in nesting distribution in response to artificial light.

In addition to potential impacts to nesting females prior to or during nesting, artificial light also has the potential to impact post-nesting behaviour. On completion of laying, nesting females are thought to use light cues to return to open ocean, orientating towards the brightest light (Witherington & Martin 2003). However, observations of nesting females and emerging hatchlings at the same beach showed that females were disorientated much less frequently than hatchlings (Witherington 1992b) indicating that nesting females are less vulnerable to impacts of artificial light on sea-finding behaviour post nesting.

4.3.1.2 Impact Assessment

The vulnerability of adult turtles to artificial light when utilising nesting habitat within the Project Area varies based on the distance to light sources, the orientation of the habitat to the Project Area, and localised topography. For example, at Ashburton River Delta, the beach is backed by a large dune extending up to 15 m in height and its orientation in relation to the project means it will be shielded from direct visibility of landside and nearshore lights along the entire length of the beach. Similar shielding at Onslow Back Beach was observed in the benchmark monitoring and modelling results (**Section 3.3** and **Appendix A**). There will also be direct visibility of the TSV's from these mainland locations when transiting between the Port and the anchorage area.

The benchmark monitoring and modelling results have confirmed that the landside and nearshore facility lighting is visible from the offshore islands within the Project Area, which means that the nesting females will have direct visibility of this lighting. Females nesting on Direction and Ashburton Islands will be exposed to brighter light (direct and sky glow) than females on the more offshore islands, including Thevenard and Bessieres. Female green turtles nesting on the north coast of Thevenard will not be exposed to the landside and nearshore lighting due to the shielding by the island's topography.

The offshore anchorage area will be most visible to nesting females on the north coast of Thevenard and on Bessieres Island. All of the islands located along the navigations channel between the Port and the anchorage area will be directly exposed to light from the TSV, particularly from Ashburton where the navigation channel makes its closest approach to the island.

The likelihood of light and glow from the **nearshore and landside facilities** being visible from nesting habitat on the mainland and on the offshore islands is Almost Certain based on the modelling results with greatest visibility from mainland beaches and Ashburton Island and substantially reduced visibility at Thevenard and Bessieres Islands. The potential for this to cause disturbance to adult female turtles or deter their use of the habitat is Insignificant due to shielding by the vegetated dunes reducing the visibility of the light from the mainland beaches and the lack of strong evidence to show that experienced nesting females are affected by light behind the beach or offshore. Inexperienced nesting females may potentially be disturbed by light behind the beach however this will only apply to a small number of neophytes that might chose to nest at the Ashburton River Delta and this consequence is therefore ranked as Insignificant. The inherent risk to nesting females from landside and nearshore lighting is therefore assessed as Medium.

The likelihood of disturbance is further reduced when additional control measures are applied (outlined in **Section 5**). Good light management of the landside and nearshore facilities will reduce the visibility of the lights to mainland and Ashburton Island nesting females to Possible, with a consequence of Insignificant resulting in a residual ranking of Low (**Table 9**).

Table 9: Summary of impact assessment for adult nesting marine turtles from landside and nearshore facility lighting.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
Residual	Insignificant (1)	Possible (3)	Low (3)

The modelling results confirm the likelihood of light and glow from the **anchorage area** being visible from nesting habitat on Thevenard and Bessieres Islands is Almost Certain and from Ashburton Island, Ashburton River Delta and Onslow Back Beach, Rare due to the substantially reduced visibility of the anchorage at these nearshore sites. The potential for the anchorage area lighting to cause disturbance to adult female turtles or deter their use of the habitat is Insignificant due to the location of the light offshore where it will not impact on nest site selection. The consequence is therefore ranked as Insignificant. The inherent risk to nesting females from anchorage lighting is therefore assessed as Medium.

The likelihood of disturbance is further reduced when additional control measures are applied (outlined in **Section 5**). Good light management at the anchorage area will reduce the visibility of the lights from Thevenard and Bessieres Island nesting females to Possible, with a consequence of Insignificant giving a residual ranking of Low (**Table 10**).

Table 10: Summary of impact assessment for adult nesting marine turtles from anchorage area lighting.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Almost certain (5)	Medium (6)
Residual	Insignificant (1)	Possible (3)	Low (3)

4.3.2 Hatchling: Onshore

4.3.2.1 Background

Artificial lights interfere with natural light levels and silhouettes disrupting onshore hatchling sea finding behaviour (Withington & Martin 2003; Pendoley & Kamrowski 2015; Kamrowski et al. 2014). Hatchlings may become disorientated - where hatchlings crawl in circuitous paths; or misorientated - where they move in the wrong direction, possibly attracted to artificial lights (Withington & 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.

Hatchling orientation has been shown to be disrupted by light produced at distances of up to 18 km from the nesting beach (Hodge et al. 2007; Kamrowski et al. 2014), although the degree of impact would be influenced by a number of factors including light intensity, visibility (a function of lamp orientation and shielding), spectral power distribution (wavelength and colour), atmospheric scattering, cloud reflectance, spatial extent of sky glow, duration of exposure, horizon elevation, and lunar phase.

4.3.2.2 Impact Assessment

The vulnerability of hatchling marine turtles to artificial light sources within the Project Area is likely to vary at each area of nesting habitat. This is because the intensity and visibility of light at each area of habitat will be different due to localised topography and its distance from light sources.

The likelihood of light and glow from **landside and nearshore lighting** being visible to emerging hatchlings nesting habitat on the mainland and on the offshore islands is Almost Certain based on the modelling results with greatest visibility from mainland beaches and at Ashburton Island, and substantially reduced visibility at Thevenard and Bessieres Islands. At Ashburton River Delta on the mainland, hatchlings will not have direct visibility of lights associated with the nearshore and landside facilities due to shielding provided by a dune system that extends up to 15 m in height in some places. Sky glow from these sources is likely to be visible, however this is less intense than if the source was directly visible. Furthermore, when sky glow is elevated above a tall dark horizon, hatchlings will use the dark horizon cue to continue to orient seaward (Pendoley & Kamrowski 2016) and this consequence is therefore ranked as Insignificant. Direct light from the transiting TSV's is likely to be visible (including from Direction Island), however the temporary nature of the moving vessels, their seaward orientation, and distance from the habitat, means it is unlikely to negatively impact hatchling orientation. The inherent risk to hatchling turtles on mainland and Ashburton beaches from landside and nearshore lighting is therefore assessed as Medium. The risk to hatchlings from landside and nearshore lighting on Thevenard and Bessieres Islands will be lower due to the substantially reduced visibility of the light at those distances.

The likelihood of disturbance is further reduced when additional control measures are applied (outlined in **Section 5**), including the shielding and redirection of Port lighting and the use of lights with suitable wavelengths and intensities. Light management at the Port will reduce the visibility of the lights to mainland and Ashburton Island to onshore hatchling turtles to Possible, with a consequence of Insignificant, giving a residual ranking of Low (**Table 11**).

Table 11: Summary of impact assessment for hatchlings onshore from landside and nearshore facility lighting.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
Residual	Insignificant (1)	Possible (3)	Low (3)

The modelling results confirm the likelihood of light and glow from **anchorage area lighting** being visible from nesting habitat on Thevenard and Bessieres Islands is Almost Certain and from Ashburton Island, Ashburton River Delta, and Onslow Back Beach, Rare due to the substantially reduced visibility between the anchorage these nearshore sites. This assessment will therefore focus on Thevenard and Bessieres islands.

Bessieres and Thevenard islands are situated <20 km from both the TSV navigation route and anchorage area (and >20 km from the Port) (**Figure 1**). At Thevenard Island, flatback turtles are known to utilise the south-east side of the island for nesting and the presence of a dune system behind the habitat will shield emerging hatchlings from artificial light associated with the OGV's at the anchorage area. Therefore, the likelihood of these lights negatively impacting hatchling flatback turtles is ranked as Rare and is not addressed further here. However, this is not the case for green turtles at Thevenard Island as they are known to utilise the north and west side of the island for nesting. This means onshore hatchlings are likely to have a direct visibility of artificial light associated with the OGV's at the anchorage area and therefore the likelihood of hatchlings being exposed to light from the anchorage is Almost Certain. Hatchlings that are exposed to light from the anchorage area will potentially be misoriented and crawl along the beach instead of directly seaward. This alteration in orientation can lead to exhaustion, dehydration, and consumption of energy reserves required for their offshore swimming frenzy, in addition to increased exposure to predation. Given that this exposure to the anchorage lights will occur continually throughout the year, including multiple nests over multiple hatchling emergence seasons, the potential consequence of this exposure is significant and therefore ranked as Moderate. The inherent ranking for this risk is therefore High.

The likelihood of the lights being visible to the onshore hatchlings can be reduced when additional control measures are applied as outlined in **Section 5** with a specific focus on OGV lights as follows:

- Reduce lumen output to as low as possible;
- Reduce colour temperature to < 2700 K (from the 6500 K currently planned);
- Shield all lights to prevent upward sky glow; and
- Aim all lights so they are not directed towards Thevenard and Bessieres Islands.

Strict light management of the OGVs as described above will reduce the visibility of the lights to the Thevenard and Bessieres onshore hatchling turtles to Possible (potential for exposure in one nesting season), with a consequence of Minor, giving a residual ranking of Medium (**Table 12**).

Table 12: Summary of impact assessment for hatchlings onshore from anchorage area lighting.

Impact	Consequence	Likelihood	Risk rating
Inherent	Moderate (3)	Almost certain (5)	High (15)
Residual	Minor (2)	Possible (3)	Medium (6)

4.3.3 Hatchling: Offshore

4.3.3.1 Background

Once in nearshore waters, artificial lights on land can interfere with the dispersal of hatchlings. The presence of artificial light can slow down their in-water dispersal (Witherington & Bjorndal 1991; Wilson et al. 2018) or increase their dispersion path, potentially depleting yolk reserves, or even attract hatchings back to shore (Truscott et al. 2017). In addition to interfering with their offshore dispersal, artificial light can influence predation rates, with increased predation of hatchlings in offshore 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 occurring in artificially lit areas and under artificial structures (refer Wilson et al. 2019) may further increase the predation risk to hatchlings.

An internal compass set while crawling down the beach, together with wave cues, are used to reliably guide hatchlings offshore (Lohmann & Lohmann 1992; Stapput & Wiltschko 2005). In the absence of wave cues, however, swimming hatchlings have been shown to orientate towards light cues (Lorne & Salmon 2007; Harewood & Horrocks 2008) and in some cases, wave cues were overridden by light cues (Thums et al. 2013, 2016; Wilson et al. 2018).

4.3.3.2 Impact Assessment

The Project Area experiences semi-diurnal tides and a spring tide range of 1.9 m. The maximum velocity of the tidal current in the Project Area is variable (0.05 - 0.40 m/s; Government of Western Australia 2018), with currents increasing in speed the further offshore. The speed is faster than the reported swimming speed of hatchlings at Thevenard Island (Wilson et al. 2018) meaning that once a hatchling is a certain distance offshore, their movement is likely to be heavily influenced by tidal currents resulting in their dispersal over a large geographical area and away from the Project Area. In summary, if a hatchling turtle was attracted to an offshore light, the tidal current would likely be too strong for the hatchling to move towards it. However, during periods when the velocity of the tidal current is slower than the hatchling swim speed, there does remain the potential for a hatchling to swim towards a light if it was attracted to and trapped by the light, potentially increasing its exposure to predation and causing exhaustion.

The likelihood of light and glow from the landside and nearshore facilities being visible to hatchlings swimming offshore from Onslow Back Beach, Ashburton River Delta and Ashburton Island is Possible, and Rare from Thevenard and Bessieres, based on the modelling results. The potential for the landside and nearshore lights to misorient hatchlings in the sea is Insignificant due to their swimming direction into waves which typically approach from a seaward direction drawing hatchlings offshore and away from the mainland lights. The inherent risk to hatchlings offshore from Port Lighting is therefore assessed as Low.

The likelihood of disturbance is further reduced when additional control measures are applied (outlined in **Section 5**). Good light management at the landside and nearshore facilities will reduce the visibility of the lights to mainland and Ashburton Island hatchlings to Unlikely, with a consequence of Insignificant resulting in a residual ranking of Low (**Table 13**).

Table 13: Summary of impact assessment for hatchlings offshore from landside and nearshore facility lighting.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Possible (3)	Low (3)
Residual	Insignificant (1)	Unlikely (2)	Low (2)

The modelling results confirm the likelihood of light and glow from **anchorage area lighting** being visible from nearshore waters at Thevenard and Bessieres Islands is Almost Certain and from Ashburton Island, Ashburton River Delta, and Onslow Back Beach, Rare due to the substantially reduced visibility between the anchorage these nearshore sites. The potential for the anchorage lights to misorient hatchlings swimming offshore is Insignificant due to their swimming direction into waves which typically approach from a seaward direction drawing hatchlings offshore where the regional tides and currents will disperse the hatchlings over a wide area and prevent them swimming purposeful towards offshore lights. The inherent risk to hatchlings offshore from anchorage lighting is therefore assessed as Medium.

The likelihood of the anchorage lights being visible to the hatchlings offshore can be reduced when additional control measures are applied as outlined in **Section 5** with a specific focus on OGV lights as follows:

- Reduce lumen output to as low as possible;
- Reduce colour temperature to < 2700 K (from the 6500 K currently planned);
- Shield all lights to prevent upward sky glow; and
- Aim all lights so they are not directed towards Thevenard and Bessieres Islands.

Strict light management of the OGVs as described above will reduce the visibility of the lights to hatchlings swimming offshore and minimise the risk of them becoming trapped in light spill around the vessels and exposed to predation. The likelihood of hatchlings seeing the light will be reduced to Possible, with a consequence of Insignificant, giving a residual ranking of Low (**Table 14**).

Table 14: Summary of impact assessment for hatchlings offshore from anchorage area lighting.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
Residual	Insignificant (1)	Possible (3)	Low (3)

4.3.4 Inter-nesting, Migration, and Foraging

4.3.4.1 Background

Little is known about the impact of artificial light on adult and juvenile turtles when they are offshore. Some studies have described the attraction of marine turtles to light that is associated with commercial fishing operations. Chemical light sticks are often used in longline fisheries to attract baitfish which then attract the larger, target fish such as tunas and swordfish (Witzell 1999). Whether the turtles are directly attracted to the light source itself or alternatively to their prey (that is attracted to the light source) is unclear, however, adult turtles have been observed feeding on prey near oil production platforms in the Gulf of Mexico (Kebodeaux 1994). In contrast, other studies have suggested that turtles may not be attracted to light sources at sea, for example Ortiz et al. (2016) found that illuminated fishing nets reduced the bycatch of green turtles as they are thought to alert them to the presence of a net.

Since marine turtles do not feed when breeding (Limpus et al. 2013), attraction of inter-nesting turtles to light sources as a secondary response to effects of light on prey distribution is not expected. To date, there is no evidence to suggest inter-nesting turtles are attracted to light from offshore vessels.

4.3.4.2 Impact Assessment

There is likely to be foraging grounds within the Project Area, including coral reef, mangrove, tidal creeks, and river mouths, which are habitats known to provide food sources for juvenile and adult marine turtles. Flatback, green, and hawksbill turtles are known to use the nearshore waters along the mainland coast and around islands for internesting and migration routes (Ferreira et al. 2020; Fossette et al. 2021; Whittock et al, 2016).

Because there is no evidence to suggest adult marine turtles use light as a cue at sea, and because foraging, interesting, and migrating marine turtles remain largely submerged the likelihood of these age classes being exposed to directly visible light and sky glow is Possible, the consequences are Insignificant, and the resulting risk is Low.

Once the control measures outlined in **Section 5** are applied to both Port and offshore anchorage lights, including the shielding and redirection of lighting and the use of lights with suitable wavelengths and intensities, the of exposure to light is reduced to Unlikely and the risk of any residual impact due to project lighting is Low. The likelihood of disturbance is further reduced when additional control measures are applied (outlined in **Section 5**). Outcomes of the risk assessment is provided in Table 15.

Table 15: Summary of impact assessment for inter-nesting, migrating, and foraging marine turtles.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Possible (3)	Low (3)
Residual	Insignificant (1)	Unlikely (2)	Low (2)

4.3.5 Significant Impact

Considering the information provided above, and the implementation of control measures outlined in **Section 5**, significant impacts to marine turtles are not expected because of project lighting as summarised in **Table 16**.

Table 16: Summary of significant impact assessment of project lighting on marine turtles, according to EPBC guidelines.

Significant Impact Criteria	Assessment of significance
Lead to a long-term decrease in the size of a population	Of greatest risk is the potential impact of light pollution disrupting hatchling turtle behaviour on the beach. Control measures, including monitoring and adaptive management, will eliminate light spill and shield any light directly visible at the nesting habitat, and minimise additional sky glow, reducing potential impacts to hatchling turtles. Should any changes in hatchling behaviour on the beach be detected pre- and post-construction, adaptive management will identify and rectify potential impacts to prevent long term declines. Accordingly, long-term decreases in the size of the population or genetic stock are not expected.
Reduce the area of occupancy of the species	Light spill on nesting habitat is not anticipated to occur due to the location of the project and the control measures in place to manage and monitor lights and minimise additional sky glow. Accordingly, the project is not expected to reduce the area of occupancy of marine turtle species.
Fragment an existing population into two or more populations	The genetic stocks for each turtle species identified in **Section 1** occur over a large geographical area and comprise several nesting beaches. Fragmentation of nesting populations within each genetic stock are not considered likely to occur given the nature of the project lighting.
Adversely affect habitat critical to the survival of a species	Beaches and adjacent waters in the vicinity of the project are identified as important habitat to the survival of flatback, green, and hawksbill turtles (**Section 1.1.1**). Areas of nesting habitat could be impacted by the direct visibility of onshore and offshore sources of light. Control measures, including monitoring and adaptive management, will eliminate light spill and shield any light directly visible at nesting habitat, and minimise additional sky glow, reducing potential impacts to nesting turtles. Should any changes in hatchling behaviour be detected post-construction, adaptive management will rectify any identified adverse effects. The project is not expected to adversely affect habitat critical to the survival of marine turtles.
Disrupt the breeding cycle of a population	The direct visibility of light at the nesting habitat is not considered to be of sufficient intensity to disrupt nesting activity but may have the potential to influence onshore hatchling behaviour. Project Area lighting will be controlled and minimised in accordance with best practice lighting design principles. Should any changes in onshore hatchling behaviour be detected after construction, adaptive management will identify and rectify potential impacts, preventing disruption to the breeding cycle. Accordingly, disruption to the marine turtle breeding cycles is not expected.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	There is a pathway for light pollution to decrease the quality of nesting habitat. However, proposed control measures will aim to minimise direct light and sky glow detected at nesting habitat. Should any changes in onshore hatchling behaviour be detected after construction, adaptive management will identify and rectify changes to nesting habitat so that the marine turtle populations are not impacted.

Significant Impact Criteria	Assessment of significance
Result in invasive species that are harmful to a species becoming established in the endangered or vulnerable species' habitat	Light sources are not expected to result in introduction of invasive species.
Introduce disease that may cause the species to decline	Not applicable to light emissions.
Interfere with the recovery of the species	The status of each marine turtle species' genetic stock is outlined in **Section 1**. With proposed control measures in place, the impact of light pollution on nesting and hatchling behaviour is unlikely to significantly affect the marine turtle populations in the long term. The implementation of monitoring and adaptive management will prevent long term impacts on nesting and hatchling behaviour. The project is not expected to interfere with the recovery of the genetic stocks.

4.4 Seabirds and Shorebirds

4.4.1 Seabirds

Species with a nocturnal component of their life history, such as procellariforms (taxonomic order that comprises albatrosses, petrels, and shearwaters), include the wedge-tailed shearwater, that breeds on nearby offshore islands. These species are at greater risk of negative impacts. The bulk of the literature concerning impacts of lighting upon procellariforms 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), with fewer investigating the impacts of light at sea. Reports of interaction between seabirds and artificial light at sea is generally anecdotal following significant interaction events (e.g. Black 2005), or by unsystematic monitoring by oil and gas operators (e.g. Day et al. 2015; Glass & Ryan 2013; Wiese et al. 2001; Ronconi et al. 2015). Deck lights and spotlights on fishing vessels have been recorded attracting numerous seabirds at night, particularly on nights with little moon light or low visibility (Black 2005; Merkel & Johansen 2011; Montevecchi 2006).

In an overview of seabirds and migratory shorebirds of the north-west marine region (Commonwealth of Australia 2012a), bright lighting was found to disorient flying birds and subsequently cause their death through collision with infrastructure or starvation due to disruptions in the ability to forage at sea (Wiese et al. 2001). Light pollution is a particular issue for wedge-tailed shearwaters due to their nocturnal habits and migratory shorebirds as they undertake their migratory flights at night (Geering et al. 2007). Gas flares and facility lights on petroleum production and processing plants are a significant source of artificial lighting that attract seabirds (Wiese et al. 2001) and could potentially attract migrating shorebirds. Nesting birds may be disoriented where lighting is situated adjacent to rookeries. This is evident for young fledglings, in particular wedge-tailed shearwaters, leaving breeding colonies for the first time (Nicholson 2002). Bright lights can also impact on migrating birds. Illumination at night from artificial lights can reduce the extent of foraging behaviour in shorebirds

(Thomas et al. 2004), potentially reducing their abilities to replace used energy reserves (body fat) or to prepare for breeding or migration.

Diurnal seabird species, such as frigatebirds, terns, noddies, and boobies, in contrast, are less vulnerable to impacts resulting from nocturnal behaviours. However, the presence of facilities can alter foraging behaviours and provide artificial roosting sites. Tasker et al. (1986) reported that a variety of seabird species recorded around oil platforms were observed feeding by the light of the gas flare at night, pecking at small unidentified items in the sea. This feeding behaviour was noted less frequently during the day (Tasker et al. 1986). Ortego (1978), reported that the only impact of artificial light associated with an oil rig in the Gulf of Mexico on the blue faced booby was increased foraging.

Artificial light sources can enable some species to take advantage of increased foraging opportunities that result in a food (energy) subsidy, particularly during periods when food availability would normally be limited (Harris and Wanless, 1997, Montevecchi 2002). Additional food resources can result in increased breeding effort and success for these species (often gulls), leading to expanding populations, with potential detrimental impacts on other seabirds and island ecosystems in the area (Surman & Dunlop 2015). Silver gulls are able to breed year-round dependent upon food sources, thus are able to increase in numbers relatively quickly (Wooller & Dunlop 1979). Increased numbers of gulls impact other seabird and shorebird species (through predation on eggs and chicks) or upon protected marine turtles (through increased predation pressure upon turtle eggs/hatchlings).

The ability to see colour depends on specialised cells in the eye called cones, and variation in the number and types of these in the retina means animals do not see the same range of colour as humans. In animals, being ‘sensitive’ to light within a specific range of wavelengths means they can see light at that wavelength, and it is likely they will respond to that light source (Seymourne *et al*. 2019; Longcore *et al*. 2018). While the sensitivity of nocturnal seabirds to short wavelength UV-blue light is relatively well understood (Machovsky-Capuska et al. 2011), there is a paucity of literature on the sensitivity of diurnal seabirds to different wavelengths. Studies on the eye physiology of terns found that pigments for vision in the short wavelength ultraviolet and violet (blue) region of the spectrum were present in some tern species, but not all that were investigated, (Machovsky-Capuska et al. 2011). Diurnal seabirds are aquatic foragers, displaying diverse foraging strategies including surface seizing and dipping, suggesting an evolutionary adaptation to high sensitivity in the shorter wavelengths (Hart 2001). However, despite being a predatory diving bird, experiments on cormorants (*Phalacrocorax carbo*), suggest that these birds have poor visual resolution in water (Martin et al. 2008). This conflicting information suggests that the sensitivity of diurnal seabirds to different wavelengths is likely to be highly species dependent.

Nearshore areas within 20 km of the Port Marine Project include mangroves, tidal creeks, and river mouths which are habitats known to provide food sources and shelter for roosting seabirds. While sparse, information summarised above suggests that seabirds may be sensitive to light across the entire spectrum, depending upon the behaviour being undertaken. Sensitivity to shorter wavelengths (ultraviolet and blue) during foraging may occur in some species, depending on the foraging strategy. Unmitigated, it is possible that direct light will illuminate foraging habitat, influencing foraging behaviour, or displace seabirds from roosting areas. Attraction of migrating birds to artificial light may occur, although the migrating seabirds in this region mostly occur in pelagic waters and near the offshore islands.

Sensitivities of seabird species to artificial light could potentially alter their use of this area, so that the risk rating is medium. However, with control measures for offshore lighting outlined in **Section 5** applied, the risk of impact is likely to be low (**Table 17**).

Table 17: Summary of the impact assessment for seabirds.

Impact	Consequence	Likelihood	Risk rating
Inherent	Insignificant (1)	Likely (4)	Medium (4)
Residual	Insignificant (1)	Possible (3)	Low (3)

4.4.2 Migratory Shorebirds

Shorebirds feed during both the day and night and increase their feeding in the lead-up to migration (Santiago-Quesada et al. 2014; Lourenço et al. 2008). Two basic types of foraging strategies have been described: visual and tactile (touch-based) foraging. Some species, such as sandpipers, switch from visual foraging during the day, to tactile foraging at night, likely due to poor night vision (Lourenço et al. 2008). However, other species, such as plovers, are better adapted to night vision and employ visual foraging strategies during both day and night (Lourenço et al. 2008). Accordingly, artificial lighting has been shown to influence the nocturnal foraging behaviour in shorebirds, often resulting in improved foraging success by increasing the availability of more successful visual foraging (Santos et al. 2010; Dwyer et al. 2013). Conversely, artificial lighting may also increase risk of predation to shorebirds potentially resulting in selection of nocturnal roost sites with lower levels of light (Rogers et al. 2006). It has been shown that the density of dunlin (*Calidris alpina*) in suitable foraging areas declined with increasing distance to the nearest roost site (Dias et al. 2006). In the great knot (C. *tenuiros*) and red knot (C. *canutus*), nocturnal roost sites with low exposure to artificial lighting were selected (e.g. streetlights and traffic), (Rogers et al. 2006). This indicates that artificial illumination of nocturnal roost sites may reduce occupation of these roost sites and consequently influence the abundance of shorebirds in nearby foraging areas.

Although research into the role of vision in foraging has been undertaken, the sensitivity of shorebirds to different wavelengths is poorly understood. As aquatic foragers, an evolutionary adaptation to high sensitivity in the shorter wavelengths may be expected. It is possible that artificial illumination at any spectral output will alter foraging or nocturnal roosting behaviours, particularly in visual foragers, but the degree of impact will likely depend on the intensity of the light.

Red light has been shown to impact migration of passerines (taxonomic order comprising songbirds) via disruption of magnetic orientation in the laboratory (Wiltschko et al. 1993) and in the field (Poot et al. 2008). No disruption to orientation was observed under blue or green light (Wiltschko et al. 1993). Some species of shorebird, such as waders, undertake long-distance migrations, with studies indicating that some species possess a magnetic compass and suggest that magnetic cues are of primary directional importance (Sanderling; Gudmundsson & Sandberg 2000).

While sparse, information summarised above suggests that shorebirds may be sensitive to light across the entire spectrum, depending upon the behaviour being undertaken. Sensitivity to shorter wavelengths (ultraviolet and blue) during foraging may occur in some species, depending on the foraging strategy, whereas during migration, shorebirds may be vulnerable to the impacts of red wavelength light on orientation.

Unmitigated, it is possible that direct light will illuminate foraging habitat, influencing foraging behaviour, or displace shorebirds from roosting areas. Attraction of migrating birds to artificial light may occur, although the numbers of birds migrating through the area is expected to be low.

Once control measures outlined in **Section 5** are applied, light spill onto nocturnal roosting habitats, which may displace roosting individuals, will be reduced. Further, light spill onto intertidal foraging habitats will be limited to areas immediately adjacent to the ship loader gantry. The absence of light spill illuminating the habitat will prevent displacement from occurring. Accordingly, with mitigation applied, potential impacts are expected to be limited to localised changes in foraging behaviours of a small number of individuals where the gantry crosses the shoreline. Prevention of upward light spill and avoidance of red lights will reduce the likelihood of migrating birds becoming disorientated and the implementation of a bird interaction procedure will reduce the likelihood of negative impacts to individuals in the unlikely event of a bird grounding. Outcomes of the risk assessment is provided in **Table 18**.

Table 18: Summary of the impact assessment for shorebirds.

Impact	Consequence	Likelihood	Risk rating
Inherent	Minor (2)	Possible (3)	Medium (6)
Residual	Insignificant (1)	Unlikely (2)	Low (4)

4.4.3 Significant Impact Assessment

Considering the information provided above, and the implementation of control measures outlined in **Section 5**, significant impacts to seabirds or migratory shorebirds are not expected because of project lighting. A summary is presented in **Table 19.**

Table 19: Summary of significant impact assessment of project lighting on seabirds and shorebirds, according to EPBC guidelines.

Significant Impact Criteria	Assessment of significance
Lead to a long-term decrease in the size of a population	Due to the limited impacts predicted, and the low risk rating for both seabirds and shorebirds, long term decreases in population size are not expected.
Reduce the area of occupancy of the species	Light sources are not expected to displace individuals or populations from existing habitat and therefore the area of occupancy is not expected to be reduced.
Fragment an existing population into two or more populations	Lights sources are not expected to act as a barrier to movement of individuals, or displace individuals or populations, and therefore fragmentation of populations is not expected.
Adversely affect habitat critical to the survival of a species	No habitat critical for EPBC listed species identified in **Section 2** is identified in the Project Area. Therefore, impacts to critical habitat are not credible.
Disrupt the breeding cycle of a population	Of the species with moderate probability of occurrence or that are known to be breed within marine habitats in the Onslow and Ashburton Region adjacent to the Project Area, Wedge-tailed Shearwaters exhibit nocturnal foraging and fledgling dispersal

Significant Impact Criteria	**Assessment of significance**
	behaviours where impacts from light could present a potential impact. However, due to the distance of their breeding islands, mitigated light sources associated with the Project Area are not expected to disrupt breeding cycles of the species present.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	Although light may be visible from foraging habitat for both seabirds and shorebirds, the presence of light is not expected to adversely impact this habitat. Nocturnal roost sites are not expected to be impacted by light to the extent that species populations will decline.
Result in invasive species that are harmful to a species becoming established in the endangered or vulnerable species' habitat	Light sources are not expected to result in introduction of invasive species. However, existing populations of invasive species may utilise artificial light to extend foraging conditions. Chicks of ground nesting birds would be most vulnerable to predation from invasive species. The absence of breeding of ground nesting bird species in the Project Area prevents significant impacts occurring because of invasive species.
Introduce disease that may cause the species to decline	Not applicable to light emissions.
Interfere with the recovery of the species	The impact assessment determined that the potential for impacts to seabirds and shorebirds were low, and the potential for significant impacts in the above criteria are not expected. Therefore, light sources associated with the project are not expected to interfere with the recovery of the species present.

5 STEP 4: ARTIFICIAL LIGHT MANAGEMENT PLAN

The objectives of this Artificial Light Management Plan (ALMP) are as follows:

- Reduce the output of light from the Project Area to as low as reasonably practicable.
- Ensure onshore sources of light are not directly visible at areas of sensitive habitat.

The following sections of the ALMP provides guidance for how best to achieve these objectives. This ALMP applies to lighting associated with the Project Area.

5.1 Best Practice Lighting Design Principles

The following best practice light design principles for external light sources, summarised in **Figure 3**, are modified from Appendix A of the guidelines (Commonwealth of Australia 2020) to be specific to the proposed project, and the wildlife described in **Section 2.**

Figure 3: Summary of best practice lighting design principles.

5.2 Lighting Design Control Measures

5.2.1 Use Minimum Number and Intensity of Lights

Starting from a base case of no lights, use only the minimum number and intensity of lights needed to provide safe and secure illumination required to meet the lighting objectives, including navigation, and health and safety requirements. Avoiding light fixtures surplus to needs will decrease overall light emissions. The intensity of light is thought to be as important a cue as colour for both marine turtles and some seabirds (Raine et al. 2017; Rodriguez et al. 2017; Mrosovsky 1972; Mrosovsky & Shettleworth 1968; Pendoley & Kamrowski 2015; Cabrera-Cruz et al. 2018) and, therefore, intensity should be reduced to as low as possible, regardless of the type, colour, and planned operation of the light.

There may be a trade-off between the number of lights and intensity of each light, which can only be explored with the use of modelling using conventional lighting design software. Intensity of light should be measured in lumens, not wattage, when comparing intensity between different lighting design options.

Control measure:

- A comparative assessment of lighting designs to identify the minimum number and intensity of lights required to meet lighting objectives.

5.2.2 Adapt Lighting for Colour, Intensity, and Timing

Potential for impacts from white light is universal across the fauna groups (Commonwealth of Australia 2020). However, the optimum wavelength for reducing potential impacts differs between the species and the behaviours being undertaken. Migrating shorebirds may be sensitive to long wavelength red light, while marine turtles and seabirds are more sensitive to short wavelength (UV to blue/green) (**Sections 2** and **4**).

Therefore, where compliant with health and safety requirements, white lights should be replaced with amber/orange lights. If white lights are required, filters to block green, blue, violet, and ultra-violet wavelengths should be applied. Although the frequency of occurrence of migratory shorebirds is predicted to be low, migrating individuals may occur (**Section 2.2**) and, therefore, the use of red and green lights should only be used when required by navigational law.

For lights that are not required to be continuously lit, smart LED lighting technology should be implemented to allow for switching off when not in use, or the use of intermittent flashing lights. The suitability of different commercial lights, with respect to reducing impacts to marine turtles, seabirds, and migratory shorebirds, is summarised in **Table 20**.

Table 20: Suitability of commercial lights. Source: Commonwealth of Australia (2020).

Light type	Suitability
Low Pressure Sodium Vapour	Recommended * 'Filtered' means this type of luminaire can be used only if a filter is applied to remove the short wavelength light
High Pressure Sodium Vapour	
Amber/orange LED	
PC Amber LED	
Filtered* LED	
Filtered* metal halide	
Filtered* white LED	
White LED	Not recommended
Metal halide	
White fluorescent	
Halogen	
Mercury vapour	

Control measures:

- Lights situated seaward of the dune at the Port to utilise amber LED emitters (~585 nm 'true amber' emitters, 'phosphor-coated amber').
- Lights situated landward of the dune at the Port and above 10 m height, to utilise amber LED emitters (~585 nm 'true amber' emitters, 'phosphor-coated amber').
- Lights situated landward of the dune <10 m and where there is a need for good colour rendition, to utilise LEDs with a Correlated Colour Temperature (CCT) equal to or lower than 2700K.
- Red and green lights only used where required by navigation law.
- If specific, intermittent tasks require a brighter white light (i.e. higher CCT), personnel are to use head torches.
- Lighting design to identify lights that are not required to be continuously lit.
- Lights that are not required to be continuously lit to be motion activated, put on a timer, or can be manually switched off.
- Flashing/intermittent lights, or reflectors to be installed onshore instead of fixed beam to identify an entrance or delineate a pathway.

5.2.3 Light only the Area Intended

Light spill is light that falls outside the area that is intended to be lit. Vertical light spill is light that spills above the horizontal plane, which contributes directly to artificial sky glow. Light spill that spills into adjacent areas, including the sea surface, is known as light trespass, and can potentially impact wildlife, such as marine turtle hatchlings, present in adjacent areas. Since birds may be present at ground level and in flight, preventing vertical light spill is as important as reducing light trespass onto the adjacent habitat for these species. To avoid any form of light spill, light fittings should be designed, located, and directed to avoid lighting anything but the target area, both onboard and overboard vessels and on land-based facilities.

Control measures:

- All lights to be directed downwards using targeted asymmetrical distribution to illuminate only the specific areas of need, while minimising the reflectance.
- All lights to be mounted at a height as low as possible while meeting lighting objectives.
- The existing vegetation and dune profile in proximity to the Port to be maintained and enhanced where feasible.
- Onshore Port lights to be directed away from turtle nesting habitat. For lights required to be directed in the direction of the habitat, lights should be placed so that buildings provide inherent shielding, where practicable.
- OGV and TSV lights to be directed downwards and direct light spill onto the ocean surface avoided unless operationally required.
- OGV and TSV lights should be aimed to prevent light being directly visible from nesting beaches.
- Jetty and gantry design to prevent gaps in the floor which would result in light shining directly onto the ocean below the gantry and jetty, were compliant with technical and safety requirements.
- Shielding of all lights to achieve an upward waste light output ratio (ULR) of 0 %. Shielding can be achieved by recessing the light fitting into roof structures, eaves or building ceilings, or the light housing which prevents horizontal light above a 45-degree angle.
- All glass (windows/doors) of buildings to have a glass light transmissivity rating of 0.5 or less.
- All glass (windows/doors) of buildings to have opaque (block-out) blinds/curtains/shutters fitted.
- OGV and TSV windows fitted with opaque (block-out) blinds/curtains/shutters unless continuous visibility is required (e.g. on the bridge).

5.2.4 Use Non-reflective, Dark Coloured Surfaces

Light reflected from highly polished, shiny, or light-coloured surfaces can contribute to sky glow. Use of dark matte surfaces can reduce reflectance and scattering of light that contributes to sky glow.

Control measures:

- Exterior finishes on all buildings to be matte and have a maximum reflective value of 30 %.
- All other surfaces, including roads and conveyors within the port, to be matte and have a maximum reflective value of 30 %, unless not technically feasible or presents a health and safety risk.

5.3 Construction Control Measures (Temporary)

- Ensure mobile light sources are not oriented towards nesting habitat or seaward (where possible) and to keep the height of these to a minimum.

5.4 Operational Control Measures

- All non-essential lighting to be switched off when not in use, including on the OGV's and TSV's (i.e. reduce to navigation lighting only when not operational).
- Building and vessel window blinds to be shut during hours between sunset and sunrise.
- Vehicle headlights to be dipped when operating within the port boundary.
- Vehicles to be parked facing away from the direction of the ocean.

6 STEP 5: BIOLOGICAL AND ARTIFICIAL LIGHT MONITORING AND AUDITING

6.1 Artificial Light Monitoring and Modelling

6.1.1 Baseline (pre-construction)

PENV completed a baseline artificial light monitoring survey at Ashburton, Bessieres, and Thevenard islands, and Ashburton River Delta on the mainland, during the new moon period in July 2021 (**Appendix A**). The survey was conducted using a digital camera and fisheye lens technique as recommended by Hänel et al. (2018) and Barentine (2019) and described in the guidelines (Commonwealth of Australia 2020).

The light monitoring data was used to represent existing light sources in modelled scenarios of the project's intended lighting design to predict the visibility of light from the Project Area at the selected monitoring sites. The modelled scenarios also considered project-specific details, including:

- Location and height of lights to be installed.
- Type of lights (e.g. LED).
- Shielding where applicable.
- Topography and vegetation.
- TSV and OGV lighting.

Where specific lighting information was unavailable, assumptions were made based on an over-estimated 'worst case' basis.

6.1.2 Operations (post-construction)

At least one artificial light monitoring survey will be undertaken post-construction of the project at the same monitoring sites, and following the same methodology, as baseline. Results will be used to verify the baseline modelling outputs and any changes to the identified light sources.

6.2 Marine Turtle Monitoring

6.2.1 Baseline (pre-construction)

Based on the outcomes of the impact assessment, onshore hatchling marine turtles were most at risk of a negative impact from Project Area lighting, with little to no impact on nesting adult turtles. Proposed monitoring will focus on measuring the orientation of hatchlings at the nesting habitat to determine the influence of artificial light on their sea-finding ability. Monitoring of adult turtles will also be undertaken to determine any potential impacts from facility lighting and confirm that the proposed additional light controls are adequate.

Therefore, proposed monitoring will focus on measuring the orientation of hatchlings at the nesting habitat to determine the influence of artificial light on their sea-finding ability.

Locations proposed for monitoring include Ashburton Island (due to it being in closest proximity to the Port and the TSV navigation route), Thevenard Island and Bessieres Island (due to its area of critical marine turtle habitat, multi-species use, and proximity to the anchorage area and TSV navigation route).

Methodology for monitoring the orientation of hatchlings will include the measurement of their tracks post-hatching (i.e., the next day) to assess two metrics; spread angle and offset angle (**Figure 4**) as follows:

- **Spread angle**: this describes track dispersion from the emergence point, capturing the spread of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean finding bearings and may indicate disruption to natural hatchling sea finding ability.
- **Offset angle:** this describes the degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e. less deviation from the most direct route) and a larger value demonstrates greater deviation from the most direct route, which may indicate disruption to natural hatchling sea finding ability.

A nest fan will be recorded if five or more hatchling tracks are sighted from a hatched clutch, indicated by a localise depression in the sand which marks the point of emergence. A sighting compass will be used to measure the bearing of the outermost tracks of the nest fan and the bearing of the most direct route to the ocean. Bearings will be measured from either the point where the track crosses the high tide line, or five metres from the clutch emergence point (whichever distance is shortest). The survey length should be a minimum of 14 days and be focused around a new moon period during the nesting season. Hatchling orientation metrics can alternatively be collected by the use of in-situ controlled release of hatchlings within an arena at night.

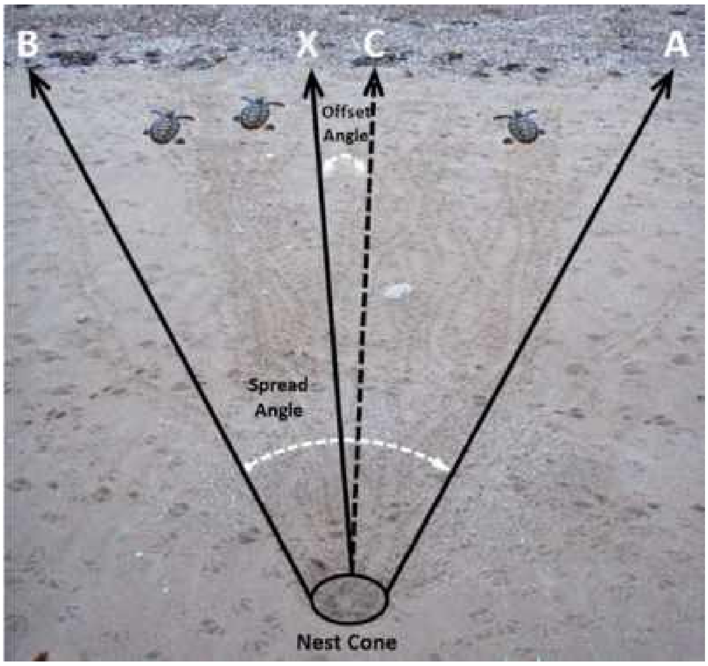


Figure 4: Hatchling orientation indices

6.2.1.1 Adult Turtles

Locations proposed for monitoring include Ashburton Island (due to it being in closest proximity to the Port and the TSV navigation route), Direction Island, Thevenard Island, and Bessieres Island (due to its area of critical marine turtle habitat, multi-species use, and proximity to the anchorage area and TSV navigation route). Methodology for monitoring the orientation of adult turtles will include the measurement of their tracks pre- and post-nesting (i.e. the next day) via the use of aerial imagery captured by an Unmanned Aerial Vehicle (UAV). Analysis will involve the use of GIS to measure the following data parameters for each identified marine turtle track (all species) in the imagery within a designated monitoring area at each surveyed location:

- **Track length ratio:** The length of the nesting marine turtle's 'up' and 'down' track for each emergence on the beach will be measured and compared. To ensure consistency, the 'up' track will be measured from a delineated line on the beach (e.g. spring high tide line) to their first activity on the beach (if an attempt or nest) or furthest extent up the beach if a false crawl (i.e. no attempt), and the 'down' track will be measured from the final activity on the beach (if an attempt or nest) or furthest extent up the beach if a false crawl to the delineated line. The hypothesis is that if the sea-finding behaviour of adult nesting turtles is influenced or impacted by artificial light, their 'down' track will be substantially longer than their 'up' track.

- **Bearing of down track:** The bearing of the turtle's 'down' track will be recorded and the angle between the track's bearing and the direct bearing to the ocean will be measured. The hypothesis is that if the sea-finding behaviour of adult nesting turtles is influenced or impacted by artificial light, the angle between the bearing of the 'down' track and the direct bearing to the ocean will be larger.

- **Distribution of nesting activity:** A nearest neighbour spatial analysis will be used to test the amount of randomness in the spatial pattern of marine turtle activity at each location within the designated monitoring area. The analysis involves the measurement of the distance between each activity and the next nearest activity. It then averages all these nearest neighbour distances. If the average distance is less than the average for a hypothetical random distribution within the same area, the distribution of the sightings is considered clustered. If the average distance is greater than the hypothetical random distribution, the sightings are considered dispersed. The hypothesis is that if marine turtles are deterred from nesting within a particular area of nesting habitat due to the visibility of light, the pattern of nesting activity may become more clustered within the darker area.

The survey length should be a minimum of 10 days. Note that no consideration will be given to the lunar phase at the time of monitoring on the basis that there is no evidence that suggests the vulnerability of adult turtles to the influence of artificial light differs across a lunar phase (unlike the case for hatchling turtles).

6.2.2 Operations (post-construction)

At least one hatchling orientation survey, and one adult turtle monitoring survey should be undertaken post-construction of the project at the same monitoring sites, and following the same methodology, as baseline (**Section 6.1.1**). By comparing with baseline data, results will be used to determine the influence of the operating project on the sea-finding ability of hatchling marine turtles and nesting adult turtles.

6.3 Seabird and Migratory Shorebird Monitoring

Based on the results of the impact assessment (i.e. all inherent risk was low), baseline (pre-construction), construction and operations (post-construction) monitoring is proposed. However, bird interactions should still be monitored during construction and operations. If bird interaction records identify that certain species are more vulnerable, or certain areas of the project experience higher frequency of interactions with birds, identification of 'problem lights' can be made using the results of the artificial light monitoring and auditing.

6.4 Auditing

Auditing schedules should be developed in consultation with subject matter experts outlining the frequency of audits to ensure:

- Compliance with control measures;
- Identification of, and measures taken to reduce, impacts of problem lights; and
- Identification of any new information regarding potential impact pathways between artificial light associated with the project and biological receptors, and any adaptive management measures that could further reduce potential impacts.

As outlined in the guidelines, audits should be undertaken by personnel qualified in environmental auditing and considered in consultation with an appropriately qualified biologist or ecologist.

6.5 Adaptive Management and Continuous Improvement

6.5.1 Marine Turtles

If the operations (post-construction) monitoring identifies an impact (i.e. a significant difference in hatchling orientation compared to baseline), additional engineering and/or operational solutions should be implemented where practicable to control the 'problem light(s)', such as:

- Changing the wavelength of light.
- Additional shielding of light.
- Changing the orientation and direction of the light fittings.
- Consideration to whether activities requiring illumination of problem lights can be undertaken during daylight hours only

An additional survey will be undertaken after implementation of any proposed actions to determine whether the actions have been successful. If engineering solutions fail then intervention at the nesting beach may be required and could include;

- Relocation of nests exposed to light
- Collection of misoriented hatchlings for release into the ocean.

A significant difference in hatchling orientation metrics (spread and offset values) between baseline and construction/operations is typically defined by a difference of greater than two standard deviations above baseline. However, this approach may differ based on the sample size of the baseline dataset and will be confirmed by a qualified statistician following the initial collection of baseline data (currently scheduled to be gathered in Jan 2023).

REFERENCES

BAMFORD, M.J., CHERRIMAN, S. & BAMFORD (2009). Survey for Migratory Waterbirds in the Wheatstone LNG Project Area, November 2008 and March 2009. Technical Appendix K1 within the Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project prepared for URS Australia Pty Ltd on behalf of Chevron Australia Pty Ltd, by M. J. and A. R. Bamford Consulting Ecologists, Kingsley, WA.

BAMFORD, M., WATKIN, D., BANCROFT, W., TISHLER, G. & WAHL, J. (2008) *Migratory Shorebirds of the East Asian-Australasian Flyway: Population Estimates and Internationally Important Sites.* Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT.

BAMFORD, M.J. & BAMFORD, A.R. (2005) *Gorgon Development on Barrow Island: Technical Report Avifauna*. Unpublished report for ChevronTexaco Australia Pty Ltd. 72pp.

BARENTINE, J.C. (2019) Methods for assessment and monitoring of light pollution around ecologically sensitive sites. *Journal of Imaging*, 5(54), e5050054.

BECKER, A., WHITFIELD, A.K., COWLEY, P.D., JÄRNEGREN, J & NAESJE, T.F. (2013) Potential effects of artificial light associated with anthropogenic infrastructure on the abundance and foraging behaviour of estuary-associated fishes. *Journal of Applied Ecology*, 50, 43-50.

BLACK, A. (2005) Light induced seabird mortality on vessels operating in the Southern Ocean: incidents and mitigation measures. *Antarctic Science*, 17 (1), 67–68.

CABRERA-CRUZ, S.A., SMOLINSKY, J.A. & BULER, J.J. (2018) Light pollution is greatest within migration passage areas for nocturnally-migrating birds around the world. *Nature Scientific Reports*, 8:e3261.

CHEVRON AUSTRALIA (2010a) Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Wheatstone Project: Technical Appendices 08 to 012 and P1 to P2. Available at: https://australia.chevron.com/-/media/australia/our-businesses/documents/wheatstone-draft-eis-ermp-technical-appendices-o8-to-o12-web3223D746DD0D.pdf (accessed: April 2021).

CHEVRON AUSTRALIA (2010b) Draft Environmental Impact Statement/Environmental Review and Management Program for the Proposed Wheatstone Project Technical Appendices N11 to N15 and 01 to 07. Available at: https://australia.chevron.com/-/media/australia/our-businesses/documents/wheatstone_draft_eis_ermp_technical_appendices_n11_to_n15_an_web0F750EAAB7E1.pdf (accessed: April 2021).

COMMONWEALTH OF AUSTRALIA (2012a). *Species group report card. Seabirds and migratory shorebirds - Supporting the marine bioregional plan for the North-west Marine Region.*

COMMONWEALTH OF AUSTRALIA (2012b). *Marine bioregional plan for the North-west Marine Region prepared under the Environment Protection and Biodiversity Conservation Act 1999*.

COMMONWEALTH OF AUSTRALIA (1999) Environment Protection and Biodiversity Conservation Act.

COMMONWEALTH OF AUSTRALIA (2013) Matters of National Environmental Significance Significant Impact Guidelines 1.1 Environmental Protection and Biodiversity Conservation Act 1999: Canberra, Australia. 39p.

COMMONWEALTH OF AUSTRALIA (2017) Recovery Plan for Marine Turtles in Australia 2017 - 2017.

COMMONWEALTH OF AUSTRALIA (2020) National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds. January 2020.

DAY, R.H., ROSE, J.R., PRICHARD, A.K. & STREEVER, B. (2015) Effects of Gas Flaring on the Behavior of Night-Migrating Birds at an Artificial Oil-Production Island, Arctic Alaska. *Arctic,* 68, 367–379.

DEPPE, L., ROWLEY, O., ROWE, L.K., SHI, N., MCARTHUR, N., GOODAY, O. & GOLDSTIEN S.J. (2017) Investigation of fallout events in Hutton's shearwaters (*Puffinus huttoni*) associated with artificial lighting. *Notornis,* 64(4), 181-191.

DIAS, M.P., GRANADEIRO, J.P., LECOQ, M., SANTOS, C.D. & PALMEIRIM, J.M. (2006) Distance to high-tide roosts constrains the use of foraging areas by dunlins: Implications for the management of estuarine wetlands. *Biological Conservation*, 131, 446-452.

DUNLOP, J.N., SURMAN, C.A. & WOOLLER, R.D. (1995) Distribution and abundance of seabirds in the eastern Indian Ocean: An analysis of potential interactions with the offshore petroleum industry. Unpublished report to Western Australian Petroleum Exploration (WAPET). 25pp.

DUNLOP, J.N., WOOLLER, R.D. & CHESHIRE, N.G. (1988) *Distribution and abundance of marine birds in the Eastern Indian Ocean. Australian Journal of Marine and Freshwater Research*, 39, 661 - 669.

EPA (2010) No.5 Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts. Available at: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/EAG%205%20Lights%20Turtle%2011110.pdf. Accessed: March 2021.

EPA (2016) Environmental Factor Guideline: Marine Fauna. Available at: https://www.epa.wa.gov.au/sites/default/files/Policies_and_Guidance/Guideline-Marine-Fauna-131216_2.pdf. Accessed: March 2021.

FERREIRA, L.C., THUMS, M., FOSSETTE, S., WILSON, P., SHIMADA, T., TUCKER, A.D., PENDOLEY, K., WAAYERS, D., GUINEA, M.L., LOEWENTHAL, G. & KING, J. (2021) Multiple satellite tracking datasets inform green turtle conservation at a regional scale. *Diversity and Distributions*, 27(2), 249-266.

FOSSETTE, S., LOWENTHAL, G., PEEL, L.R., VITENBERGS, A., HAMEL, M.A., DOUGLAS, C., TUCKER, A.D., MAYER, F. & WHITING, S.D. (2021) Using Aerial Photogrammetry to Assess Stock-Wide Marine Turtle Nesting Distribution, Abundance and Cumulative Exposure to Industrial Activity. *Remote Sensing*, 13(6), 116.

FRITSCHES, K.A. (2012) Australian Loggerhead sea turtle hatchlings do not avoid yellow. *Marine and Freshwater Behaviour and Physiology,* 45(2), 79-89.

GEERING, A., AGNEW, A. & HARDING, S. (2007) *Shorebirds of Australia,* CSIRO Australia.

GLASS, J.P. & RYAN, P.G. (2013) Reduced seabird night strikes and mortality in the Tristan rock lobster fishery. *African Journal of Marine Science*, 35, 589 – 592.

GBRMPA (2009). Environmental Assessment and Management (EAM) Risk Management Framework http://www.gbrmpa.gov.au/__data/assets/pdf_file/0008/4949/gbrmpa_EAMRiskManagementFramework.pdf

GYURIS, E. (1994) The rate of predation by fishes on hatchlings of the green turtle (*Chelonia mydas*). *Coral Reefs*, 13, 137-144.

HÄNEL, A, POSCH, T., RIBAS, S.J., AUBÉ, M., DURISCOE, D., JECHOW, A., KOLLATH, Z., LOLKEMA, D., MOORE, C., SCHMIDT, N., SPOELSTRA, H., WUCHTERL, G. & KYBA, C.C.M. (2018) Measuring night sky brightness: Methods and challenges. *Journal of Quantitative Spectroscopy and Radiative Transfer*, doi: 10.1016/j.jqsrt.2017.09.008.

HAREWOOD, A. & HORROCKS, J.A. (2008) Impacts of coastal development on hawksbill hatchling survival and swimming success during the initial offshore migration. *Biological Conservation*, 141, 394-401.

HARRIS, M.P. & WANLESS, S. (1997) The effect of removing large numbers of gulls Larus spp. on an island population of oystercatchers *Haematopus ostralegus*: implications for management. *Biological Conservation*, 82, 167-171.

HART, N.S. (2001) The visual ecology of avian photoreceptors. *Progress in Retinal and Eye Research*, 20, 675-703.

HAYS, G.C., BRODERICK, A.C., GLEN, F., GODLEY, B.J., HOUGHTON, J.D.R. & METCALFE, J.D. (2002) Water temperature and internesting intervals for loggerhead (*Caretta caretta*) and green (*Chelonia mydas*) sea turtles. *Journal of Thermal Biology, 27*, 429-432.

HODGE, W., LIMPUS, C.J. & SMISSEN, P. (2007) *Queensland turtle conservation project: Hummock Hill Island nesting turtle study December 2006 conservation technical and data report*.

HORCH, K.W., GOCKE, J.P., SALMON M. & FORWARD R.B. (2008) Visual spectral sensitivity of hatchling loggerhead (*Caretta caretta*) and leatherback (*Dermochelys coriacea*) sea turtles, as determined by single-flash electroretinography. *Marine and Freshwater Behaviour and Physiology*, 41(2), 107-119.

HU, Z., HU, H. & HUANG, Y. (2018) Association between nighttime artificial light pollution and sea turtle nest density along Florida coast: A geospatial study using VIIRS remote sensing data. *Environmental Pollution*, 239, 30-42.

HUMPHREYS, G., PALING E.I., CRAIG, M., KOBRYN H., SAWERS, P. & EYNON, H. (2005) *Yannarie Salt Project Mangrove and Coastal Ecosystem Study.* Baseline Ecological Assessment prepared for Straits Salt Pty Ltd by Biota Environmental Sciences Pty Ltd.

JOHNSTONE, R.E., BURBIDGE, A.H. & DARNELL, J.C. (2013) Birds of the Pilbara region, including seas and offshore islands, Western Australia: distribution, status and historical changes. *Records of the Western Australian Museum, Supplement*, 78, 343-441.

KAMROWSKI, R.L., LIMPUS, C., PENDOLEY, K. & HAMANN, M. (2014) Influence of industrial light pollution on the sea-finding behaviour of flatback turtle hatchlings. *Wildlife Research* 41 (5), 421-434.

KEBODEAUX, T.R. (1994) Increased sea turtle sightings present no cause for concern. *Underwater Magazine*.

KYBA, C.C.M., RUHTZ, T., FISCHER, J. & HOLKER, F. (2011) Cloud coverage acts as an amplifier for ecological light pollution in urban ecosystems. *PLoS One, 6*(3), e17307.

LE CORRE, M., OLLIVIER, A., RIBES, S. & JOUVENTIN, P. (2002) Light-induced mortality of petrels: a 4-year study from Réunion Island (Indian Ocean). *Biological Conservation*, 105, 93-102.

LEVENSON, D.H., ECKERT, S.A., CROGNALE, M.A., DEEGAN, J.F. & JACOBS, G.H. (2004) Photopic spectral sensitivity of green and loggerhead sea turtles. *Copeia*, 2, 908-914.

LIMPUS, C.J., PARMENTER, C.J. & CHALOUPKA, M. (2013) Monitoring of coastal sea turtles: Gap analysis 5. Flatback turtles, *Natator depressus*, in the Port Curtis and Port Alma region. Report produced for the Ecosystem Research and Monitoring Program Advisory Panel as part of Gladstone Ports Corporation's Ecosystem Research and Monitoring Program.

LIMPUS, C.J. & KAMROWSKI, R.L. (2013) Ocean-finding in marine turtles: The importance of low horizon elevation as an orientation cue, *Behaviour*, 150, 863-893.

LOHMANN, C.M.F. & LOHMANN, K.J. (1992) Geomagnetic orientation by sea turtle hatchlings. In: Proceedings of the 12th International Symposium on Sea Turtle Biology and Conservation (eds. J.I. Richardson & T.H. Richardson), Jekyll Island.

LOHMANN, K.J., WITHERINGTON B.E., LOHMANN C.M.F. & SALMON M. (1997) Orientation, navigation, and natal beach homing in sea turtles, in The Biology of Sea Turtles. Volume I, P.L. Lutz and J.A. Musick, Editors., CRC Press: Washington D.C. p. 107-135.

LORNE, J.K. & SALMON, M. (2007) Effects of Exposure to Artificial Lighting on Orientation of Hatchling Sea Turtles on the Beach and in the Ocean. *Endangered Species Research*, 3, 23-30.

LOURENÇO, P.M., SILVA, A., SANTOS, C.D., MIRANDA, A.C., GRANADEIRO, J.P. & PALMEIRIM, J.M. (2008) The energetic importance of night foraging for waders wintering in a temperate estuary. *Acta Oecologica*, 34, 122-139.

MACHOVSKY-CAPUSKA, G., HUYNEN, L., LAMBERT, D. & RAUBENHEIMER, D. (2011) UVS is rare in seabirds. *Vision Research*, 51, 1333-1337.

MARTIN, G.R., WHITE, C.G., & BUTLER, P.J. (2008) Vision and the foraging technique of great cormorants *Phalacrocorax carbo*: Pursuit or close-quarter foraging? *Ibis*, 150, 485–490.

MERKEL, F.R. & JOHANSEN, K.L (2011) Light-induced bird strikes on vessels in Southwest Greenland. *Marine Pollution Bulletin*, 62, 2330-2336.

MONTEVECCHI, W.A. (2002) Interactions between fisheries and seabirds. Chapter 16, In: Biology of Marine Birds. J.Burger ed.

MONTEVECCHI, W.A. (2006). Influences of artificial light on marine birds. In: Rich, C., Longcore, T. (Eds.), Ecological Consequences of Artificial Night Lighting. Island Press, Washington, D.C., USA, pp. 94e113.

MROSOVSKY, N. (1972) The water finding ability of sea turtles. *Brain Behaviour and Evolution*, 5, 202-225.

MROSOVSKY, N. & SHETTLEWORTH, S.J. (1968) Wavelength preferences and brightness cues in the water finding behaviour of sea turtles. *Behaviour*, 32, 211-257.

NICHOLSON, L.W. (2002) Breeding strategies and community structure in an assemblage of tropical seabirds on the Lowendal Islands, Western Australia. PhD dissertation, Murdoch University, Perth, WA.

ORTEGO, B. (1978) Blue-faced boobies at an oil production platform. *Auk*, 95, 762-763.

ORTIZ, N., MANGEL, J.C., WANG, J., ALFARO-SHIGUETO, J., PINGO, S., JIMENEZ, A., . . GODLEY, B.J. (2016) Reducing green turtle bycatch in small-scale fisheries using illuminated gillnets: the cost of saving a sea turtle. *Marine Ecology Progress Series,* 545, 251-259.

PENDOLEY, K.L., (2005) Sea Turtles and Industrial Activity on the North West Shelf, Western Australia. Ph.D thesis, Murdoch University, Perth.

PENDOLEY ENVIRONMENTAL (2009a) Marine turtle beach Survey-Onslow Mainland area and Nearby Islands. Unpublished report for to URS – Chevron Wheatstone Project Team, Rev 0.

PENDOLEY ENVIRONMENTAL (2009b) API Project Onslow-Ashburton North Marine Turtle Surveys January & March 2008. Unpublished report for AECOM, Rev 0.

PENDOLEY, K.L. & KAMROWSKI, R.L. (2015) Influence of horizon elevation on the sea-finding behaviour of hatchling flatback turtles exposed to artificial light-glow. *Marine Ecology Progress Series*, 529, 279-288.

PENDOLEY, K.L., WHITTOCK, P.A., VITENBERGS, A. & BELL, C. (2016) Twenty years of turtle tracks: marine turtle nesting activity at remote locations in the Pilbara, Western Australia. *Australian Journal of Zoology*, 64, 217-226.

PILCHER, N.J., ENDERBY, S., STRINGELL, T. & BATEMAN, L. (2000) Nearshore turtle hatchling distribution and predation. In N. Pilcher & G. Ismail (Eds.), *Sea turtles of the Indo-Pacific: research management and conservation. Proceedings of the Second ASEAN Symposium and Workshop on Sea Turtle Biology and Conservation.* (pp. 151-166) London: ASEAN Academic Press.

POOT, H., ENS, B.J., DE VRIES, H., DONNERS, M.A.H., WERNAND, M.R. & MARQUENIE, J.M. (2008) Green light for nocturnally migrating birds. *Ecology and Society*, 13, 47-47.

RAINE, H., BORG, J.J., RAINE, A., BAIRNER, S. & BORG CARDONA, M. (2007) Light Pollution and Its Effect on Yelkouan Shearwaters in Malta; Causes and Solutions. BirdLife Malta: Malta: Life Project Yelkouan Shearwater.

REED, J.R., SINCOCK, J.L. & HAILMAN, J.P. (1985) Light attraction in endangered procellariform birds: Reduction by shielding upward radiation. Auk 102:377-383.RICH, C. & LONGCORE T, eds. (2006) Ecological consequences of artificial night lighting. Island press: Washington DC. 480.

RODRIGUEZ, A., GARCÍA, D., RODRÍGUEZ, B., CARDONA, E.P.L. & PONS, P. (2015a) Artificial lights and seabirds: Is light pollution a threat for the threatened Balearic petrels? *Journal of Ornithology*, 156, 893-902.

RODRÍGUEZ, A., RODRÍGUEZ, B. & NEGRO, J.J. (2015b) GPS tracking for mapping seabird mortality induced by light pollution. *Scientific Reports*, 5, 10670.

RODRÍGUEZ, A., DANN, P. & CHIARADIA, A. (2017) Reducing light-induced mortality of seabirds: High pressure sodium lights decrease the fatal attraction of shearwaters. *Journal for Nature Conservation*, 39, 68-72.

ROGERS, D.I., PIERSMA, T. & HASSELL, C.J. (2006) Roost availability may constrain shorebird distribution: Exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation*, 133(2), 225-235.

RONCONI, R.A., ALLARD, K.A. & TAYLOR, P.D. (2015) Bird interactions with offshore oil and gas platforms: review of impacts and monitoring techniques. *Journal of Environmental Management*, 147, 34-45.

SALMON, M. (2003) Artificial night lighting and sea turtles. *Biologist*, 2003 (50), 163-168.

SALMON, M. & WITHERINGTON, B. (1995) Artificial lighting and seafinding by loggerhead hatchlings: Evidence for lunar modulation. *Copeia,* 1995, 931-938.

SANTIAGO-QUESADA, F., ESTRELLA, S.M., SANCHEZ-GUZMAN, J.M. & MASERO, J.A. (2014) Why water birds forage at night: a test using black-tailed godwits *Limosa limosa* during migratory periods. *Journal of Avian Biology*, 45(4), 406-409.

SANTOS, C.D., MIRANDA, A.C., GRANADEIRO, J.P., LOURENÇO, P.M., SARAIVA, S. & PALMEIRIM, J.M. (2010) Effects of artificial illumination on the nocturnal foraging of waders. *Acta Oecologica*, 36, 166-172.

STAPPUT, K. & WILTSCHKO, W. (2005) The sea-finding behaviour of hatchling olive ridley sea turtles, *Lepidochelys olivacea*, at the beach of San Miguel (Costa Rica). *Naturwissenschaften*, 92(5), 250-253.

SURMAN, C.A. & DUNLOP, J.N. (2015) Impact Assessment of aquaculture on seabird communities of the Abrolhos Islands, to support the MidWest Aquaculture Development Zone proposal. Report for Department of Fisheries DoF21/2013, Government of Western Australia.

SURMAN, C.A. & NICHOLSON, L.W. (2015) Exmouth Sub-basin Marine Avifauna Monitoring Program: Report on Aerial Surveys February 2013-March 2014. Unpublished report prepared for Apache Energy Ltd. by Halfmoon Biosciences. 122 pp.

TASKER, M.L., JONES, P.H., BLAKE, B.F., DIXON, T.J. & WALLIS, A.W. (1986). Seabird associations with oil production platforms in the North Sea. *Ringing & Migration*, 7, 7-14.

THOMAS, R.J., KELLY, D.J. & GOODSHIP, N.M. (2004) Eye design in birds and visual restraints on behaviour. *Ornitologia Neotropical*, 15, 243-250.

THUMS, M., WHITING, S.D, REISSER, J.W., PENDOLEY, K.L., PATTIARATCHI C.B., HARCOURT, R.G., MCMAHON, C.R. & MEEKAN, M.G. (2013) Tracking sea turtle hatchlings—A pilot study using acoustic telemetry. *Journal of Experimental Marine Biology and Ecology,* 440, 156-163.

THUMS, M., WHITING, S.D., REISSER, J., PENDOLEY, K.L., PATTIARATCHI, C.B., PROIETTI, M. & MEEKAN, M.G. (2016) Artificial light on water attracts turtle hatchlings during their near shore transit. *Royal Society Open Science, 3*(5), 160142.

TRUSCOTT, Z., BOOTH, D.T. & LIMPUS, C.J. (2017) The effect of on-shore light pollution on sea-turtle hatchlings commencing their off-shore swim. *Wildlife Research*, 44(2), 127-134.

WANG, J.H, BOLES, L.C., HIGGINS, B. & LOGMANN, K.J. (2007) Behavioural responses of sea turtles to lightsticks used in longline fisheries. *Animal Conservation*, 10, 176-182.

WHITTOCK, P.A., PENDOLEY, K.L. & HAMMAN, M. (2014) Inter-nesting distribution of flatback turtles *Natator depressus* and industrial development in Western Australia. *Endangered Species Research*, 26, 25-38.

WHITTOCK, P.A., PENDOLEY, K.L. & HAMMAN, M. (2016a) Flexible foraging: Post-nesting flatback turtles on the Australian continental shelf. *Journal of Experimental Marine Biology and Ecology*, 477, 112-119.

WHITTOCK, P.A., PENDOLEY, K.L. & HAMMAN, M. (2016b) Using habitat suitability models in an industrial setting: the case for internesting flatback turtles. *Ecosphere*, 7(11), e01551.

WIESE, F.K., MONTEVECCHI, W.A., DAVOREN, G.K., HUETTMANN, F., DIAMOND, A.W. & LINKE. J. (2001) Seabirds at risk around offshore oil platforms in the North-west Atlantic. *Marine Pollution Bulletin*, 42, 1285–1290.

WILSON, P., THUMS, M., PATTIARATCHI, C., MEEKAN, M., PENDOLEY, K., FISHER, R. & WHITING, S. (2018) Artificial light disrupts the nearshore dispersal of neonate flatback turtles *Natator depressus*. *Marine Ecology Progress Series*, 600, 179-192.

WILSON, P., THUMS, M., PATTIARATCHI, C., WHITING, S., PENDOLEY, K., FERREIRA, L.C. & MEEKAN, M. (2019) High predation of marine turtle hatchlings near a coastal jetty. *Biological Conservation*, 236, 571-579.

WILTSCHKO, W., MUNRO, U., FORD, H., & WILTSCHKO, R. (1993) Red light disrupts magnetic orientation of migratory birds. *Nature*, 364, 525-527.

WITHERINGTON, B.E. & BJORNDAL, K.A. (1991) Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta*. *Biological Conservation*, 55(2), 139-149.

WITHERINGTON, B.E. (1992a) Behavioural responses of nesting sea turtles to artificial lighting. *Herpetologica,* 48, 31-39.

WITHERINGTON, B.E. (1992b) Sea-finding behaviour and the use of photic orientation cues by hatchling sea turtles. PhD thesis, University of Florida, Gainesville.

WITHERINGTON, B.E. & BJORNDAL, K.A. (1991a) Influences of artificial lighting on the seaward orientation of hatchling loggerhead turtles *Caretta*. *Biological Conservation*, 55(2), 139-149.

WITHERINGTON, B.E. & BJORNDAL, K.A. (1991b) Influences of wavelength and intensity on hatchling sea turtle phototaxis: implications for sea-finding behaviour. *Copeia*, 1991, 1060-1090.

WITHERINGTON, B. & MARTIN, R.E. (2003) Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Florida Fish and Wildlife Conservation Commission FMRI Technical Report TR-2: Jensen Beach, Florida. p. 84

WITZELL, W.N. (1999) Distribution and relative abundance of sea turtles caught incidentally by the U.S. pelagic longline fleet in the western North Atlantic Ocean, 1992–1995. *Fisheries Bulletin,* 97, 200-211.

WOOLLER, R.D. & DUNLOP, J.N. (1979) Multiple laying in the Silver Gull *Larus novaehollandiae,* Stephens on Carnac Island, Western Australia. *Australian Wildlife Research*, 6, 325-3.

Appendix A: Ashburton Infrastructure Project: Artificial Light Monitoring and Modelling Technical Report

MINERAL RESOURCES LIMITED (MRL)

ASHBURTON INFRASTRUCTURE PROJECT: ARTIFICIAL LIGHT MONITORING AND MODELLING

Prepared by

Pendoley Environmental Pty Ltd

For

Mineral Resources Limited (MRL)

01 October 2021

PENDOLEY ENVIRONMENTAL

DOCUMENT CONTROL INFORMATION

TITLE: ASHBURTON INFRASTRUCTURE PROJECT: ARTIFICIAL LIGHT MONITORING AND MODELLING

Disclaimer and Limitation

This report has been prepared on behalf of and for the use of MRL. Pendoley Environmental Pty Ltd. takes no responsibility for the completeness or form of any subsequent copies of this Document. Copying of this Document without the permission of MRL is not permitted.

Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		21/09/2021	[redacted]
Rev IA	Internal Review	24/09/2021	24/09/2021	
Rev A	Client review	24/09/2021	30/09/2021	
Rev 0	Final report issued	01/10/2021	01/10/2021	

Printed:	1 October 2021
Last saved:	1 October 2021 03:13 PM
File name:	J88002 Ashburton Artificial Light Monitoring and Modelling Rev A
[redacted]	
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Ashburton Infrastructure Project: Artificial Light Assessment
[redacted]	
[redacted]	
Report number:	J88002
[redacted]	

1 SCOPE AND OBJECTIVES

Mineral Resources Limited (MRL) engaged Pendoley Environmental (PENV) to undertake benchmark artificial light monitoring and subsequent modelling to inform an Artificial Light Impact Assessment (ALIA) for the proposed Ashburton Infrastructure Project (AIP). Monitoring locations were selected based on sensitive marine turtle habitat located within the Project Area buffer zone, defined as 20 km from any project related development or activity (**Figure A1**) as stated in the *National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds* (Commonwealth of Australia 2020). Project facilities and vessels considered in the assessment include:

- Landside Development Envelope
    - Storage and loading infrastructure
    - Desalination plant
    - Power station
    - Administration buildings
    - Sewage treatment facility
- Nearshore Development Envelope
    - Dedicated berth
    - Jetty wharf
    - Ship loader, including 2 Transhipment Vessels (TSVs)
- Offshore Development Envelope
    - 2 Ocean Going Vessels (OGVs) (at anchorages A and B)
    - 2 TSV's unloading at one OGV (anchorage A)

Specifically, the objectives of this survey were to:

1. Conduct benchmark artificial light monitoring to understand the visibility of light from existing sources at sensitive habitat within the Project Area.
2. Undertake artificial light modelling of major proposed infrastructure and vessels within the Project Area, accounting for the existing lighting environment.

2 METHODOLOGY

2.1 Benchmark Artificial Light Survey

2.1.1 Survey Locations and Schedule

Five monitoring locations were selected for benchmark light data collection (see **Figure A1** and **Table A1**). The selection of these locations was based on identified marine turtle nesting habitat within the Project Area (see **Section 2.1**). Artificial light data was collected from all monitoring locations on each of the three monitoring nights on the new moon between 7th and 13th July 2021. Weather conditions were generally clear and free of cloud, with the exception of the second monitoring night (9th July) where intermittent cloud cover was present throughout the night.

Table A1: Monitoring locations and positions (datum: WGS84).

Survey location	Latitude	Longitude
Thevenard Island	-21.460390°	114.971830°
Bessieres Island	-21.528892°	114.765875°
Ashburton Island	-21.593200°	114.937890°
Onslow Back Beach	-21.678130°	115.054170°
Ashburton River Delta	-21.684030°	114.953400°

2.1.2 Data Capture

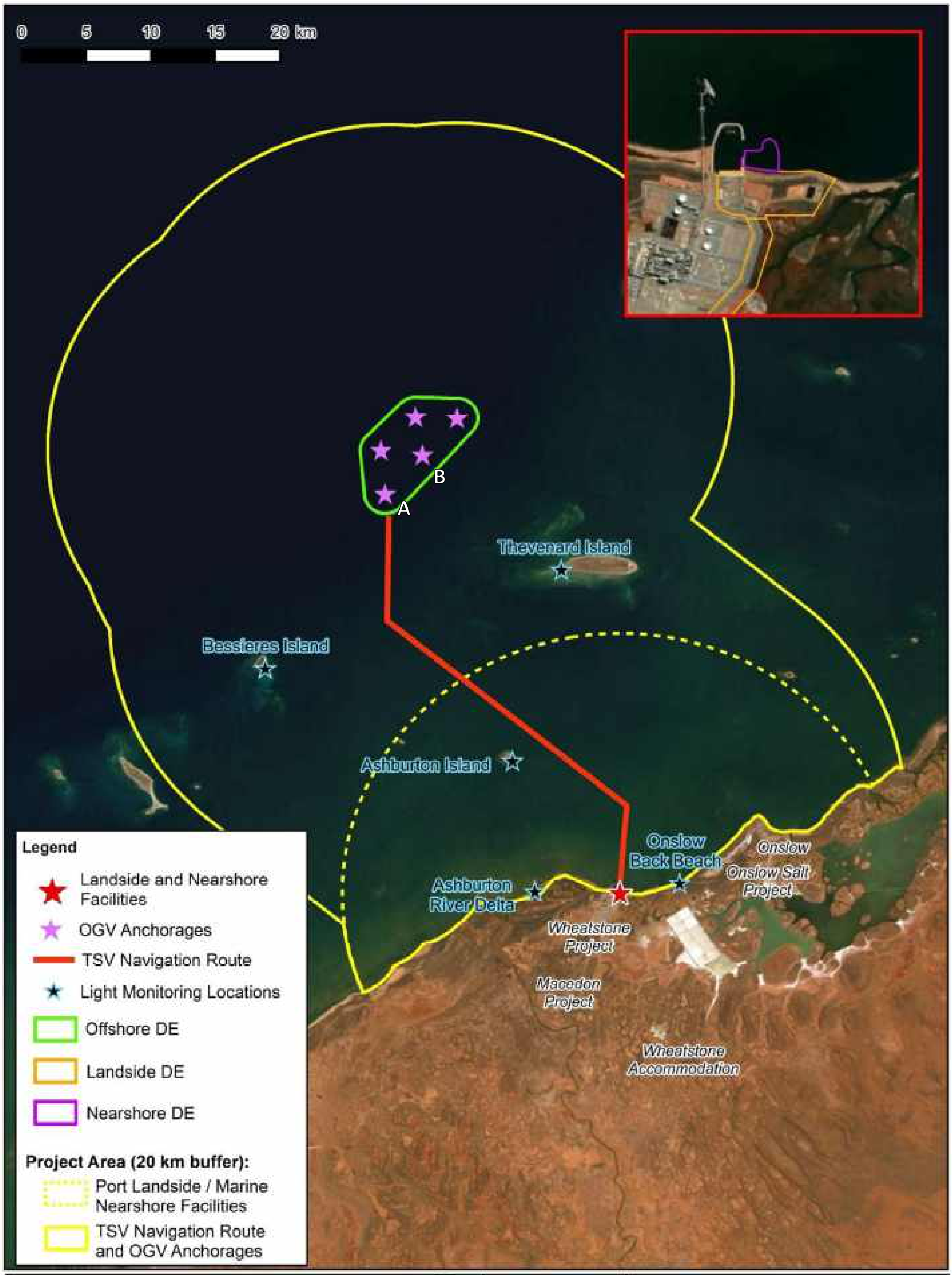
Light data was gathered at each survey location using a Sky42™ light monitoring camera. The camera is a calibrated Canon EOS 700D DSLR combined with a fish-eye lens and custom-built hardware to acquire low-light images of the entire night sky. The cameras are built into a rigid housing with a protective lid that automatically opens during image capture and closes between capture intervals. The cameras were deployed at all survey locations on each survey day and were programmed to automatically begin taking photos in 15-minute intervals between sunset and sunrise. Images were downloaded from the cameras every second day.

2.1.3 Data Analysis

The quality of an image captured by a Sky42 light monitoring camera can be influenced by atmospheric factors such as the presence of the moon, twilight, cloud, rain, dust, humidity, or physical factors such as accumulation of sand or dust on the lens. Any images that are affected by physical factors were removed from the analysis, as well as any images that were affected by the moon or twilight.

All suitable images were processed using specialised software to determine "whole-of-sky" and "horizon" sky brightness levels. Whole-of-sky (WOS) is the mean value of sky glow in the entire image, and horizon is the mean value of sky glow within the 60° – 90° outer band (**Figure A2**). All images have been quantified in units of visual magnitudes per arc second^2 (V mag), a common unit used to measure astronomical sky brightness that represents light intensity on an inverse logarithmic scale.

Note that the colour coding used in the processed imagery represents the scale of intensity of light and is not representative of the colour of light as perceived by a human/turtle eye or Sky42 camera.



J88001 MRL Artificial Light Management Plan

Figure A1: Light monitoring locations relative to Project Area and Development Envelopes

N

Drawn: P. Whittock
Date: 11/06/2021
Drawing File Ref:
PENV-J88001-1083-A

PENDOLEY ENVIRONMENTAL

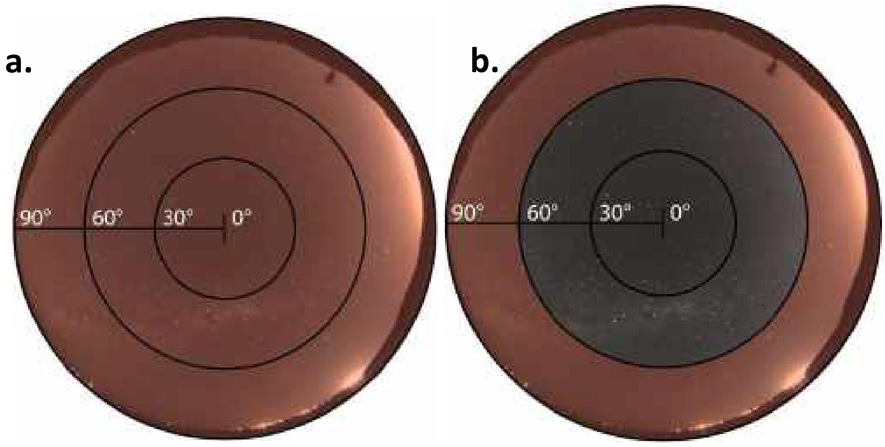


Figure A2: Measurement of mean pixel values; a. Whole-of-sky brightness (full image); b. Horizon brightness (60° – 90°). Shaded areas denote the region of the sky being measured.

Additionally, for each monitoring location, a set of images was generated detailing the raw fisheye image, quantified fisheye image (in V mag), and "unwrapped" versions as a re-projected all-sky benchmark image allowing horizon light sources to be easily identified (for an example, see **Figure A3**). The re-projected data from the all-sky image for each site (**Figure A3c**) was used as input into the artificial light modelling to represent the existing lighting environment at each site.

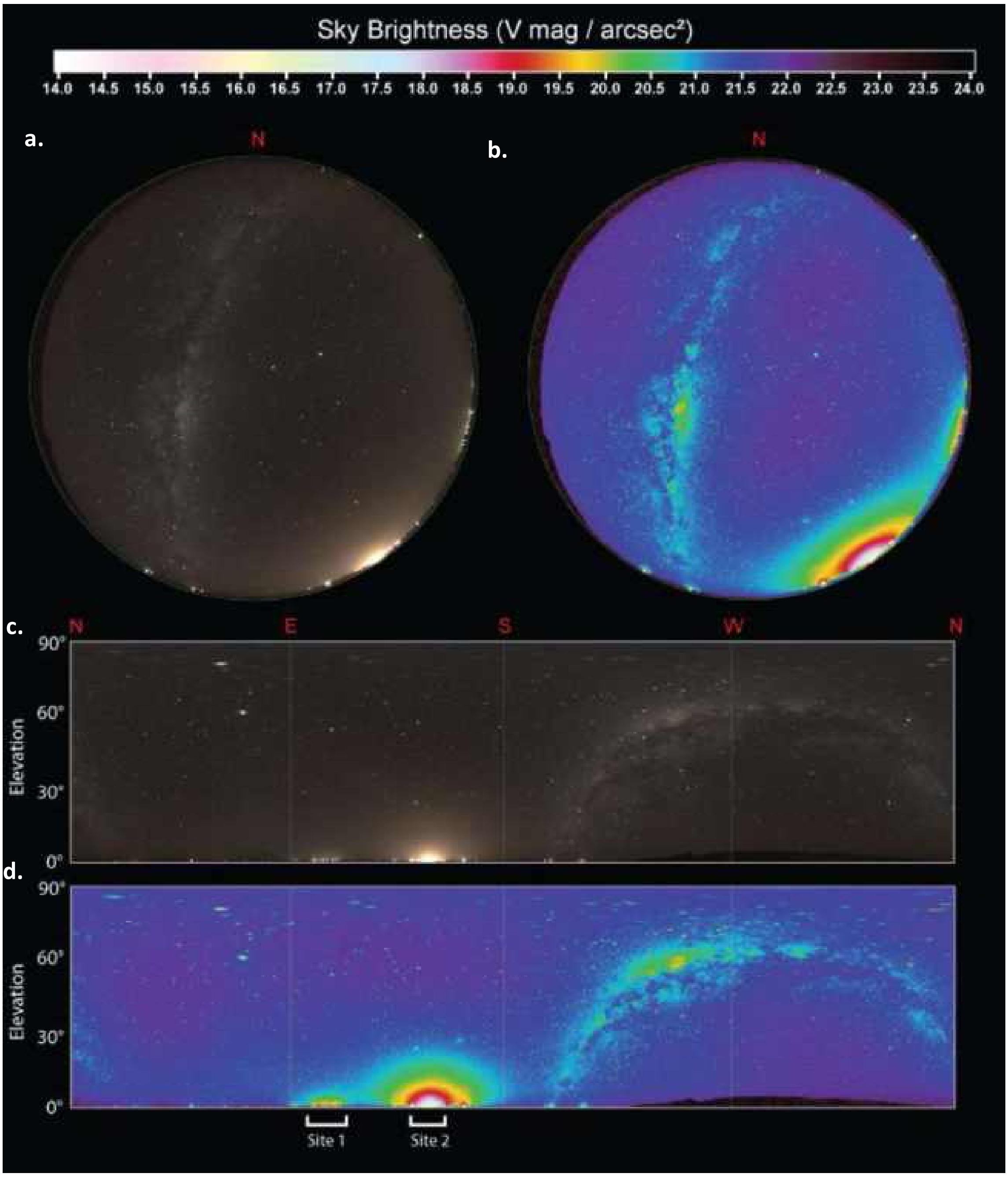


Figure A3: Example outputs from Sky42 camera data analysis: a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image**.**

2.2 Artificial Light Modelling

Currently, there are no standard commercial models for landscape scale modelling of artificial light emissions (Commonwealth of Australia 2020). Recognising this gap and the growing need to respond to both local and national regulatory concerns over artificial light impacts on wildlife and on dark sky conservation values required to meet IDA DSP certification requirements, PENV has recently invested in considerable research and development effort to develop a landscape scale model of artificial light. This has been recently applied for our Australian oil and gas clients, and for a large-scale development in Saudi Arabia (The Red Sea Development Project).

The base model used for this work was the ILLUMINA model that has been developed by Physics Professor Dr Martin Aubé of Sherbrooke University, Canada (Aube et al. 2005). This well-documented, open-source model was selected for its ability to represent light across large areas and distances and across the entire visible spectrum, including biologically meaningful light from 350 nm – 700 nm.

Unlike commercially available engineering light models that are commonly used to design human centric lighting for the relatively small footprint of single or multiple buildings, parking lots, streetlighting etc., ILLUMINA is a three-dimensional model that accounts for both line-of-sight light visibility in addition to the glow derived from atmospheric scattering of light. The model also addresses the attenuation/loss of light over landscape scale distances and, consequently, the areal extent of light glow across the sky can be modelled. Additional details of the equations and model parameterisation can be found in Aube et al. (2005).

2.2.1 Inputs

The following general parameters were used as inputs into the model:

- Topography and reflectance: NASA Shuttle Radar Topography Mission (SRTM) digital elevation data (1 arc-second resolution).
- GPS coordinates for the observer viewpoints at (**Table A1**).
- Weather conditions: all scenarios are considered free of any influencing atmospheric or weather conditions (sun, moon, rain, cloud).
- A detailed lighting inventory (light types, positions, heights, intensity) for the landside and nearshore infrastructure and vessels including OGV's, TSV's and tugboats based on information provided by MRL. A summary of lighting inventories is provided in **Appendix B**

2.2.2 Outputs

All-sky modelled image: A projected all-sky modelled image 'as viewed' from each of the five monitoring locations (for an example, see **Figure A4b**) was produced and combined additively with benchmark camera imagery (**Figure A4a**) to show the predicted increase in brightness across the whole sky, including the horizon, from the monitoring locations (**Figure A4c**). Note - The model outputs in units of absolute radiance; $W/m^2/sr$, where W = watts, m^2=metres squared and sr = steradian.

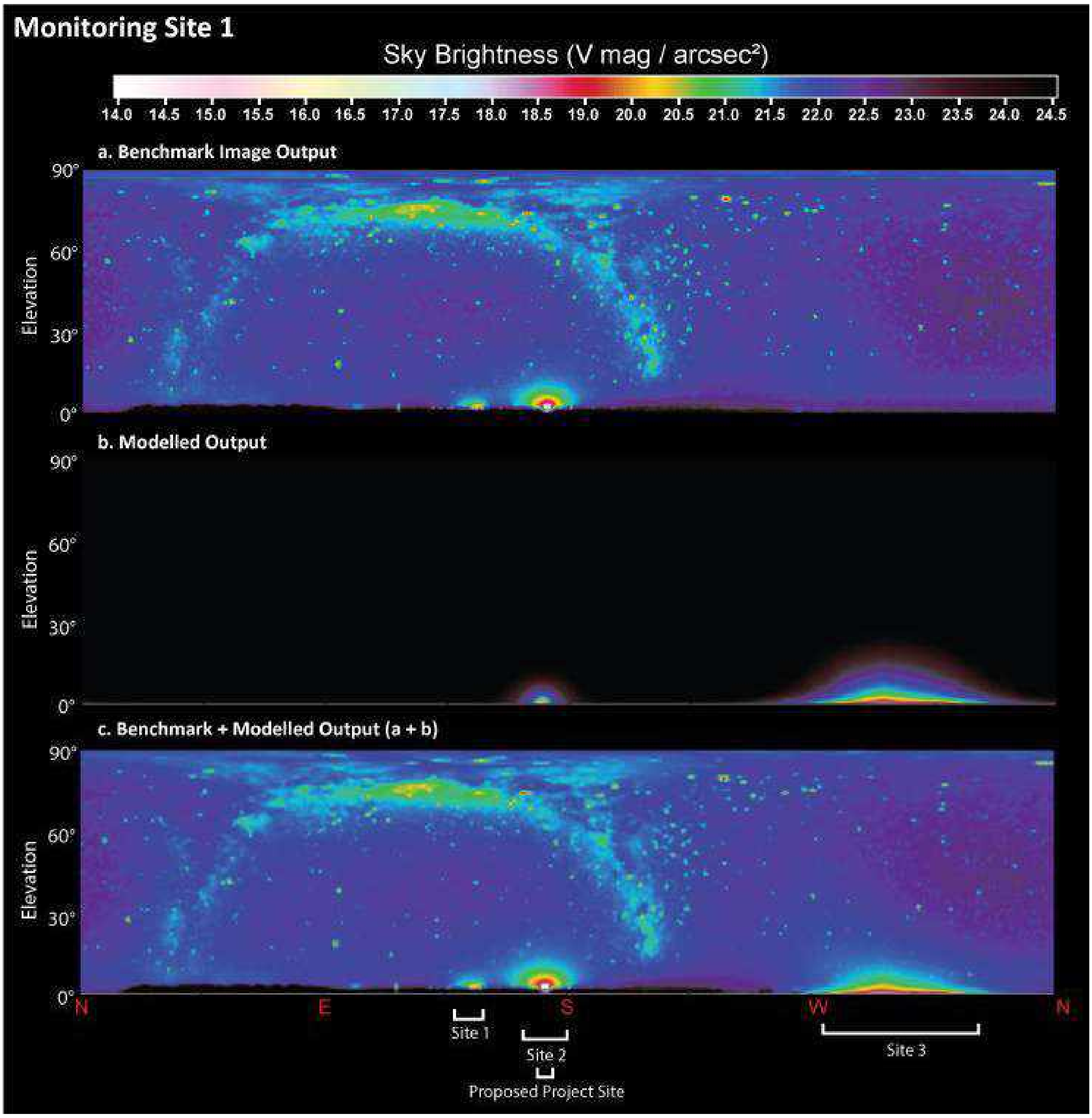


Figure A4: Example all-sky benchmark imagery and modelled all-sky image from an observer location: a. benchmark image recorded by a Sky42 camera; b. modelled brightness based on lighting design; c. benchmark + modelled brightness.

2.2.3 Model Assumptions

When developing the lighting inventory, several assumptions were made:

- Only external lighting has been considered in the model (i.e. no internal lighting that may be reflected externally).
- Where manufacturer specifications on luminaire spectra were not available, PENV generated their own spectral power curves based on what is typical for the type/colour temperature of the luminaire.
- OGV Lighting was merged and then divided evenly into 3 main areas on the vessel (front/middle/rear), as opposed to being placed in individual positions. Due to the distance of the OGV's from observer viewpoints, it is not expected this simplification would meaningful impact the results.

2.2.4 Model Limitations

While the underlying science of light behaviour is well known, the methods required to both measure and model light intensity and areal extent of sky glow on a landscape scale are still in the research and development phase and consequently are constrained by the following limitations:

- Results have not yet been definitively ground-truthed for large-scale projects (Linareset al. 2018; Linares Arroyo et al. 2020). While the approach outlined within this report is considered sound at the time of writing, future model results may not be comparable due to updates in the science and methodology that underpin the current software.
- The precision of the model outputs is directly related to the level of input detail. At this stage of the project, many aspects are still in a state of flux and may be changed prior to development beginning, potentially reducing the precision of the model outputs.
- The model has converted units of absolute radiance ($W/m^2/sr$) to units of photometric luminance ($Vmag/arcsec^2$). Where absolute radiance represents light equally across the whole visible spectrum, visual magnitudes represent only the human visual (green) band of the spectrum and may not fully represent light as perceived by marine turtles or seabirds.

3 RESULTS AND DISCUSSION

3.1 Benchmark Light Survey

Data was successfully collected from the five survey locations during each night of monitoring. A single clear image was selected from each site for analysis and processed results are shown in **Figures A5 – A9**.

The Wheatstone LNG Facility, situated near Onslow, was the largest source of sky brightness and was visible from all survey locations (see **Figures A5** – **A9**). This was followed by the Onslow township (including Onslow Salt facilities), visible from all sites other than Ashburton River Delta due to the presence of high dunes and the overlapping sky glow of Wheatstone between the monitoring location and light source. The Wheatstone Camp was also visible as an individual source from Ashburton River Delta.

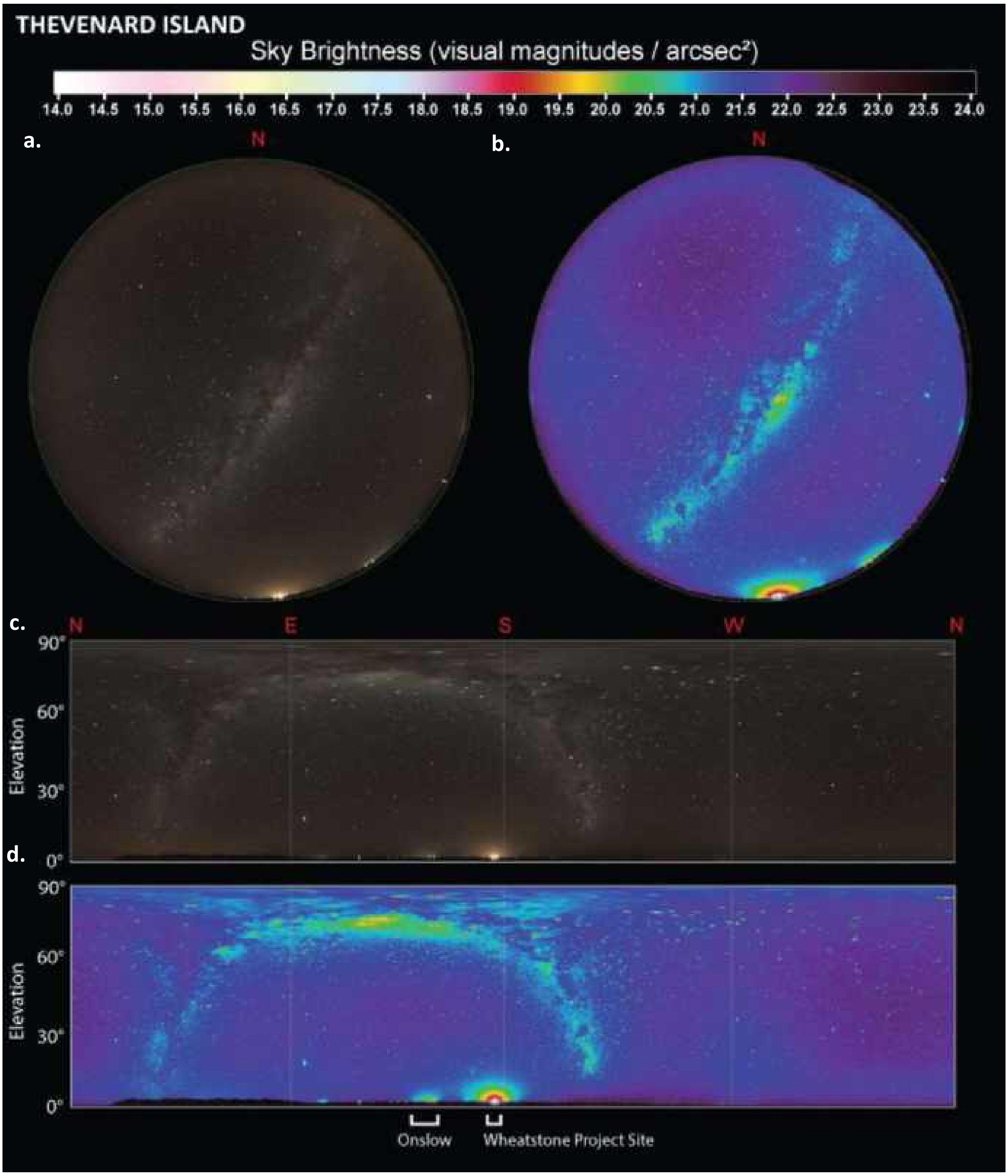


Figure A5: Artificial light monitoring results from Thevenard Island on 8th July 2021 at 12:27am; a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image**.**

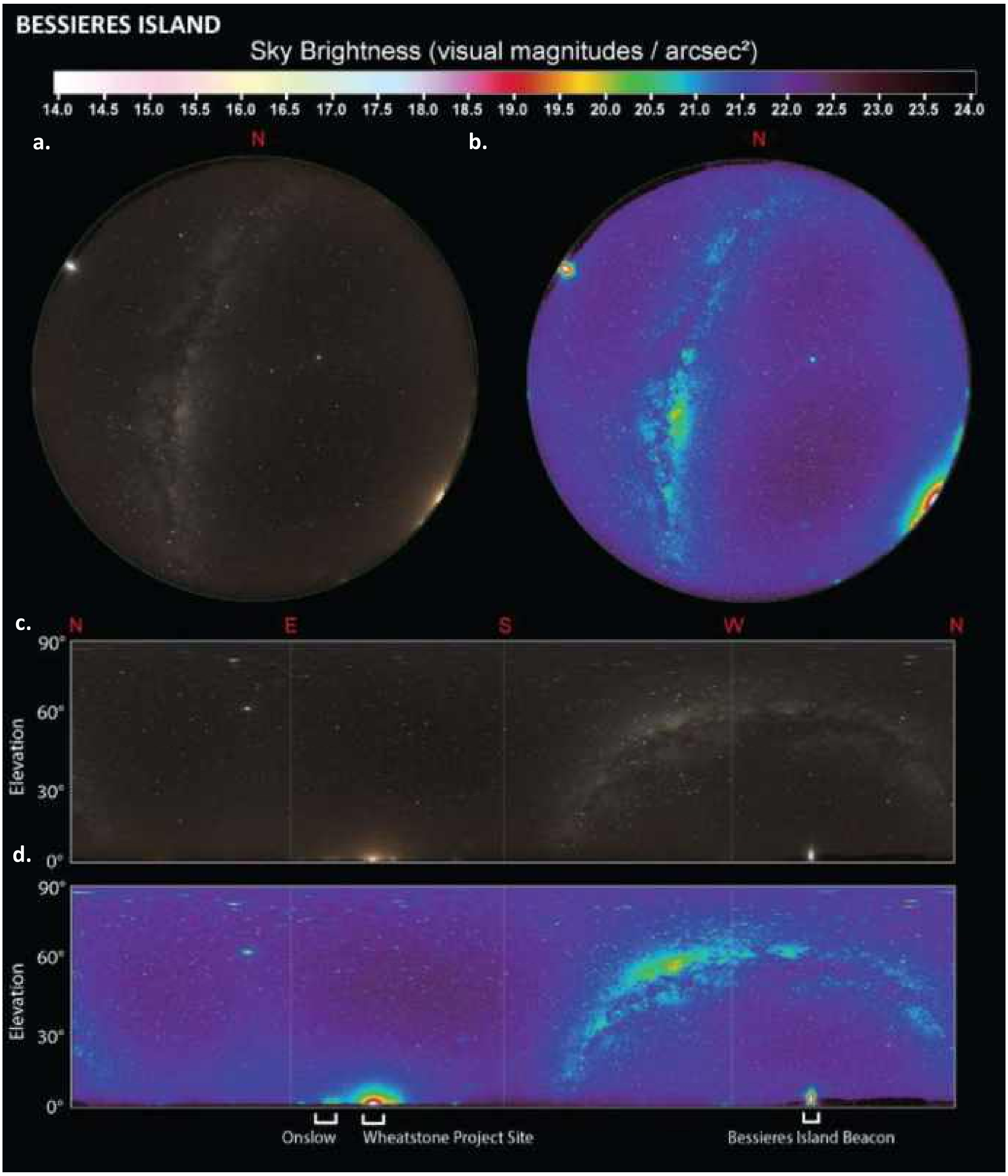


Figure A6: Artificial light monitoring results from Bessieres Island on 12th July 2021 at 2:08am; a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image**.**

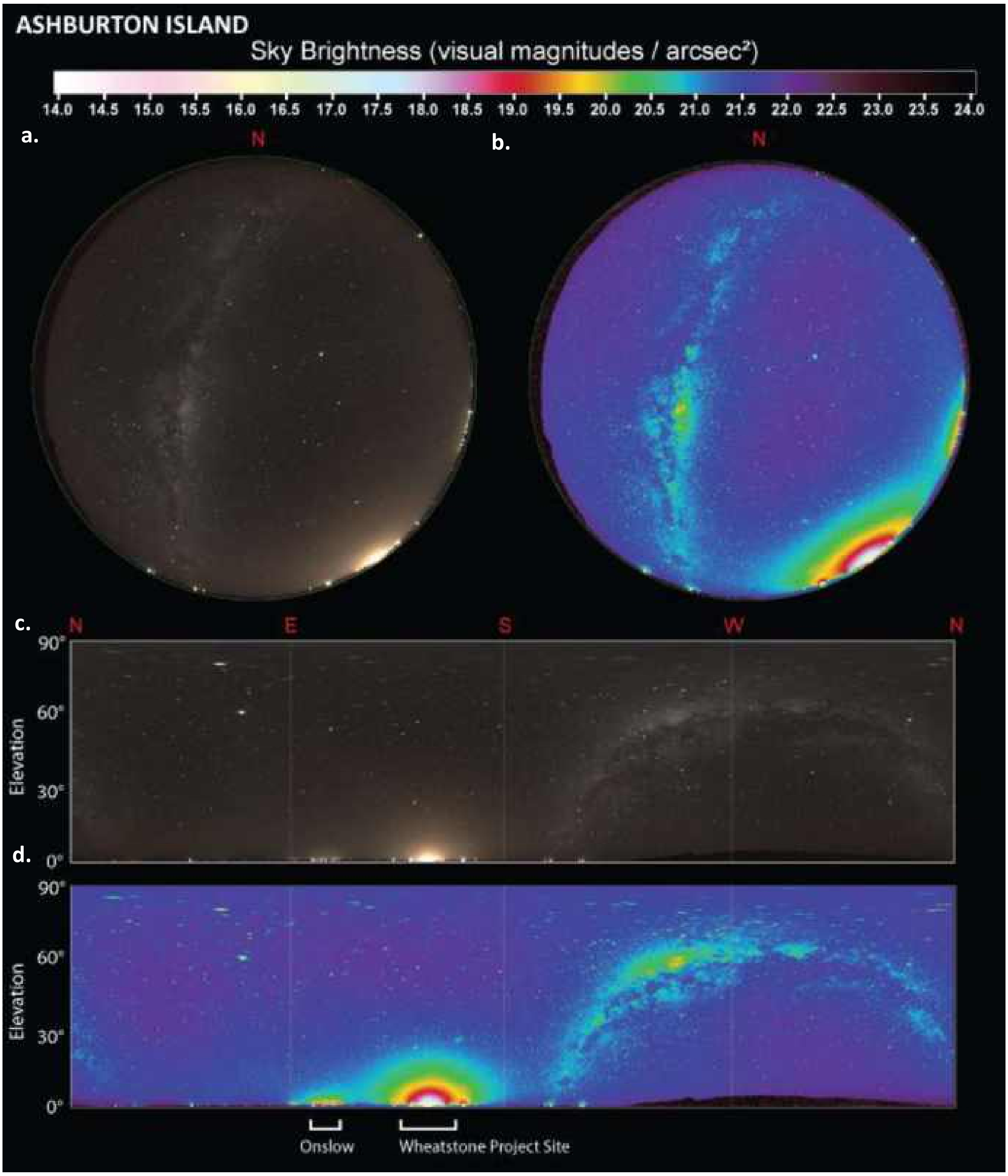


Figure A7: Artificial light monitoring results from Ashburton Island on 8th July 2021 at 2:02am; a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image**.**

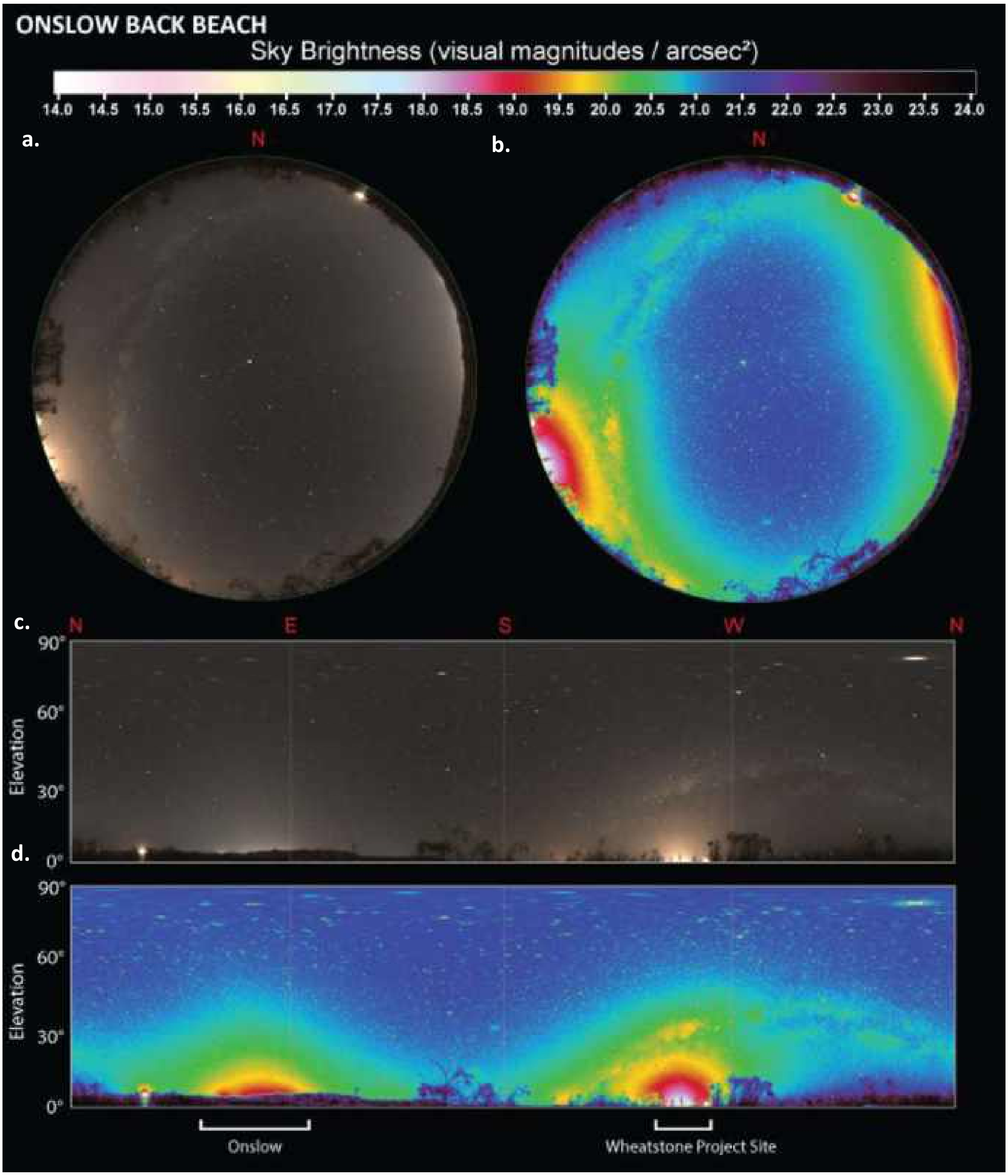


Figure A8: Artificial light monitoring results from Onslow Back Beach on 10th July 2021 at 3:36am; a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image**.**

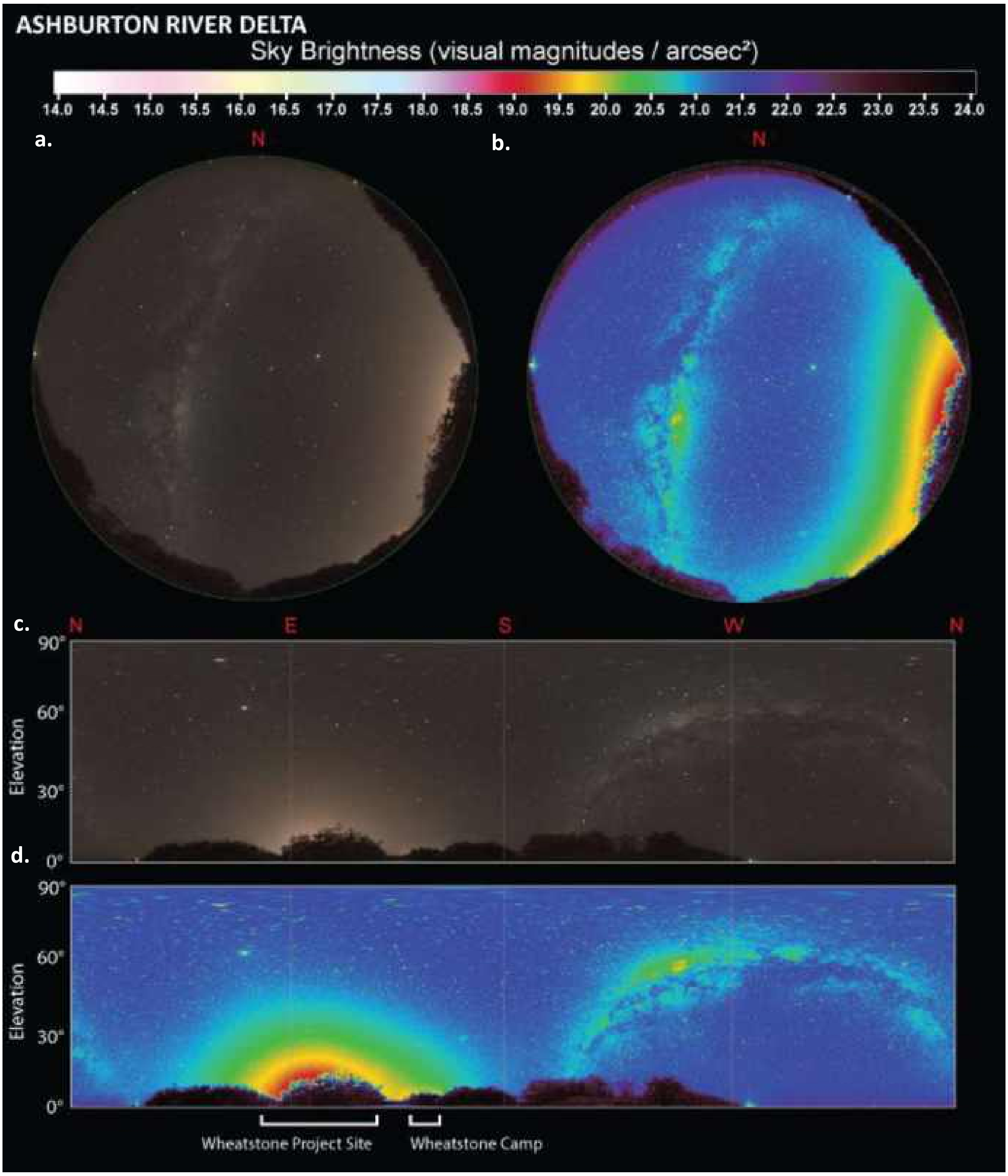


Figure A9: Artificial light monitoring results from Ashburton River Delta on 8th July 2021 at 2:09am; a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image**.**

3.2 Light Modelling

The results of the light modelling show that light emissions from the port landside and nearshore facilities are visible from all locations at varying intensities (though merging or directly overlapping with the Wheatstone project site) (**Figures A10 – A14**). Light emissions from the OGV's at anchorage points A and B will be highly visible from Thevenard Island and Bessieres Island, however they are shielded by sand dunes at Ashburton Island (**Figures A10 – A14**), and almost undetectable at the onshore monitoring locations.

The largest increase in WOS brightness, once modelled outputs were added to the benchmark data, was at Onslow Back Beach (10 %; See **Table 6**), due to the proximity and direct visibility of the landside and nearshore MRL facilities. WOS brightness at Thevenard Island, Bessieres Island and Ashburton River Delta increased by 6 %, and at Ashburton Island by 4 %.

The largest increases in horizon brightness are at Thevenard Island (19 %) and Bessieres Island (14 %), due to the high visibility of light emissions and large sky glow extent from the OGV's at anchorages A and B (**Figure A10**). This is followed by Onslow Back Beach (13 %), again due to the direct visibility of the landside and nearshore MRL facilities, Ashburton Island (9 %) and Ashburton River Delta (8 %).

Overall, the results of this assessment show that while there are likely to be substantial light emissions from the project landside and nearshore activities, these emissions directly overlap with the Wheatstone project site from most of the sensitive locations and minimally increase sky brightness in this region relative to the existing light levels. Light emissions from the OGV's anchored offshore near Thevenard Island are likely to have the greatest potential impacts as these are a new light source with a wide areal extent of sky glow and are not naturally shielded when viewed from anchorage facing shorelines on Thevenard or Bessieres Island.

Table 1: Comparison of benchmark and benchmark + modelled sky brightness values (visual magnitudes / arcsec^2). Note that the scale is inverse, brightness increases with decreasing visual magnitude / arcsec^2 values.

Sky Brightness Metric	Survey location	Sky brightness (V mag)		Increase in brightness (%)
		Benchmark	Benchmark + Modelled	
WOS	Thevenard Island	21.52	21.46	+ 6
	Bessieres Island	21.70	21.64	+ 6
	Ashburton Island	21.37	21.33	+ 4
	Onslow Back Beach	20.86	20.76	+ 10
	Ashburton River Delta	21.22	21.05	+ 6
Horizon	Thevenard Island	21.61	21.43	+ 19
	Bessieres Island	21.69	21.55	+ 14
	Ashburton Island	21.13	21.05	+ 8
	Onslow Back Beach	20.45	20.31	+ 13
	Ashburton River Delta	21.00	20.90	+ 9

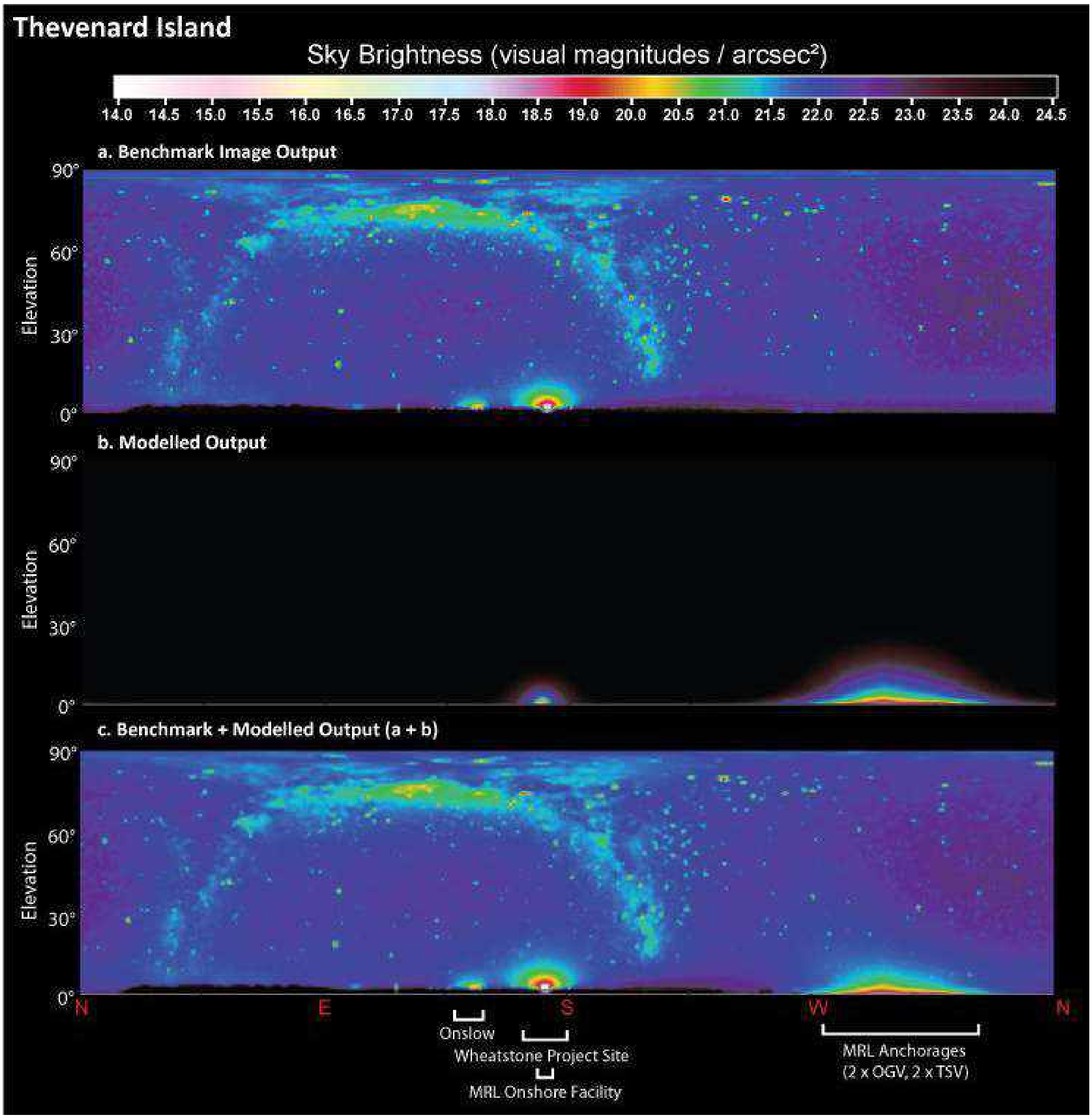


Figure A10: Artificial light modelling results for Thevenard Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on lighting design provided by MRL; c. Benchmark monitoring image + modelled brightness.

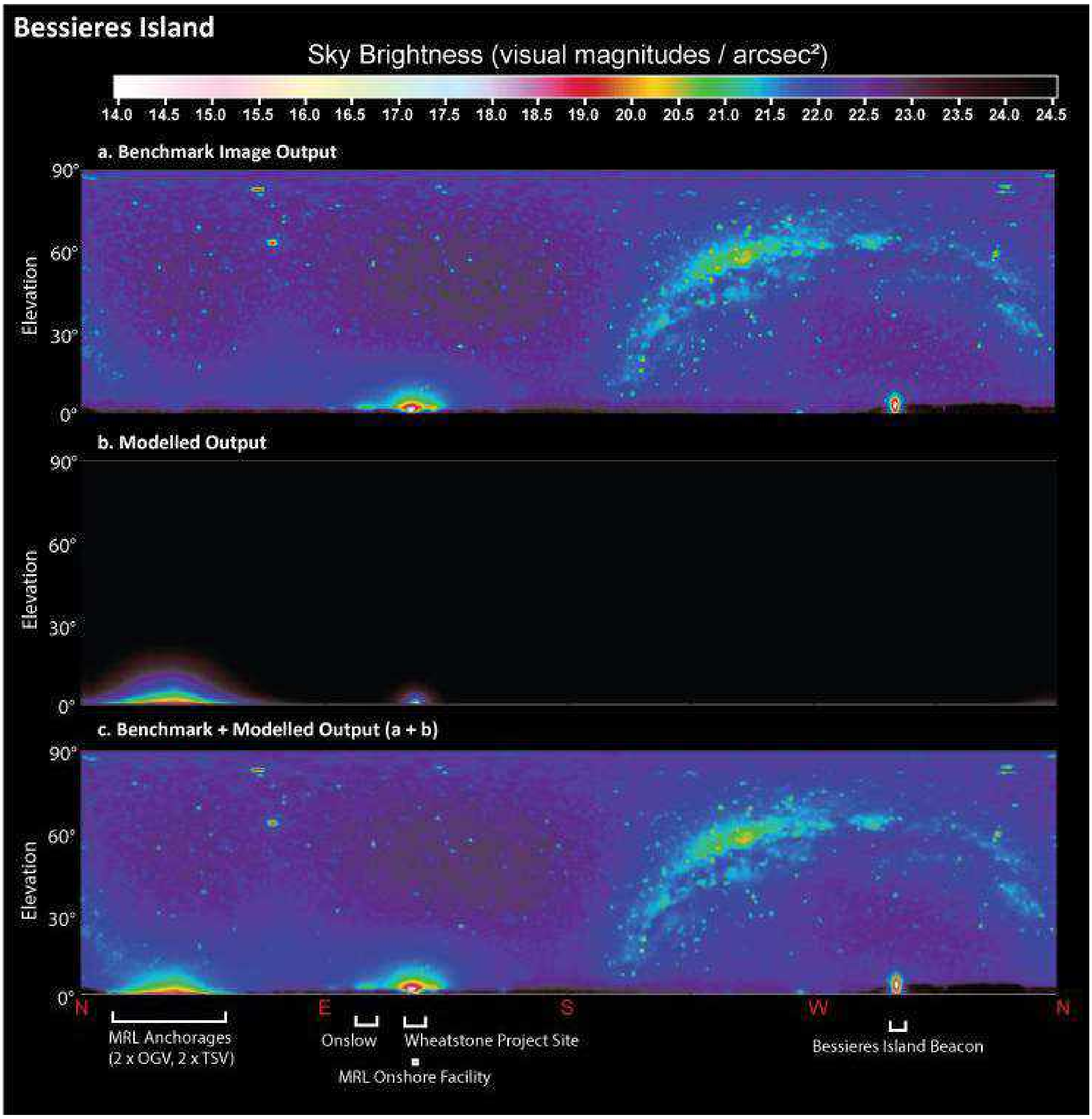


Figure A11: Artificial light modelling results for Bessieres Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on lighting design provided by MRL; c. Benchmark monitoring image + modelled brightness.

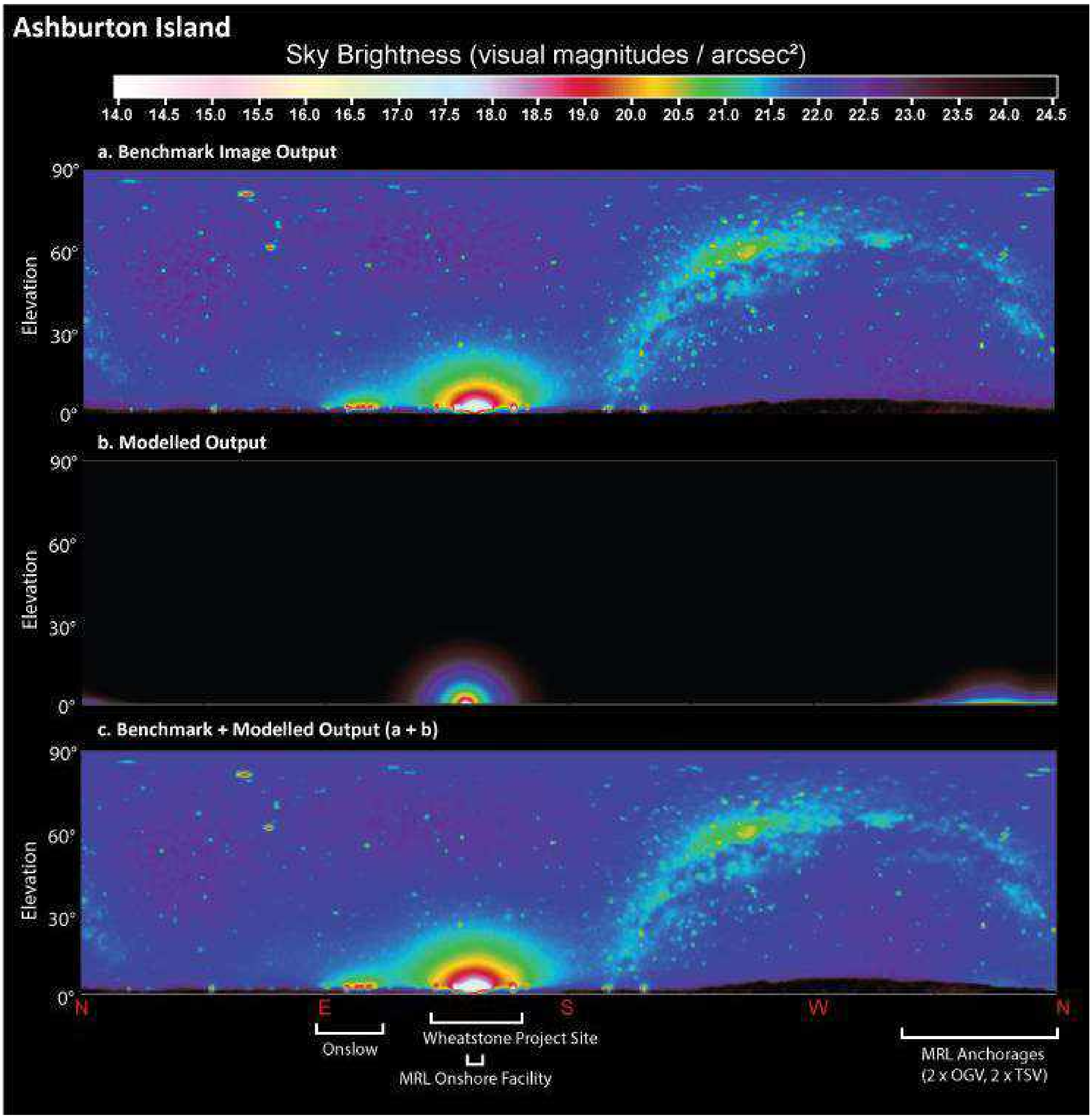


Figure A12: Artificial light modelling results for Ashburton Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on lighting design provided by MRL; c. Benchmark monitoring image + modelled brightness.

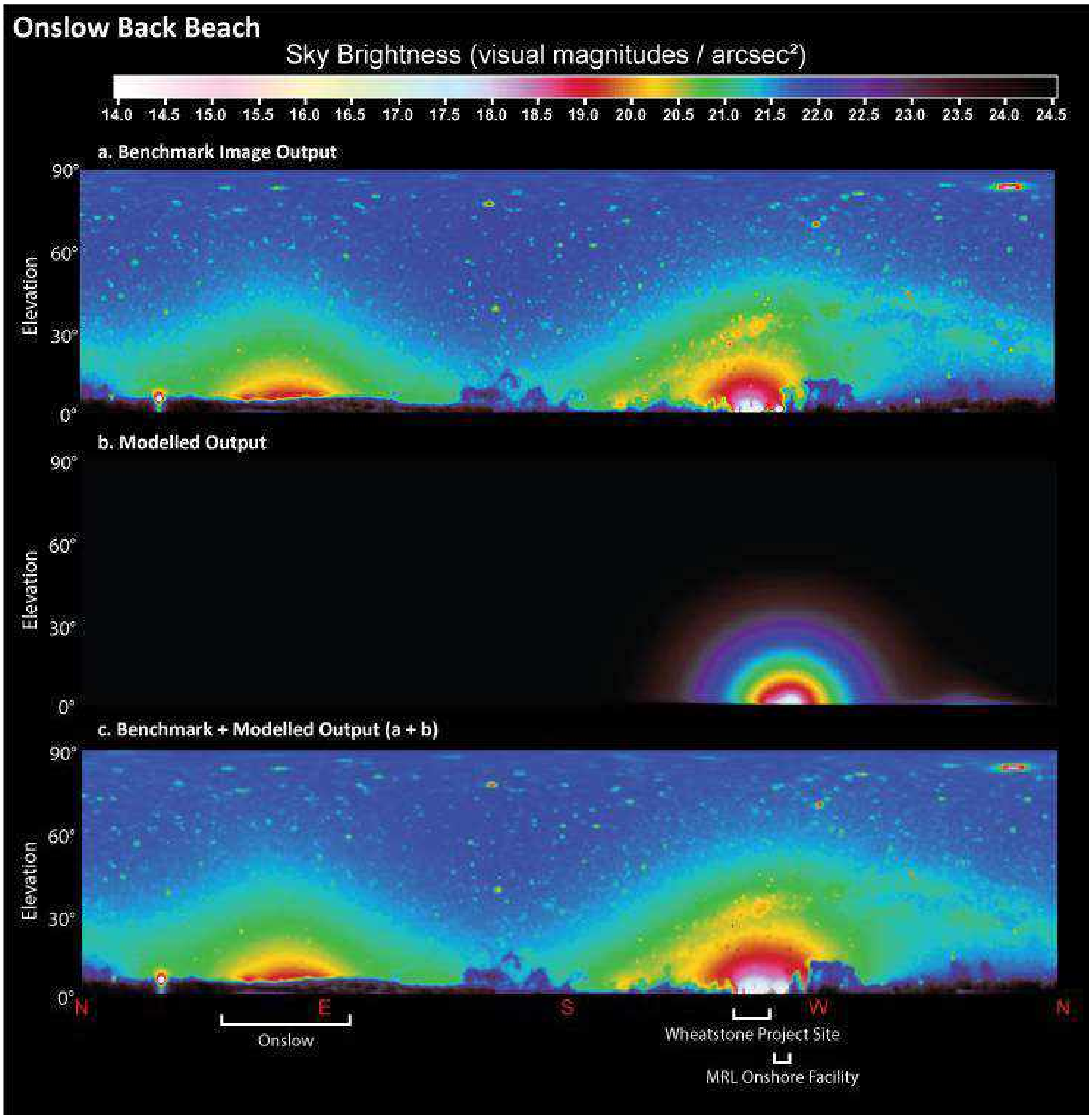


Figure A13: Artificial light modelling results for Onslow Back Beach: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on lighting design provided by MRL; c. Benchmark monitoring image + modelled brightness.

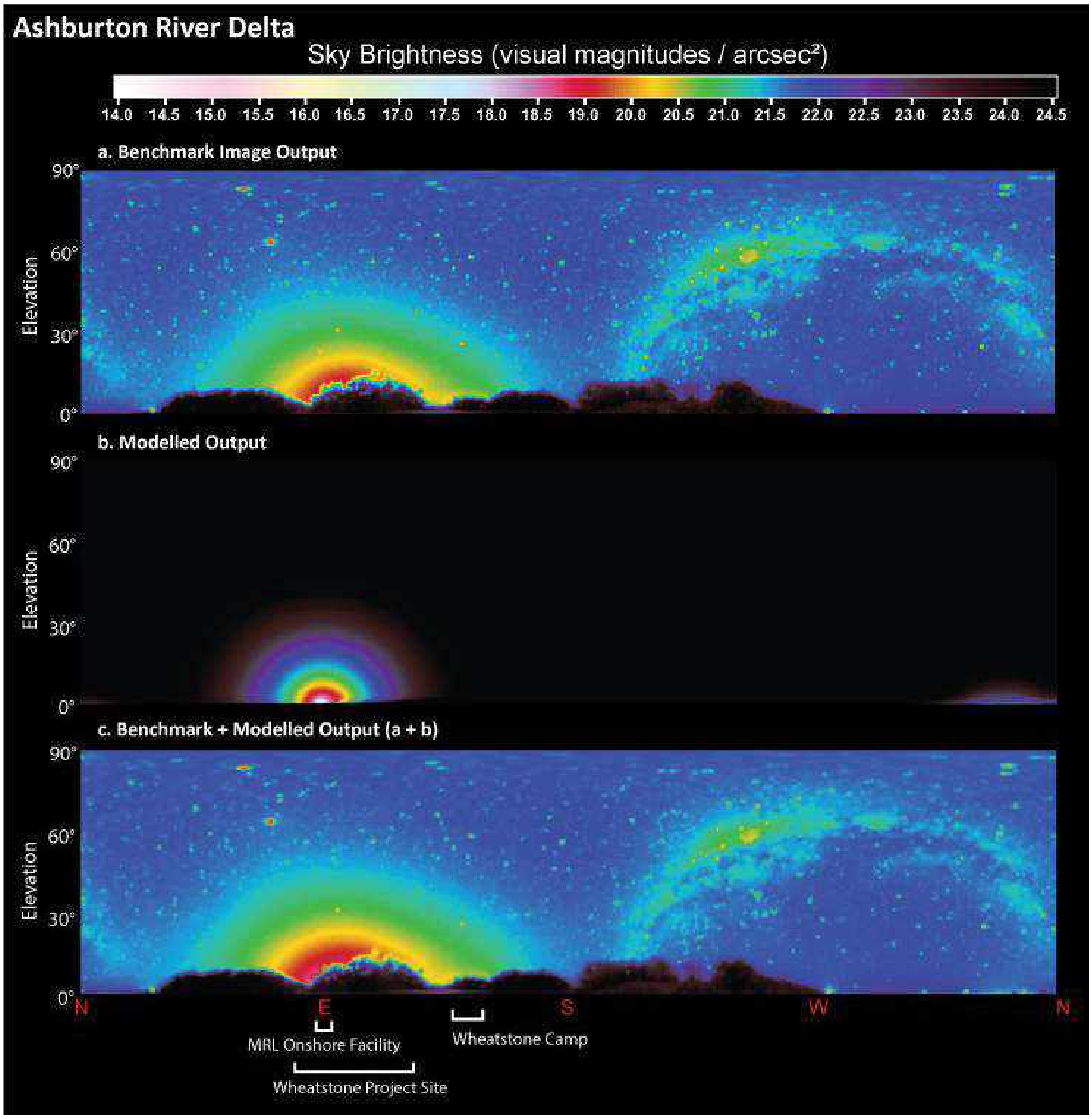


Figure A14: Artificial light modelling results for Ashburton River Delta: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on lighting design provided by MRL; c. Benchmark monitoring image + modelled brightness.

Appendix B: Lighting Inventory

Table B2: Landside and nearshore facilities lighting inventory summary.

Model #	Power (lumens)	Quantity	Light Spectra
BA	4200	8	Amber LED
BAE	4200	16	Amber LED
CA	3900	55	Amber LED
CAE	3900	109	Amber LED
FA	29200	10	4000K LED
FAA	11700	7	Amber LED
FLA	60100	12	4000K LED
SL1	16000	25	4000K LED
SL1D	32000	6	4000K LED

Table B3: OGV lighting inventory summary.

Model #	Power (lumens)	Quantity	Light Spectra
TG27	23000	2	3500K Tungsten Halogen
TG18	4800	2	3500K Tungsten Halogen
TG18	8500	8	3500K Tungsten Halogen
TG15	47000	8	HPS
CCD9-6	960	19	4000K Incandescent
CFT2	47000	8	HPS
CFY21-2	4000	42	4000K Fluorescent

Table B4: TSV lighting inventory summary.

Model #	Power (lumens)	Quantity	Light Spectra
FL70 MB	27000	12	5000K LED
FL70 NB	27000	8	5000K LED
TITAN-S1	4876	12	4000K LED
FL45	12151	2	4000K LED

Appendix C: Bird Interaction Procedure

1 BIRD INTERACTION PROCEDURE

1.1 Overview

As discussed in **Section 4.4**, artificial light sources can attract birds crossing the sea at night as well as nocturnally foraging seabirds (Montevecchi, 2006; Ronconi et al., 2015). Lighthouses, ships, offshore platforms and various vertical constructions at land can have the same effect (Rodriguez, et al. 2015a). Nocturnally migrating birds are attracted on a broadscale to lit areas (McLaren et al., 2018). Migratory shorebird species can reduce their energy reserves by interacting with artificial light by avoidance or disorientation behaviours (Wiltschko et al., 1993).

Light pollution has been found to be a concern for burrow-nesting seabirds globally, with documented impacts on over 50 species of shearwaters, petrels, and puffins (Rodriguez et al., 2017b). Fledglings of burrow-nesting seabirds, and to a lesser extent adults, are attracted to and then grounded (i.e., forced to land) by lights when they fly at night (Rodriguez et al., 2017b)

While coastal light pollution can disrupt adult seabirds provisioning their chicks on colonies, fledglings consistently account for the majority (68% - 99%) of the grounded birds (Rodriguez et al., 2017b). Fledgling seabird “fallout” occurs when chicks leaving their nests become disoriented by onshore lighting and become stranded on land instead of flying out to sea. The magnitude of fallout is likely influenced by the number of chicks fledging, the prevailing environmental and celestial conditions (Montevecchi, 2006), and the features of anthropogenic lights, which vary as a function of light fixture design and bulb type (Rodriguez, 2017a).

Most observations of fledgling groundings have coincided with the finding of birds which had collided with the lights or other parts of the vertical structures (Rodriguez, et al., 2015a). Specific weather conditions (e.g. heavy clouds, fog, drizzle) can increase the magnitude of grounding and fallout events around artificial lights (Ronconi et al., 2015).

Light pollution is a particular issue for wedge-tailed shearwaters due to their nocturnal habits, as well as migratory shorebirds as they undertake their migratory flights at night (Geering et al. 2007). Gas flares and facility lights on petroleum production and processing plants are a significant source of artificial lighting that attract seabirds (Wiese et al. 2001; Nicholson, 2002) and could potentially attract migrating shorebirds. Nesting birds may be disoriented where lighting is situated adjacent to rookeries. This is evident for young fledglings, in particular wedge-tailed shearwaters, leaving breeding colonies for the first time (Nicholson 2002).

1.2 Interaction Procedure for Grounded Birds

This procedure focuses primarily upon the wedge-tailed shearwater, as this species presents the greatest risk for artificial light interaction at the Project site. However, the surveys described would include any observations of interactions by other avian species with the Project infrastructure, if they occurred. This would only be in the timeframe outlined below, but could include short-term mitigation such as further shielding of lighting during the peak season for migratory shorebirds to occur (September – April). The operational control measures outlined in **Section 5.4** would be expected to provide the best possible outcomes for reducing light interactions with most migratory shorebird species.

During the months of April and May, wedge-tailed shearwater fledglings from colonies on islands adjacent to the Project site could become disorientated by Project infrastructure lighting at night (Nicholson, 2002; Rodriguez et al., 2017b). This species fledge their nests from mid-April until early May from offshore islands of the Pilbara region (Nicholson, 2002) during the night only. Once they are in the air they can become disoriented by, and attracted to, artificial light within 20 km of their location. This could potentially cause groundings and fallout to occur within the artificially lit areas of the gantry and Project infrastructure, leading to damage and death of the fledglings if they are not recovered and released at an appropriate time away from the light source (Rodriguez, et al., 2017b; Ronconi et al., 2015; Nicholson, 2002).

The Bird Interaction Procedure would require that a dedicated fauna handling ornithologist/technician be present at the site for two weeks from mid-April to conduct 2 hourly nocturnal surveys to locate disoriented birds that may be interacting with lit areas of the gantry and infrastructure. Any live disoriented birds would need to be retained in purpose-built boxes until pre-dawn, where they would need to be released away from light sources so that they can fly out to pelagic waters and away from land before the full light of dawn occurs.

1.3 Recovered Fledglings

All recovered wedge-tailed shearwater fledglings would be weighed, measured, and if alive, undamaged birds would be marked with an ABBBS band by the ornithologist/technician (Bird banding license required). If any fledglings are overlooked during the nocturnal surveys, they would be recovered from infrastructure during a daytime search in the early morning. To encourage dispersal to pelagic areas of the ocean, while avoiding predation by birds of prey, recovered birds that are alive and undamaged would need to be retained in a purpose-built box in a quiet, cool, dark area until pre-dawn the following day, when they would be released at pre-dawn.

Recovered birds that have died will be weighed and measured and this data will be reported to DBCA/regulators for their records. Any individuals that are recovered with damage that is not compatible with being able to fledge will need to be assessed and reported to DBCA, awaiting a decision on the correct procedure to adopt in this instance (e.g. euthanasia).

2 REFERENCES

MCLAREN, J.D., BULER, J.J., SCHRECKENGOST, T., SMOLINSKY, J.A., BOONE, M., EMIEL VAN LOON, E., DAWSON, D.K. & WALTERS, E.L. (2018) Artificial light at night confounds broad-scale habitat use by migrating birds. Ecol Lett, 21: 356-364. https://doi.org/10.1111/ele.12902

RODRÍGUEZ, A., DANN, P. & CHIARADIA, A. (2017a) Reducing light-induced mortality of seabirds: High pressure sodium lights decrease the fatal attraction of shearwaters. *Journal for Nature Conservation*, 39, 68-72.

RODRIGUEZ, A., HOLMES, N.D., RYAN, P.G., WILSON, K.J., FAULQUIER, L., MURILLO, Y., RAINE, A.F., PENNIMAN, J.F., NEVES, V., RODRIGUEZ, B., NEGRO, J.J., CHIARADIA, A., DANN, P., ANDERSON, T., METZGER, B., SHIRAI, M., DEPPE, L., WHEELER, J., HODUM, P., GOUVEIA, C., CARMO, V., CARREIRA, G.P., DELGADO-ALBURQUEQUE, L., GUERRA-CORREA, C., COUZI, F.X., TRAVERS, M. & CORRE, M.L. (2017b) Seabird mortality induced by land-based artificial lights. *Conservation Biology* 31(5):986-1001. doi: 10.1111/cobi.12900. Epub 2017 May 17. PMID: 28151557

APPENDIX C
BENCHMARK HATCHLING TURTLE ORIENTATION REPORT

MINERAL RESOURCES LIMITED (MINRES)

ASHBURTON INFRASTRUCTURE PROJECT: BENCHMARK HATCHLING TURTLE ORIENTATION REPORT

Prepared by

Pendoley Environmental Pty Ltd

For

Mineral Resources Limited (MinRes)

30 June 2023

PENDOLEY ENVIRONMENTAL

PENDOLEY ENVIRONMENTAL

DOCUMENT CONTROL INFORMATION

TITLE: ASHBURTON INFRASTRUCTURE PROJECT: BENCHMARK HATCHLING TURTLE ORIENTATION REPORT

Disclaimer and Limitation

This report has been prepared on behalf of and for the use of Mineral Resources Limited (MinRes). Pendoley Environmental Pty Ltd. takes no responsibility for the completeness or form of any subsequent copies of this Document. Copying of this Document without the permission of Mineral Resources Limited (MinRes) is not permitted.

Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		07/05/2023	[redacted]
Rev IA	Technical Review	08/05/2023	09/05/2023	
Rev A	Client review	23/05/2023	26/06/2023	
Rev 0	Final report issued	26/06/2023	30/06/2023	

Printed:	30 June 2023
Last saved:	30 June 2023 02:33 PM
File name:	P:\06 Projects\J88 MRL\J88005 Baseline Hatchling Orientation\04 Technical Reports\J88005 MRL Benchmark Hatchling Orientation Rev0.docx
[redacted]	
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Ashburton Infrastructure Project
Client	Mineral Resources Limited (MinRes)
[redacted]	
Report number:	J88005
Cover photo:	Hatchling fan on Bessieres Island (Credit: A. Mitchell)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

The Ashburton Infrastructure Project (the Project) involves the mining of three iron ore deposits approximately 50 km south of Pannawonica and includes a 147 km long private haul road from the mine area to the Port of Ashburton with proposed additional nearshore and onshore port facilities, and offshore anchorage areas. The Project is located entirely within the Shire of Ashburton in the West Pilbara region of Western Australia and the Project proponent is Mineral Resources Limited (MinRes). MinRes expects the Project will deliver about 20 – 40 million tonnes per annum (Mtpa) of iron ore for export over about 30 – 40 years as a Direct Shipping Ore.

In February 2021, MinRes engaged Pendoley Environmental (PENV) to undertake a Port Nearshore Marine Fauna Light Spill Impact Assessment (the assessment) for inclusion within their Department of Water and Environmental Regulation (DWER) Works Approval and Pilbara Ports Authority (PPA) Development Application. The assessment complied with the recently published *National Light Pollution Guidelines for Wildlife* (the guidelines; Commonwealth of Australia 2020) and identified potential impacts of Project-related artificial light on marine turtles and other light sensitive species, including seabirds and migratory shorebirds. It also provided recommendations on best practice lighting design and included a consolidated list of control measures and monitoring strategies that could prevent or minimise Project-related lighting impacts to light sensitive species.

1.2 Scope of Works

The assessment was finalised and approved in June 2022 and identified that marine turtle hatchlings were most at risk of a negative impact from Project-related lighting, particularly at Bessieres and Thevenard islands due to their proximity to the offshore ocean-going vessel (OGV) anchorage area, and at Ashburton Island due to their proximity to landside and nearshore facilities (**Figure 1**) (PENV 2022). The assessment recommended that hatchling orientation and light monitoring be undertaken on these islands to determine the influence of Project-related artificial light on hatchling sea-finding.

Consequently, MinRes engaged PENV to undertake baseline hatchling orientation monitoring at Ashburton, Bessieres, and Thevenard islands during the following 2022/23 marine turtle hatching season and to establish trigger and threshold values based on the resulting dataset. While baseline artificial light data was obtained in June 2021 as part of the assessment, updated light data was also collected during the season and is presented in this report.

1.3 Baseline Monitoring Limitation

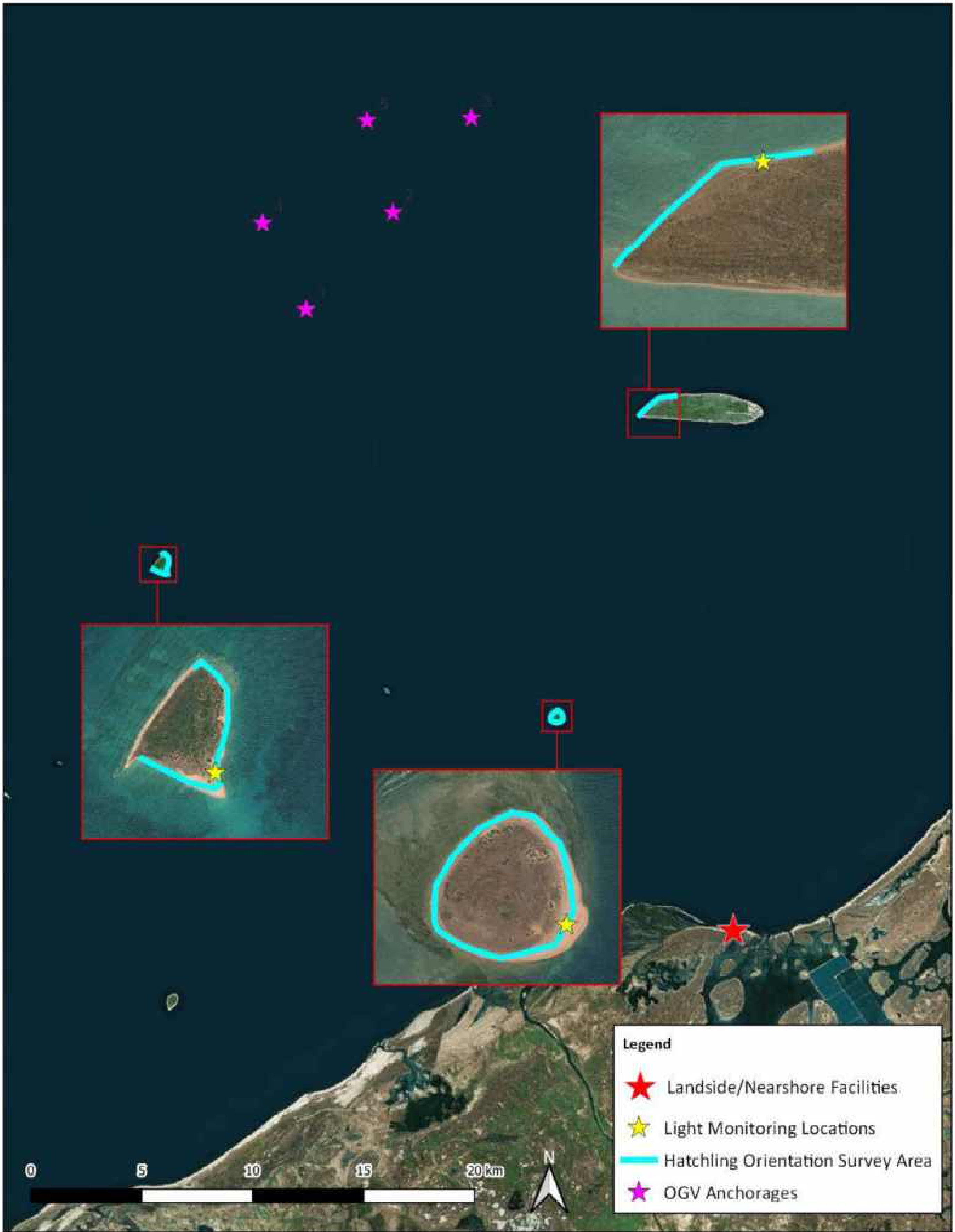
MinRes received development approval for the Project in December 2022 and commenced construction of the Project in January 2023. Unfortunately, PENV were not informed of these activities until after they had already started, which resulted in inability to collect a pre-construction hatchling orientation baseline dataset, as recommended in the assessment. Construction activities, including night-time dredging, occurred at the landside and nearshore facilities at the Port of Ashburton. No activities were situated at the OGV anchorage area (**Figure 1**).

Based on light modelling outputs, the assessment concluded that lighting associated with construction activities at the Port of Ashburton, including dredging, would have minimal visibility and be low in brightness when viewed from habitat at Bessieres and Thevenard islands and therefore present a lower risk of impact to hatchling turtles. This was primarily due to the significant distance (31 km and 25 km, respectively) between the islands and the light source, as well as the shielding provided by the islands' topography and vegetation. Instead, the assessment focused on lighting from vessels situated at the offshore OGV anchorage area which was highly visible in the light modelling outputs from the two islands and thus present a higher risk of impact to hatchling turtles. **Therefore, due to the absence of any vessels at the OGV anchorage area during the monitoring period, any data captured at Bessieres and Thevenard islands in 2022/23 is considered as a suitable 'benchmark' for determining the influence of Project-related artificial light on hatchling sea-finding and for establishing trigger and threshold values.**

Ashburton Island stands as an exception to the previous statement, as the assessment determined that lighting from the landside and nearshore facilities had a higher likelihood of being visible and brighter from the habitat compared to Bessieres and Thevenard islands. This is because the island is situated at a closer distance of 12 km from the light source. **Therefore, any hatchling orientation data captured from this habitat during 2022/23 may have been influenced by Project-related artificial light.**

Additionally, consideration of impacts to hatchling orientation at Direction Island was added to recommended conditions for the project after PENV had been engaged to undertake baseline surveys. As such, while baseline data on light impacts to adult turtles were collected in 2022/23 for Direction Island, no baseline data are available for hatchling orientation at this island.

In light of the above baseline data limitations, hatchling orientation trigger and threshold criteria have been developed for Ashburton and Direction Islands using the criteria for Bessieres island (considered to be most conservative). These will be reviewed as future monitoring data are collected.



J88005 MRL Baseline Hatchling Orientation Survey

Figure 1: Hatchling orientation survey area and light survey locations.

[redacted]

Date: 04/05/2022
Drawing File Ref:
PENV-J88005-1400-A

PENDOLEY ENVIRONMENTAL

2 METHODOLOGY

2.1 Survey Location and Schedule

Field Survey 1 (FS1) was completed over a 16-day period on the new moon between the 17th January and 1st February 2023 and was scheduled to coincide with the peak hatching period for flatback (*Natator depressus*) and green (*Chelonia mydas*) turtles for their respective genetic stock (flatback: F-Pil; green: G-NWS; Commonwealth of Australia 2017). During FS1, hatchling orientation and light monitoring was undertaken daily at Ashburton, Bessieres, and Thevenard islands (**Figure 1**). Note that the light monitoring site at Thevenard Island was relocated in FS1 to a more relevant location where marine turtle hatching density was higher (**Table 1** and **Figure 1**).

Due to low samples collected at Bessieres Island during FS1, a second 10-day field survey (FS2) was undertaken to collect additional hatchling orientation data over a new moon phase between the 14th and 24th March 2023. During FS2, only Bessieres Island was monitored daily, with additional surveys conducted opportunistically at Ashburton Island.

Table 1: Details of Sky42 light monitoring camera deployments.

Survey Location	Latitude	Longitude	Camera Height (m)
Ashburton Island	-21.59322	114.93793	0.5 m
Bessieres Island	-21.52862	114.76531	0.5 m
Thevenard Island	-21.45254	114.98329	0.5 m

2.2 Data Capture

2.2.1 Hatchling Orientation

The most common method to monitor the influence of existing artificial light on the sea-finding behaviour of hatchling turtles is to record the angles of their tracks left on the beach (a 'nest fan') after they emerge from the nest and crawl to the ocean (Pendoley 2005).

A nest fan was recorded if five or more hatchling tracks were sighted from a hatched clutch. Hatchling tracks fan out from a localised depression in the sand which marks the point of emergence. A sighting compass was used to measure the bearing of the outermost tracks of the nest fan (vectors A and B,) and the bearing of the most direct route to the ocean (vector X, **Figure 2**). Bearings were measured from the point where the track crossed the high tide line. Single hatchling tracks that were more than 30˚ from the outermost track of the main fan were recorded as outliers, following methodology guidance of Pendoley (2005).

A GPS location was recorded at the emergence point of the nest. In addition, a circle was drawn in the sand around the depression, and a line drawn through all hatchling tracks, to ensure the same nest fan was not recorded on subsequent monitoring days.

2.2.2 Artificial Light

Artificial light data was captured at each monitoring site using a Sky42 light monitoring camera. The camera is a calibrated Canon EOS 700D DSLR combined with a fish-eye lens and custom-built hardware to acquire low-light images of the entire night sky. The cameras are built into a weatherproof housing with a protective lid that automatically opens during image capture and closes between capture intervals.

The cameras were deployed on tripods at the survey locations each night and were programmed to automatically begin taking photos in 10-minute intervals between sunset and sunrise. Images were downloaded the following morning, and camera maintenance and pre-deployment checks performed to ensure correct operation for the next monitoring night.

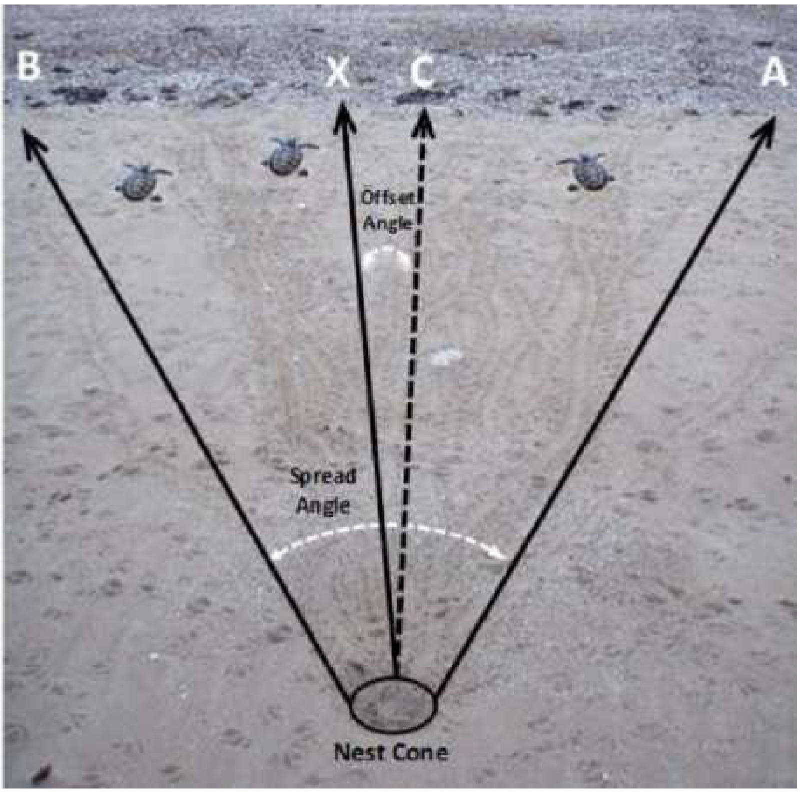


Figure 2: Hatchling orientation angles recorded for a nest fan and associated spread and offset angles. Black arrows indicate metrics that are captured in the field. Dashed black arrow indicates middle indices between A and B that is used to calculate the offset angle.

2.3 Data Analysis

2.3.1 Hatchling Orientation

Hatchling orientation data from each survey location were analysed to provide:

- **Spread angle**: The range of dispersion of tracks from the emergence point, describing the degree of dispersion of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean finding bearings and may indicate disruption to natural hatchling sea finding ability.

- **Offset angle:** The degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e., less deviation from the most direct route) and a larger value demonstrates greater deviation from the most direct route which may indicate a disruption to natural hatchling sea finding ability.

2.3.2 Artificial Light

The quality of an image captured by a Sky42 light monitoring camera can be influenced by atmospheric factors such as the presence of the moon, twilight, cloud, rain, dust, humidity, or physical factors such as accumulation of sand or dust on the lens. Any images that are affected by physical factors were removed from the analysis, as well as any images that were affected by the moon or twilight.

All suitable images from each survey location were processed using specialised software to determine "whole-of-sky" and "horizon" sky brightness levels. Whole-of-sky (WOS) is the mean value of sky glow in the entire image (**Figure 3a**) and horizon is the mean value of sky glow within the 60° – 90° outer band (most relevant for hatchling marine turtles; **Figure 3b**).

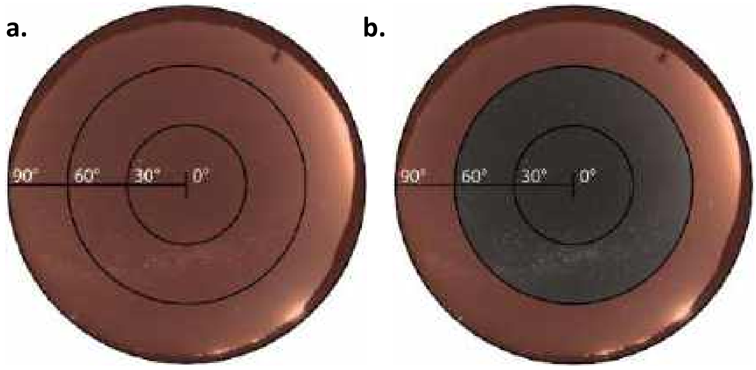


Figure 3: Measurement of mean pixel values within a specific field of view; a. Whole-of-sky brightness (full image); b. Horizon brightness (60 – 90°). Shaded areas denote the region of the sky being measured.

Sky brightness has been represented in units of visual magnitudes per square arc second (Vmag/arcsec^2; Vmag), which quantifies brightness on an inverse logarithmic scale (higher values represent a lower level of brightness, while lower values represent a higher level of brightness). A naturally dark sky with no presence of artificial light is approximately 22 Vmag, compared to measurements within a suburban area which typically report values of 19 – 20 Vmag (**Table 2** and **Figure 4**).

Additionally, for each survey location, a set of figures was generated including the raw fisheye image, processed fisheye image (in Vmag), and "unwrapped" versions as re-projected all-sky benchmark images allowing horizon light sources to be easily identified. Note that the colour coding used in the processed imagery represents the scale of intensity of light and is not representative of the colour of light as perceived by a human or Sky42 camera.

Table 2: Qualitative description of Sky42 whole-of-sky (0 – 90°) Vmag. Use as a guide only.

WOS Brightness (0 – 90°) (Vmag)	Description
21.5 – 22.0	Ideal natural dark night sky: see **Figure 4a**
21.0 – 21.5	Rural night sky
20.0 – 21.0	Semi-rural night sky
19.0 – 20.0	Suburban night sky
18.0 – 19.0	Urban night sky: see **Figure 4b**
< 18.0	Urban/Industrial night sky

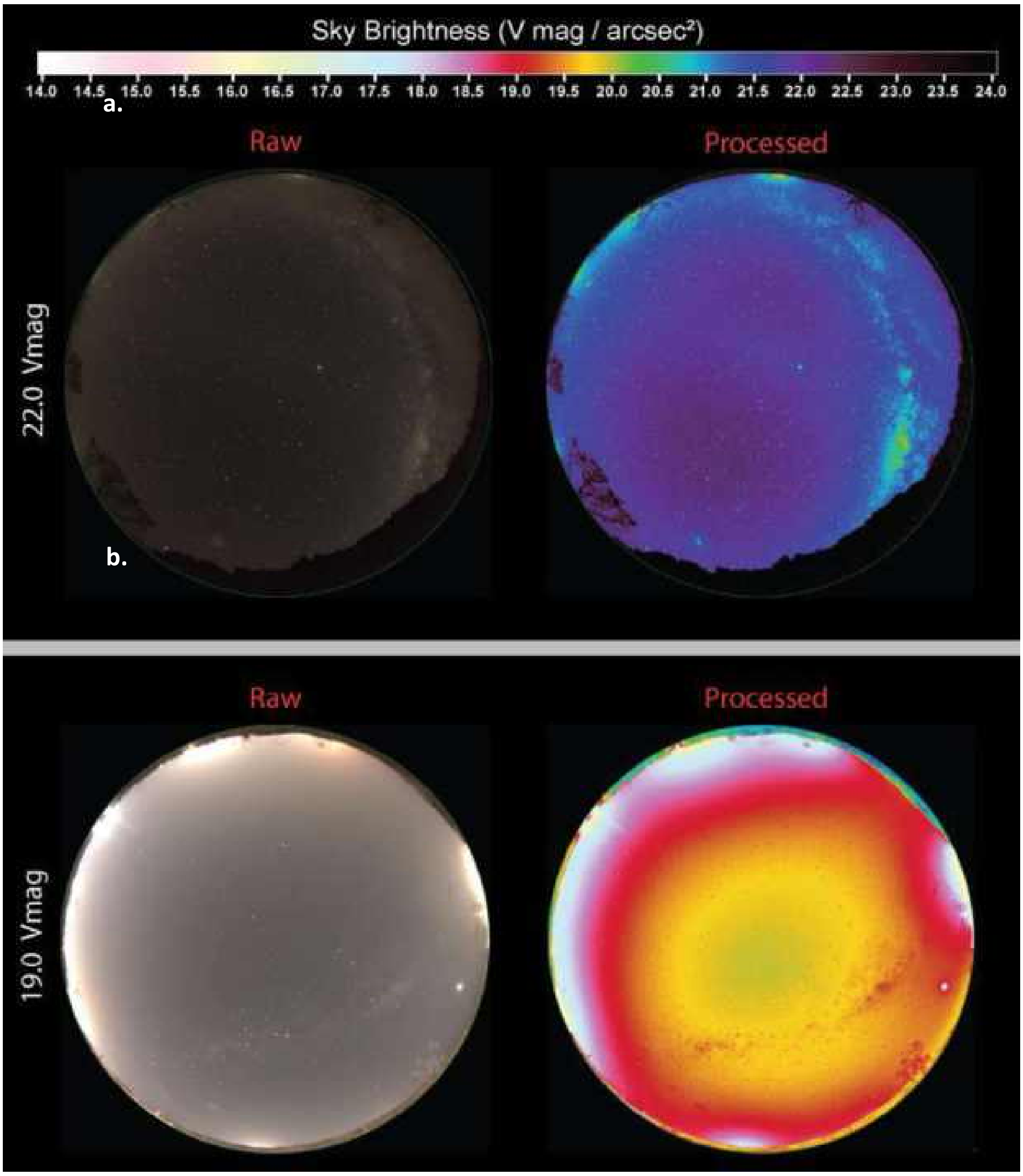


Figure 4: Examples of a dark and bright night sky. a. An 'ideal' natural dark sky with a whole-of-sky brightness value of 22.0 Vmag. b. A bright sky with a whole-of-sky brightness value of 19.0 Vmag, representative of a suburban night sky.

2.4 Post-baseline Trigger and Threshold Criteria

As per the Environmental Protection Authority (EPA) instructions on preparing an Environmental Management Plan under Part IV of the *Environmental Protection Act 1986* (EPA 2021), trigger and threshold criteria were defined based on spread and offset angles. These criteria are outcome-based and specific to the baseline hatchling turtle orientation data recorded at the survey locations presented in this report. Trigger criteria are intended to forewarn of the approach of the threshold criteria and must be set at a conservative level to ensure trigger level actions are implemented well in advance of the threshold criteria. Threshold criteria are indicators selected to represent the limit of acceptable impact beyond which there is likely to be a significant impact on the hatchling sea-finding behaviour.

The spread and offset angle data were analysed statistically using a Bayesian projected normal regression model for circular data (Cremers 2018a). A Markov Chain Monte Carlo (MCMC) algorithm was used to fit a Bayesian regression model for circular data that is projected onto a normal distribution. These types of analyses are robust, as they can account for multiple variables that may influence the data as well as random effects. A circular data analysis is important when analysing bearings and angles as they are periodic in nature and results may be misinterpreted if using typical linear analysis methods (Cremers 2018b).

The mean of the spread angle and offset angle at each survey location was determined, as well as an upper bound and lower bound for each mean. The upper and lower bounds indicate that there is a 95 % probability that the true mean lies between the upper and lower bounds, based on the data (this is also known as the 95 % highest posterior density interval; Cremers 2018a).

The upper and lower bounds of the benchmark mean (for both spread angle and offset angle) can be used to test if the post-baseline data are different to the benchmark data. If the post-baseline mean is beyond the upper bound of the benchmark data but the lower bound is within the benchmark upper bound, then this implies that there *may* be a difference between the benchmark and post-baseline data (a trigger; **Figure 5a**). However, if the post-baseline lower bound is not within the upper bound of the benchmark data, then this implies that there is a significant difference between the benchmark and post-baseline data (a threshold; **Figure 5b**) (Cremers 2018a). Specifically, trigger and threshold criteria are as follows:

Trigger criteria:

- The mean of the post-baseline offset angle exceeds the upper bound of the benchmark offset angle but the post-baseline lower bound is still within the benchmark upper bound; **or**
- The mean of the post-baseline spread angle exceeds the upper bound of the benchmark spread angle but the post-baseline lower bound is still within the benchmark upper bound.

Threshold criteria:

- The lower bound of the post-baseline offset angle exceeds the upper bound of the benchmark offset angle; **or**
- The lower bound of the post-baseline spread angle exceeds the upper bound of the benchmark spread angle.

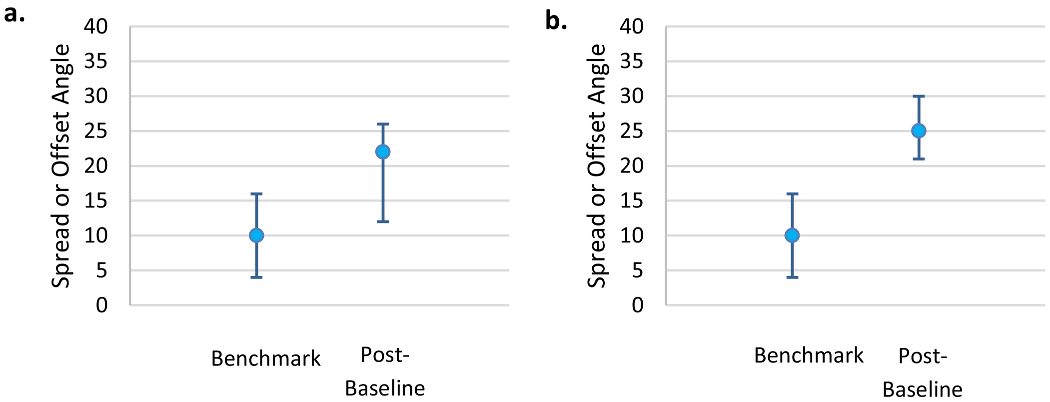


Figure 5: Examples of comparisons between benchmark and post-baseline datasets. a. Possible change (trigger): the lower bound of the post-baseline dataset is above the benchmark mean, but below the benchmark upper bound; b. Significant change (threshold): the lower bound of the post-baseline dataset exceeds the upper bound of the benchmark dataset.

3 RESULTS

3.1 Hatchling Orientation

A total of 87 marine turtle hatchling nest fans were collected over both field surveys. Of these, 30 fans were collected at Ashburton Island (**Figure 8**), 25 at Ashburton Island (**Figure 6**), and 32 at Thevenard Island (**Figure 7**). The mean spread and offset angles, and the lower and upper bounds for each survey location are shown in **Tables 3** and **4**.

Of an estimated 980 individual hatchling tracks within the fans, 18 individual tracks (1.8 %) were outliers and hence removed from the data analysis.

Table 3: The mean spread angle, upper bound, and lower bound for each survey location.

Survey Location	Mean	Lower Bound	Upper Bound
Ashburton Island	64.0°	NA	NA
Bessieres Island	43.0°	35.0°	51.0°
Thevenard Island	50.0°	43.0°	57.0°

Table 4: The mean offset angle, upper bound, and lower bound for each survey location.

Survey Location	Mean	Lower Bound	Upper Bound
Ashburton Island	10.3°	NA	NA
Bessieres Island	8.5°	6.0°	10.9°
Thevenard Island	10.5°	5.7°	15.2°

Figure 6: Spread (left) and offset (right) angles of hatchling fans at Ashburton Island.

J88005 MRL Baseline Hatchling Orientation

Figure 7: Spread (left) and offset (right) angles of hatchling fans at Bessieres Island.

N

[redacted]
Date: 04/05/2023
Drawing File Ref:
PENV-J88005-0001-A

PENDOLEY ENVIRONMENTAL

J88005 MRL Baseline Hatchling Orientation

Figure 8: Spread (top) and offset (bottom) angles of hatchling fans at Thevenard Island.

N

[redacted]

Date: 04/05/2023

Drawing File Ref:

PENV-J88005-0001-A

PENDOLEY ENVIRONMENTAL

3.2 Artificial Light

Light sources that were visible in imagery captured at each survey location included the Wheatstone LNG Development and Onslow townsite (**Figures 9** – **11**). In addition, night-time dredging activities associated with the Project were also detected within the imagery captured at Ashburton Island (**Figure 9**). These same dredging activities were visible as low-level sky glow in imagery at Bessieres (**Figure 10**) and Thevenard (**Figure 11**) islands and were not distinguishable from the light generated by the Wheatstone LNG development situated nearby. Note that no offshore vessel lighting was detected from any survey location in the direction of where the OGV anchorage area would be situated (**Figures 9** – **11**).

The median WOS and horizon brightness at each survey location correlated strongly with the visibility of the identified light sources. For example, Ashburton Island, which had the highest visibility of these light sources, recorded the highest values for both WOS and horizon brightness (20.78 Vmag and 20.53 Vmag, respectively) (**Table 5** and **Figure 9**). Whereas Bessieres and Thevenard islands recorded substantially darker values due to their distance from these light sources on the mainland and the natural shielding by dunes/vegetation at the survey locations (**Table 5** and **Figures 11** – **12**).

Table 5: Median sky brightness in Vmag for whole-of-sky and horizon at each survey location. Note that Vmag is an inverse logarithmic scale meaning higher values represent a lower level of brightness, while lower values represent a higher level of brightness.

Survey Location	Median Sky Brightness (Vmag)	
	WOS	Horizon
Ashburton Island	20.78	20.53
Bessieres Island	21.50	21.52
Thevenard Island	21.50	21.55

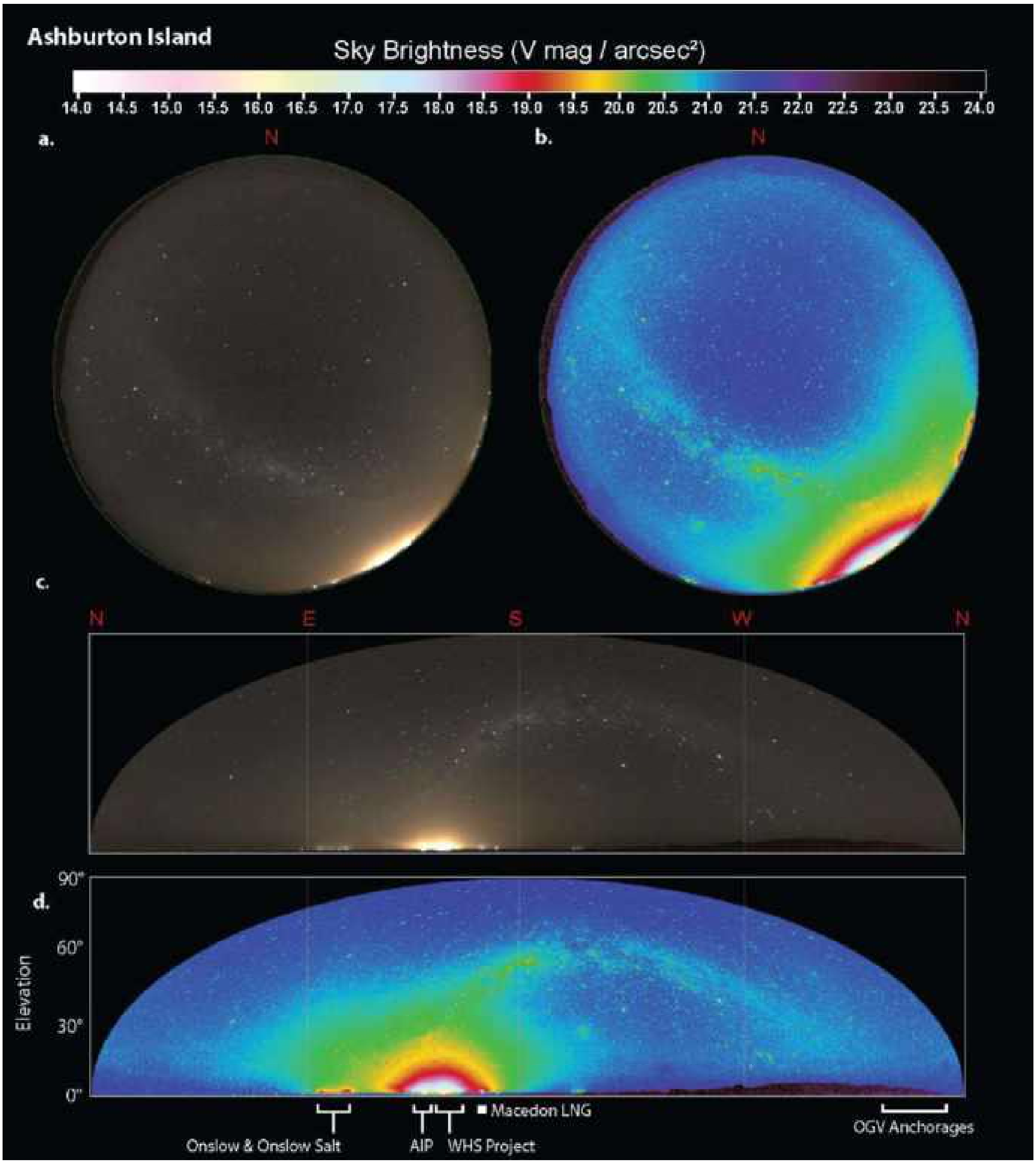


Figure 9: Median artificial light monitoring results from Ashburton Island on 24th January 2023. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources.

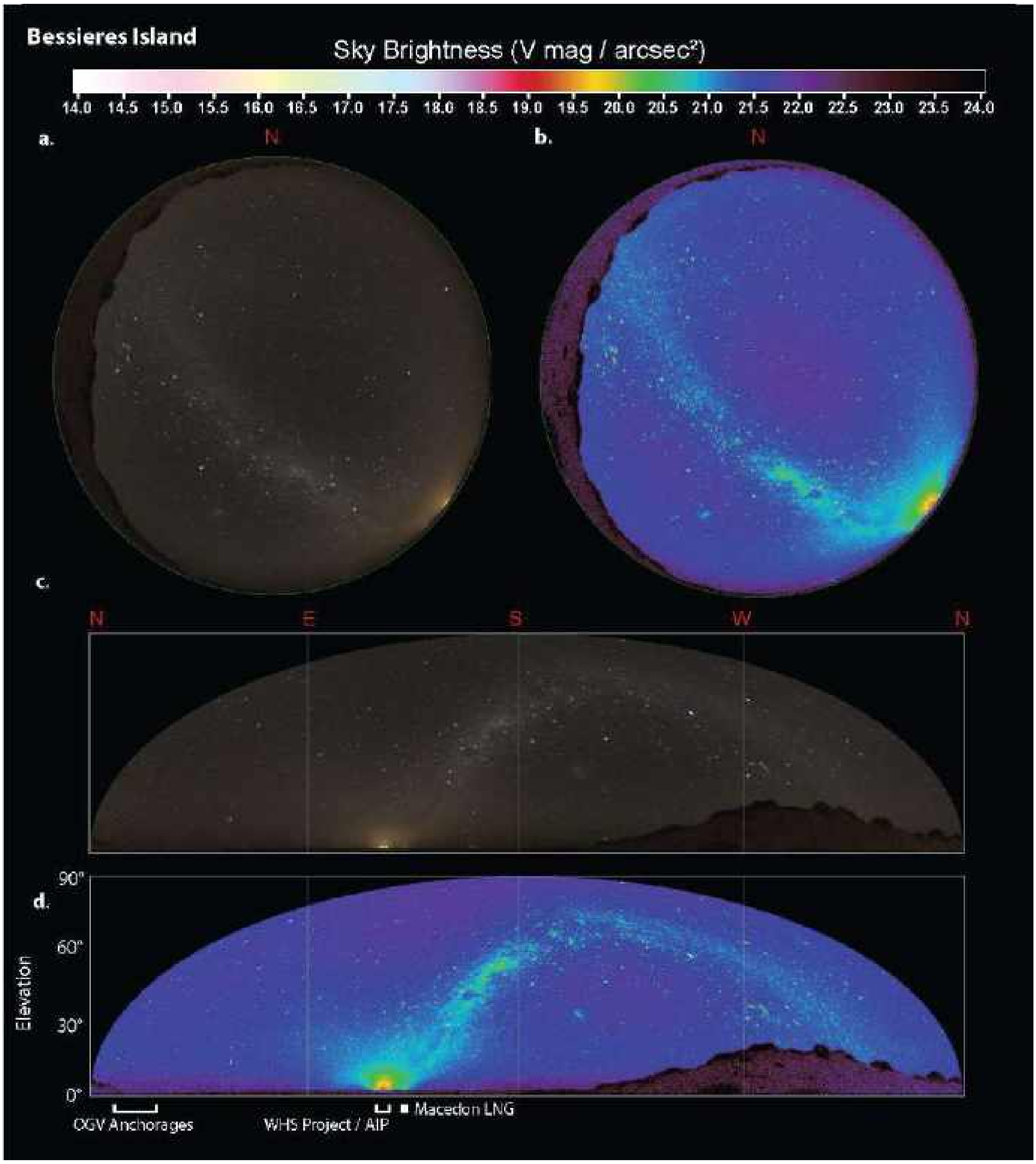


Figure 10: Median artificial light monitoring results from Bessieres Island on 27th January 2023. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources.

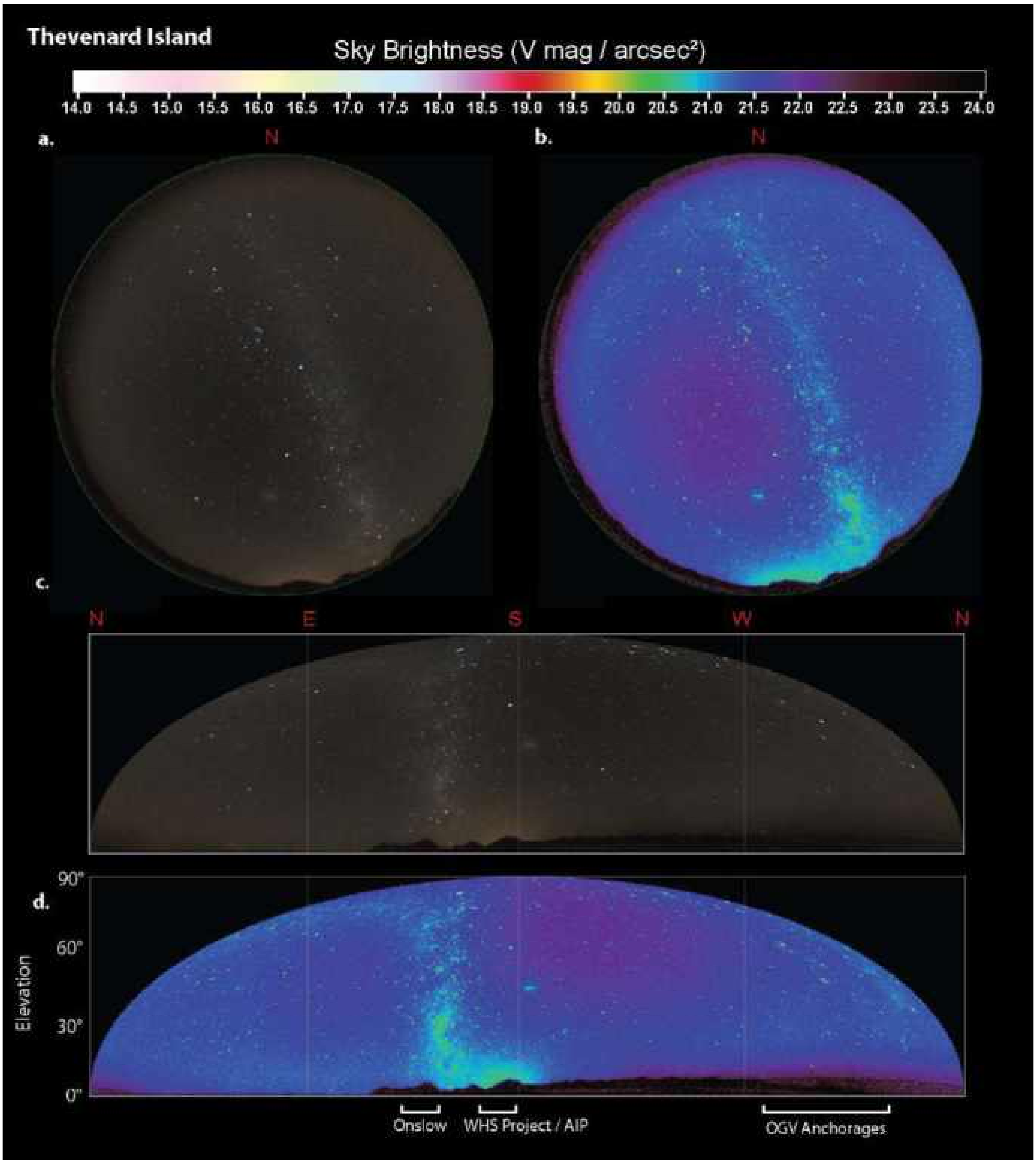


Figure 11: Median artificial light monitoring results from Thevenard Island on 24th January 2023. a. raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image. White labels = current light sources.

3.3 Post-baseline Trigger and Threshold Criteria

Trigger and threshold criteria for post-baseline datasets were determined from the mean, lower bound, and upper bound for Bessieres and Thevenard islands (**Tables 3** and **4**).

3.3.1 Spread Angle

Trigger Criteria:

- Bessieres Island: The mean exceeds 51° and the lower bound is below 51°.
- Thevenard Island: The mean exceeds 57° and the lower bound is below 57°.
- Ashburton and Direction Islands: The mean exceeds 51° and the lower bound is below 51°.

Threshold Criteria:

- Bessieres Island: The lower bound exceeds 51°.
- Thevenard Island: The lower bound exceeds 57°.
- Ashburton and Direction Islands: The lower bound exceeds 51°.

3.3.2 Offset Angle

Trigger Criteria:

- Bessieres Island: The mean exceeds 10.9° and the lower bound is below 10.9°.
- Thevenard Island: The mean exceeds 15.2° and the lower bound is below 15.2°.
- Ashburton and Direction Islands: The mean exceeds 10.9° and the lower bound is below 10.9°.

Threshold Criteria:

- Bessieres Island: The lower bound exceeds 10.9°
- Thevenard Island: The lower bound exceeds 15.2°.
- Ashburton and Direction Islands The lower bound exceeds 10.9°.

4 SUMMARY

Two field surveys were undertaken during the peak hatching period for flatback and green turtles within the region in January and March 2023 and coincided with new moon conditions. A sufficient sample of nest fans were recorded at each survey location, consisting of a total of 87 nest fans; 30 at Ashburton Island, 25 at Bessieres Island, and 32 at Thevenard Island. Unfortunately, due to the commencement of some Project-related construction activities at the Port of Ashburton in January 2023, the hatchling orientation dataset was only considered a suitable benchmark dataset for establishing trigger and threshold criteria for Bessieres and Thevenard islands, with artificial light from the construction activities clearly visible in imagery captured from nearby Ashburton Island.

The benchmark results indicated that most hatchling tracks reached the ocean, with 1.8 % of hatchling tracks recorded as outliers meaning an individual track was recorded as being >30° from the primary nest fan. Out of the three survey locations, the largest mean nest fan spread angle (64°) was recorded at Ashburton Island which also coincided with the highest level of whole-of-sky and horizon brightness (**Table 5**). This indicates that the existing light sources in the region e.g. Wheatstone LNG Development, Onslow townsite, and the Project-related construction activities, may have a greater influence on the sea-finding behaviour of hatchling turtles as they crawl to the ocean compared to at Bessieres and Thevenard islands. Based on this finding, it is also justified not to establish trigger and threshold criteria for Ashburton Island using the hatchling orientation dataset.

The benchmark dataset for Bessieres and Thevenard islands represents a wide range of hatchling orientation values recorded during new moon conditions, before any construction or operation activities took place at the OGV anchorage area. Lower and upper bounds for the nest fan spread and offset angles were estimated for both islands using the benchmark dataset (see **Tables 3** and **4**). These bounds, serving as defined statistical limits, offer a reliable and robust outcome-based representation of existing hatchling behaviour. They can be utilised in future post-baseline monitoring to identify the influence of artificial lighting on hatchlings. Furthermore, incorporating these values into trigger and threshold criteria provides confidence that any exceedance of these criteria either serves as a suitable forewarning or indicates a significant change.

5 REFERENCES

COMMONWEALTH OF AUSTRALIA (2017) Recovery Plan for Marine Turtles in Australia 2017 - 2017. Available at: https://www.agriculture.gov.au/sites/default/files/documents/recovery-plan-marine-turtles-2017.pdf.

COMMONWEALTH OF AUSTRALIA (2020) National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds. January 2020. Available at: https://www.agriculture.gov.au/sites/default/files/documents/national-light-pollution-guidelines-wildlife.pdf.

CREMERS, J. (2018a) Bpnreg: Bayesian Projected Normal Regression Models for Circular Data. Available online: https://CRAN.R-project.org/package=bpnreg.

CREMERS, J. & KLUGKIST,I. (2018b) One Direction? A Tutorial for Circular Data Analysis Using R With Examples in Cognitive Psychology. *Frontiers in Psychology*, 10.3389/fpsyg.2018.02040, 9.

EPA (2021) Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans, EPA, Western Australia. Available at: https://www.epa.wa.gov.au/sites/default/files/Forms_and_Templates/Instructions%20%20Preparing%20Environmental%20Protection%20Act%201986%2 0PIV%20Environmental%20Management%20Plans.pdf.

PENDOLEY, K. (2005) Sea turtles and industrial activity on the North West Shelf, Western Australia. PhD Thesis. Murdoch University, Perth.

PENV (2022) Ashburton Infrastructure Project: Artificial Light Impact Assessment and Management Plan. Report prepared for Mineral Resources Limited, June 2022 (Rev 1).

MINERAL RESOURCES

APPENDIX D

BASELINE ADULT TURTLE NESTING BEHAVIOUR & HABITAT UTILISATION REPORT

MINERAL RESOURCES LIMITED (MINRES)

ASHBURTON INFRASTRUCTURE PROJECT: BASELINE ADULT TURTLE NESTING BEHAVIOUR & HABITAT UTILISATION REPORT

Prepared by

Pendoley Environmental Pty Ltd

For

Mineral Resources Limited (MinRes)

30 June 2023

PENDOLEY ENVIRONMENTAL

PENDOLEY ENVIRONMENTAL

DOCUMENT CONTROL INFORMATION

TITLE: ASHBURTON INFRASTRUCTURE PROJECT: BASELINE ADULT TURTLE NESTING BEHAVIOUR & HABITAT UTILISATION REPORT

Disclaimer and Limitation

This report has been prepared on behalf of and for the use of Mineral Resources Limited (MinRes). Pendoley Environmental Pty Ltd. takes no responsibility for the completeness or form of any subsequent copies of this Document. Copying of this Document without the permission of Mineral Resources Limited (MinRes) is not permitted.

Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		03/05/2023	[redacted]
Rev IA	Technical Review	03/05/2023	05/05/2023	
Rev A	Client review	23/05/2023	26/06/2023	
Rev 0	Final report issued	26/06/2023	30/06/2023	

Printed:	30 June 2023
Last saved:	30 June 2023 02:08 PM
File name:	P:\06 Projects\J88 MRL\J88006 Baseline Adult Orientation\04 Technical Reports\J88006 Baseline Adult Turtle Nesting Behaviour and Habitat Utilisation Report_Rev0.docx
Author:	Dr Paul Whittock
Project manager:	Adam Mitchell
Name of organisation:	Pendoley Environmental Pty Ltd
Name of project:	Ashburton Infrastructure Project
Client	Mineral Resources Limited (MinRes)
Client representative:	Sarah Osbourne
Report number:	J88006
Cover photo:	Green turtles at Bessieres Island (Credit: P. Whittock)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

The Ashburton Infrastructure Project (the Project) involves the mining of three iron ore deposits approximately 50 km south of Pannawonica and includes a 147 km long private haul road from the mine area to the Port of Ashburton with proposed additional nearshore and onshore port facilities, and offshore anchorage areas. The Project is located entirely within the Shire of Ashburton in the West Pilbara region of Western Australia and the Project proponent is Mineral Resources Limited (MinRes). MinRes expects the Project will deliver about 20 - 40 million tonnes per annum (Mtpa) of iron ore for export over about 30 - 40 years as a Direct Shipping Ore.

In February 2021, MinRes engaged Pendoley Environmental (PENV) to undertake a Port Nearshore Marine Fauna Light Spill Impact Assessment (the assessment) for inclusion within their Department of Water and Environmental Regulation (DWER) Works Approval and Pilbara Ports Authority (PPA) Development Application. The assessment complied with the recently published *National Light Pollution Guidelines for Wildlife* (the guidelines; Commonwealth of Australia 2020) and identified potential impacts of Project related artificial light on marine turtles and other light sensitive species, including seabirds and migratory shorebirds. It also provided recommendations on best practice lighting design and included a consolidated list of control measures and monitoring strategies that could prevent or minimise Project related lighting impacts to light sensitive species.

1.2 Scope of Works

For adult marine turtles, the assessment predicted that Project-related artificial light would be visible at their nesting habitat on the mainland and offshore islands (e.g. Ashburton, Bessieres, and Thevenard). However, due to the shielding of light from a 15 m vegetated dune at mainland nesting habitat, the distance of the island nesting habitat from the mainland facilities (i.e. >20 km), and the proposed implementation of lighting control measures, the assessment classified the residual consequence level of the visible light to adult marine turtles as 'low' and no further post-construction survey was proposed in the assessment's Artificial Light Management Plan (ALMP; PENV 2022).

The DWER Marine Ecosystems Branch (MEB) reviewed the assessment's ALMP in August 2022 and commented that '*given the proximity of the proposed development to Thevenard Island and Bessieres Island which are critical marine turtle habitats, the impact on nesting adult turtles should be considered. In addition, the post-construction operations survey should also assess any potential changes to adult nesting turtles because of the project*' (comment #4F). MEB also requested that monitoring of adult turtles be incorporated into the ALMP to validate MinRes' predicted impact and confirm that the implemented lighting control measures are adequate.

In addition, the recommended conditions set out for the Project by the Environmental Protection Authority (EPA) in February 2023 under Assessment No. 2320 (EPA 2023) included:

- *B3-1 The proponent must implement the proposal to meet the following environmental objectives:*

  - *(3) minimise the risk of **adult marine turtle** and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to **adult marine turtle nesting utilisation**, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island.*

- *B3-4 The proponent must update the Artificial Light Impact Assessment and Management Plan Revision 6 (Report number J88001), that satisfies the requirements of condition C5 and demonstrates how achievement of the marine fauna environmental objectives in condition B3-1(3) and condition B3-1(4) will be achieved and submit it to the CEO.*

Consequently, MinRes requested PENV to undertake baseline monitoring of adult turtle nesting behaviour i.e. orientation and habitat utilisation, that would satisfy the MEB comment and the EPA's recommended conditions. The baseline data would be used to demonstrate any potential impact of artificial light on adult turtle nesting during construction and/or operations and support an update to the ALMP.

2 METHODOLOGY

At the time of designing the baseline survey in October 2022, no previous studies outlined a methodology for measuring the impact of artificial light on adult turtle nesting behaviour. Therefore, the methodology outlined in this section was novel at the time and aimed to use overhead aerial imagery to measure adult turtle nesting behaviour from the length, sinuosity, and orientation of their tracks on the beach and to describe the distribution and utilisation of the available nesting habitat. Note that in December 2022, Shimada et al. (2022) published a methodology for measuring a change in adult turtle behaviour in response to changing levels of artificial light which validated our approach for measuring the orientation of their tracks on the beach.

2.1 Survey Location and Schedule

Suitable sandy beach habitat was surveyed to determine the presence of marine turtle nesting activity between the 7th and 16th December 2022 at Ashburton, Bessieres, Direction, and Thevenard Islands (**Figure 1** and **Table 1**). Due to the extent of the potential nesting habitat at Thevenard Island (12 km island perimeter), three coastal sections of the island were monitored on the south-east, south-west, and north-west side of the island (cumulative monitored area of 4.6 km). Note that due to the absence of marine turtle nesting activity on the south-west section of Thevenard Island, survey effort shifted to the south-east coastal section of the island after Survey Day 6 (**Table 1**).

The timing of the field survey aligned with the known peak nesting period for flatback (*Natator depressus*) and green (*Chelonia mydas*) turtle nesting for their respective genetic stock (flatback: F-Pil; green: G-NWS; Commonwealth of Australia 2017). These islands were selected to ensure compliance with the recommended condition B3-1(3) in EPA (2023) which was based on the outcomes of the assessment that stated Project lighting from the nearshore facilities and from vessels present at the ocean-going vessel (OGV) anchorages may be visible at the beach habitat. Note that the survey was completed prior to any night-time construction activities associated with the Project.

Table 1: Monitoring effort at each location during the survey. Survey Day 1 is the 7th December 2022. Note: Aerial imagery captured at Bessieres Island on Survey Day 1 did not overlap with nesting beach habitat and was therefore discarded.

Survey Location		Island Perimeter (km)	Length of Monitored Habitat (km)	Survey Day									
				1	2	3	4	5	6	7	8	9	10
Ashburton Island		1.4	1.4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Bessieres Island		3.1	2.0		✓	✓	✓	✓	✓	✓	✓	✓	✓
Direction Island		1.7	1.7	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Thevenard Island	South-east	12.0	1.6					✓	✓	✓	✓	✓	✓
	South-west		1.7	✓	✓	✓	✓	✓					
	North-west		1.3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

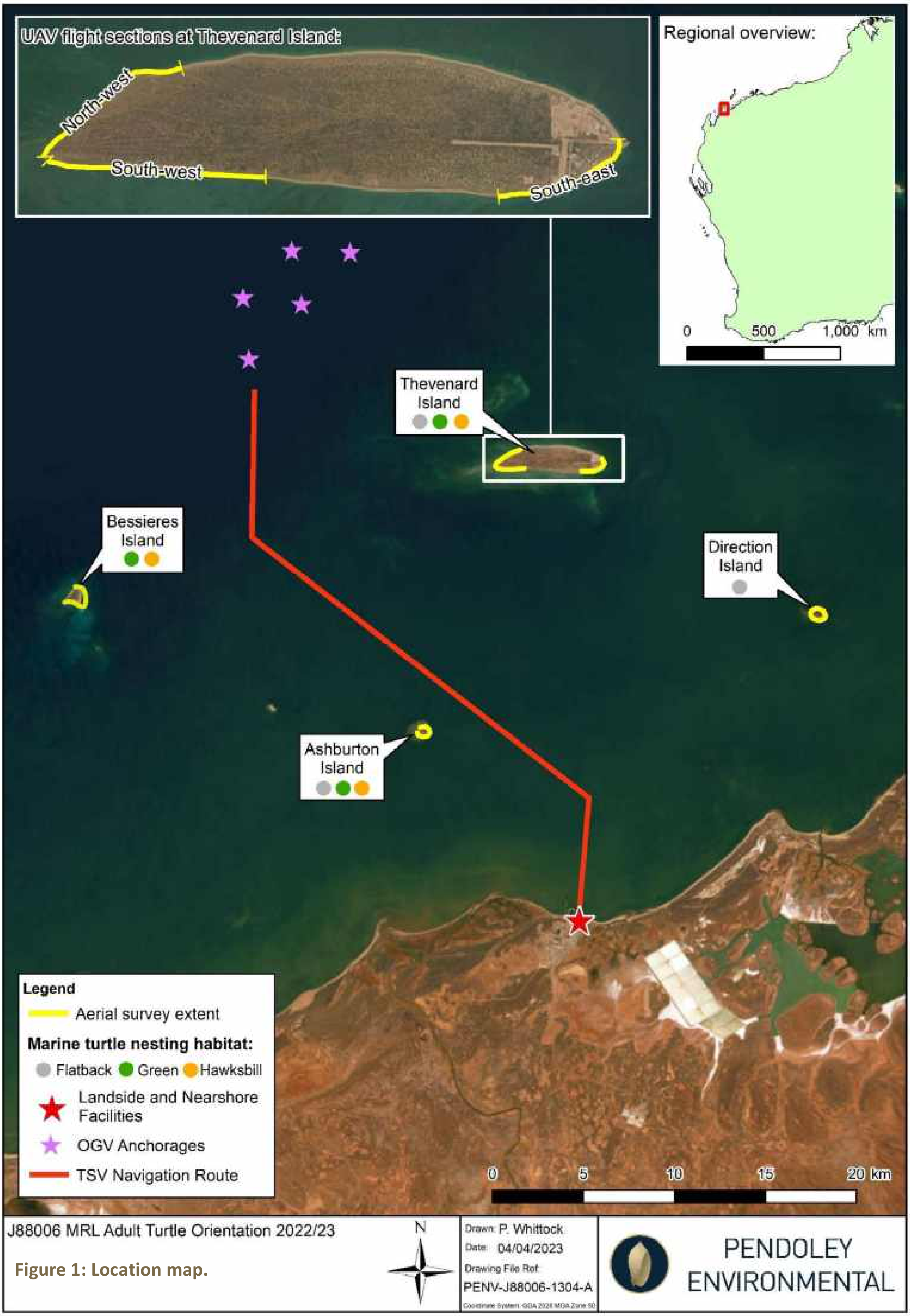


Figure 1: Location map.

2.1 Data Capture

Aerial images of overnight marine turtle nesting activity were recorded using an Unmanned Aerial Vehicle (UAV). The UAV was launched and landed by a qualified pilot from a vessel in proximity to each island and automatically flown along a pre-programmed flight path that extended across the island's nesting habitat. Flights were repeated each day of the survey.

The UAV was a Phantom 4 Pro V2 (manufacturer: DJI; weight = 1.4 kg). During the flight, the UAV travelled at an altitude of 30 m relative to the height of the launch site on the vessel (~2 – 3 m above ground) and at a speed of 4.5 ms^{-1}. The UAV's camera (20 MP, fixed focus at ∞, 84° field of view) was set at a 90° angle to point directly to the ground and captured images at two second intervals. Captured images had a ground sampling distance of ~0.8 cm per pixel and an overlap of >75 % which was considered sufficient for the generation of an orthomosaic with a suitable resolution for turtle track detection.

The UAV flights were completed at all survey locations between 07:00 and 11:00 each day of the survey. The completion of the flights in the morning ensured shadows in the captured images facilitated the identification of features within the turtle tracks.

2.2 Data Processing

The georeferenced aerial images recorded at each survey location were stitched into one daily orthomosaic using Pix4Dmapper Pro software (v4.6.3). Each generated orthomosaic was displayed in QGIS (v3.16.11) and visually screened for overnight marine turtle nesting activity. New overnight activity was identified by comparing the orthomosaic with the previous survey day's orthomosaic. Turtle species, GPS coordinate, and type of nesting activity (false crawl i.e. resulting in no nesting attempt, nesting attempt, or successful nest) were identified for each track using visible characteristics, including track width, shape and orientation of flipper marks, tail drag marks, and displaced sand. In addition, for each identified track with a successful nest, the occurrence of any prior nesting attempts along the same track was recorded.

2.3 Data Analysis

2.3.1 Adult Nesting Behaviour

Adult turtle nesting behaviour was determined from specific track morphometrics measured using QGIS (v3.16.11) for each marine turtle emergence that featured a successful nest. Note that some detected nests were excluded from the adult nesting behaviour analysis if their tracks were not clearly visible in the imagery e.g. obscured by other nesting turtles, eroded due to effects of wind, washed away due to a high tide. Measured track morphometrics included:

- **Length Ratio:** The length of the 'up' (landward) and 'down' (seaward) tracks of each marine turtle emergence were compared as a ratio i.e. length of 'down' track divided by length of 'up' track (see **Figure 2a**). To ensure consistency, the length of the 'up' track was measured from a delineated tide line on the beach (e.g. high tide line) to the nest site, and the length of the 'down' track was measured from the nesting pit on the beach to the same delineated tide line. The hypothesis is that if the sea-finding behaviour of an adult nesting turtle is influenced or impacted by artificial light, their 'down' track will be substantially longer than their 'up' track resulting in a ratio of >1. Note that this ratio was only calculated for marine turtle emergences that featured no prior nesting attempts because the length of the 'up' track would be biased.

- **Offset Angle of the 'down' track:** The bearings from the nesting pit to the point the turtle's 'down' track intersected a 5 m distance buffer from the nesting pit, and from the nesting pit directly to the ocean, were measured (see **Figure 2b**). The offset angle between the two bearings was then calculated. The hypothesis is that if the **initial sea-finding behaviour** of a nesting turtle i.e. within the first 5 m after departing the nesting pit, is influenced by artificial light, the offset angle between the bearing of the 'down' track and the direct bearing to the ocean will increase due to misorientation. The offset angle was calculated for all suitable marine turtle emergences that featured a successful nest (with or without a prior nesting attempt).
- **Sinuosity Index:** The sinuosity index is a measure of how much the 'down' track deviates from a straight line and is calculated by dividing the length of the 'down' track (as per the length ratio described above) by the straight-line distance between the nesting pit and the point the 'down' track intersects the delineated tide line on the beach (see **Figure 2a**). A sinuosity index of 1 indicates a perfectly straight line, while a value >1 indicates a more sinuous track. The hypothesis is that if the sea-finding behaviour of an adult nesting turtle during the **entirety of their crawl to the ocean** is influenced or impacted by artificial light, the turtle may crawl in a more circuitous fashion resulting in a sinuosity index substantially greater than 1. Note that the sinuosity index was calculated for all suitable marine turtle emergences that featured a successful nest (with or without a prior nesting attempt).

2.3.2 Habitat Utilisation

2.3.2.1 Density of Nesting Activity

The density of nesting activity within a 20 m radius was calculated for all species combined at each survey location using the heatmap tool in QGIS (v3.16.11). The heatmap was generated using a Kernel Density Estimation and a quartic interpolation function with a 20 m search radius. This function and search radius were selected based on the spatial distribution of activity across the monitored nesting habitat.

2.3.2.2 Pattern of Nesting Activity

The analysis followed similar methods to Hamann et al. (2022) which investigated the pattern of marine turtle nesting activity at Raine Island, Queensland. The analysis in this study involved calculating the centroid location of each island, and, using a northern bearing from the centroid, calculating the bearing in degrees to each marine turtle nesting activity identified during all survey days (including the first survey day). The pattern of nesting activity around each island was then determined using the 'Circular' package in R using the following metrics:

- **Angle of the mean vector ($\bar{\theta}$):** This represents the mean bearing of nesting activity around the island.

- **Length of the mean vector ($\bar{r}$):** Provides an indication of how congregated the nesting activity is, with $\bar{r}$ = 0 showing that nesting activity is spread evenly around the island and $\bar{r}$ = 1 showing that nesting activity is strongly clustered in the same direction.

To analyse the pattern of nesting activity on an island, all suitable nesting habitat must be surveyed because any change in activity will be detected from repeat analysis. However, at Thevenard Island, due to its large size, only 4.6 km of the 12 km perimeter was monitored for nesting activity. This limits our ability to detect any future change in nesting patterns to a specific cause because turtles may be nesting in other suitable habitat on the island outside the monitored area. Thus, we were unable to include an analysis of the nesting activity patterns for Thevenard Island.

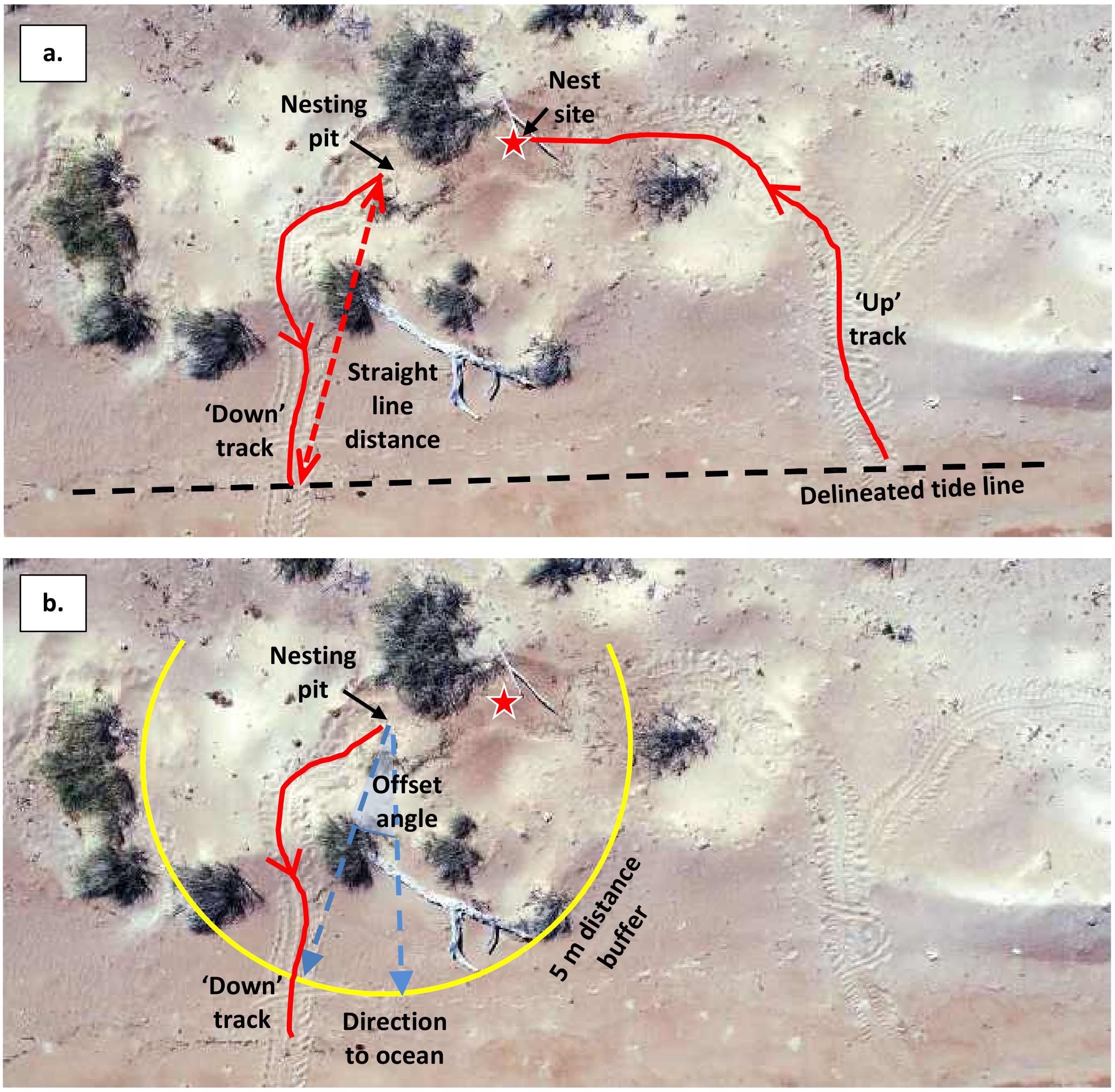


Figure 2: a. Track and straight-line measurements recorded to/from a marine turtle nest/nesting pit and a delineated high tide line for calculating the length ratio and sinuosity index; b. Offset angle of down track recorded from the nesting pit between the initial direction to the ocean and the direction of the down track at the point of intersection with a 5 m distance buffer. Solid red lines indicate the 'up' and 'down' track. Blue lines indicate the measured bearings for the direction to the ocean and from the nesting pit to the intersection of the 'down' track with 5 m distance buffer line.

2.4 Post-baseline Trigger and Threshold Criteria

As per the Environmental Protection Authority (EPA) instructions on preparing an Environmental Management Plan under Part IV of the *Environmental Protection Act 1986* (EPA 2021), trigger and threshold criteria were defined for each track morphometric outlined in **Section 2.4.1**. These criteria are outcome-based and specific to the baseline adult turtle nesting behaviour data recorded at the survey locations presented in this report. Trigger criteria are intended to forewarn of the approach of the threshold criteria and must be set at a conservative level to ensure trigger level actions are implemented well in advance of the threshold criteria. Threshold criteria are indicators selected to represent the limit of acceptable impact beyond which there is likely to be a significant impact on the adult turtle nesting behaviour.

The trigger and threshold criteria were based on the specific track morphometric recorded for all suitable marine turtle emergences at all survey locations over a ten-day period and were defined as:

- **Trigger criteria:** Two standard deviations from the mean of the specific track morphometric.
- **Threshold criteria:** Three standard deviations from the mean of the specific track morphometric.

Note that no trigger or threshold criteria are defined for changes to the habitat utilisation by nesting marine turtles. Instead, this metric will be used to qualitatively compare habitat use during construction and operations and assist with the diagnosis of any exceedance in trigger or threshold criteria for adult turtle nesting behaviour due to artificial light e.g. certain areas of habitat that turtles could move to may shield artificial light. The absence of trigger or threshold criteria is justified after evaluating the Project's artificial lighting through light modelling as part of the assessment (see PENV 2022) which determined that the extent of the visibility and intensity of artificial light was insufficient to illuminate any area of beach and hence deter an adult turtle from nesting.

2.5 Assumptions

The following assumptions applied when designing the methodology and defining the track morphometrics included in the data analysis:

- At the survey locations, there is no pathway for artificial light to influence the nest site selection of an adult turtle as they crawl ‘up’ the beach following their emergence from the ocean. Once their nesting activity is complete, adult turtles use the lowest elevated light horizon as their primary cue to find their way to the ocean from their nesting pit (Limpus 1971; Limpus & Kamrowski 2013). Therefore it is assumed that at this point, the visibility of artificial light can influence a turtle’s ability to distinguish the dim seaward light horizon potentially causing their misorientation (Berry et al. 2013; Kamrowski et al. 2014). The outcome of a misorientation event could be additional expenditure of energy reserves due to crawling further on the beach, or not finding the ocean and becoming stranded.
- If tidal conditions suit, some marine turtle species can nest during the daylight before nautical twilight (i.e. dusk) or after morning nautical twilight (i.e. dawn). In this study, it is assumed that all recorded nesting activity occurred during night-time conditions. Note that no nesting adult turtles were observed within the aerial imagery captured during the survey.

- The moon phase is not considered an influencing factor on the track morphometrics defined to describe adult turtle nesting behaviour. This is supported by the findings of Shimada et al. (2022) that found no relationship between the moon illumination and the nesting orientation of 550 adult flatback turtle tracks at four island sites in Queensland over six seasons.

3 RESULTS

3.1 Marine Turtle Nesting Activity

3.1.1 Detection

The detection of nesting activity from aerial imagery of the south-east section of Thevenard Island was obstructed by footprints and other disturbances in the sand caused by personnel involved with the Department of Biodiversity, Conservation and Attractions (DBCA) led flatback turtle tagging program. Therefore, only successful nests where tracks were not obscured were recorded for inclusion in the adult nesting behaviour analysis, with no classification of false crawls or nesting attempts possible. This also meant that this section of coast was excluded from the habitat utilisation analysis.

The detection of nests within the aerial imagery at all other survey locations did not appear to be affected by any other activity on the beach or weather conditions e.g. wind, rain.

3.1.2 Classification of Activity

A total of 431 marine turtle emergences were recorded within the aerial imagery at all survey locations (**Table 2**). Of these, 289 were assigned to flatback turtles (67 %), 126 to green turtles (29 %), and 16 to hawksbill turtles (4 %). All 'down' tracks at all survey locations were recorded as reaching the ocean.

In total, 100 marine turtle nests were detected within the aerial imagery at all surveyed locations (**Table 2**). Of these 100 nests, 30 were either recorded on the first survey day or were laid close to the high tide line without featuring an 'up' or 'down' track and were therefore excluded from the adult nesting behaviour analysis. Furthermore, twelve nests recorded from overnight aerial imagery featured prior nesting attempts meaning they were also excluded from the track length ratio analysis.

Table 2: Marine turtle nesting activity identified from aerial imagery captured during the survey.

Marine Turtle Species		Survey Location (*n* = Number of Survey Days)						Total
		Ashburton Island (*n* = 10)	Bessieres Island (*n* = 9)	Direction Island (*n* = 10)	Thevenard Island			
					South-east (*n* = 6)	South-west (*n* = 5)	North-west (*n* = 10)	
Number of False Crawls	Flatback	18	0	17	NA	0	0	35
	Green	0	10	0	NA	4	15	29
	Hawksbill	1	0	0	NA	0	0	1
Number of Attempts	Flatback	90	1	100	NA	0	0	191
	Green	0	17	2	NA	4	45	68
	Hawksbill	1	5	1	NA	0	0	7
Number of Nests	Flatback	30	1	21	10	0	1	63
	Green	0	8	1	0	2	18	29
	Hawksbill	2	6	0	0	0	0	8
Total Nests		32	15	22	31			100
Nests with obscured tracks i.e. excluded from all nesting behaviour analysis		13	0	12	2			30
Nests that featured prior attempts i.e. excluded from length ratio only		6	3	3	0			12

3.2 Adult Nesting Behaviour

3.2.1 Length Ratio

The mean length of the 'up' and 'down' tracks to/from a successful nest (without prior nesting attempts) was 14.66 ± 8.87 m (range = 1.86 – 49.39, *n* = 58) and 14.23 ± 9.71 m (range = 2.61 – 44.97, *n* = 58), respectively. There was no significant difference between the length of the 'up' track compared to the length to the 'down' track (Wilcoxon signed rank-sum test; V = 16682, p = 0.51).

The mean track length ratio between the 'down' and 'up' tracks was 0.98 ± 0.33 (range = 0.28 – 2.04, *n* = 58) indicating that, on average, the length of the 'down' track was shorter than the associated 'up' track.

Between species, the mean track length ratio for flatback turtles was 1.01 ± 0.32 (range = 0.43 – 2.04, *n* = 31) and for green turtles was 0.97 ± 0.31 (range = 0.28 – 1.51, *n* = 23). There was no significant difference in the track length ratio recorded for flatback turtles compared to green turtles (Wilcoxon rank-sum test; statistic value = 0.06; p = 0.95). The track length ratio recorded for hawksbill turtles were not compared due to the low sample size (*n* = 4).

Between survey locations, the mean track length ratio was 1.05 ± 0.34 (range = 0.54 – 2.04, *n* = 13) at Ashburton Island, 1.01 ± 0.33 (range = 0.44 – 1.40, *n* = 12) at Bessieres Island, 0.89 ± 0.10 (range = 0.66 – 0.98, *n* = 7) at Direction Island, and 0.96 ± 0.35 (range = 0.28 – 1.99, *n* = 26) at Thevenard Island. A statistical test to understand any difference in the track length ratio between survey locations was not completed due to an insufficient sample size at Ashburton, Bessieres, and Direction islands.

3.2.2 Offset Angle of the 'Down' Track

The mean offset angle of the 'down' track from the direction to the ocean at 5 m distance from the nesting pit was 20.1 ± 20.9° (range = 1 – 117, *n* = 70).

Between species, the mean offset angle for flatback turtles was 20.7 ± 18.5° (range = 1 – 91°, *n* = 41) and for green turtles was 20.5 ± 25.6° (range = 1 – 117°, *n* = 25). There was no significant difference in the offset angles recorded between species (Mann-Whitney; U = 5715, p = 0.34). Tracks of hawksbill turtles were not compared due to the low sample size (*n* = 4).

Between survey locations, the mean offset angle was 18.1 ± 12.7° (range = 2 – 41°, *n* = 19) at Ashburton Island, 15.2 ± 12.0° (range = 1 – 35°, *n* = 12) at Bessieres Island, 16.8 ± 13.4° (range = 2 – 48°, *n* = 10) at Direction Island, and 24.6 ± 28.7° (range = 1 – 117°, *n* = 29) at Thevenard Island. There was no significant difference in between the offset angle values at Ashburton Island when compared to Thevenard Island (Mann-Whitney; U = 2247, p = 0.98). A statistical test to understand any difference in the offset angle at Bessieres and Direction islands was not completed due to an insufficient sample size.

3.2.3 Sinuosity Index

The mean sinuosity index of the 'down' track from a successful nest was 1.05 ± 0.05 (range = 1.00 – 1.27, *n* = 70).

Between species, there was less sinuosity in flatback turtle 'down' tracks (1.04 ± 0.03, range = 1.00 – 1.12, *n* = 41) compared to green turtle 'down' tracks (1.06 ± 0.06 range = 1.00 – 1.27, *n* = 25), however there was no significant difference between the sinuosity index values (Mann-Whitney; U = 5722, p = 0.45). Tracks of hawksbill turtles were not compared due to the low sample size (*n* = 4).

Between survey locations, the mean sinuosity index was 1.04 ± 0.03 (range = 1.00 – 1.12, *n* = 19) at Ashburton Island, 1.04 ± 0.04 (range = 1.01 – 1.15, *n* = 12) at Bessieres Island, 1.03 ± 0.02 (range = 1.00 – 1.07, *n* = 10) at Direction Island, and 1.06 ± 0.06 (range = 1.00 – 1.27, *n* = 29) at Thevenard Island. There was no significant difference between the sinuosity index values at Ashburton Island when compared to Thevenard Island (Mann-Whitney; U = 2250, p = 0.84). A statistical test to understand any difference in the sinuosity index at Bessieres and Direction islands was not completed due to an insufficient sample size.

3.3 Habitat Utilisation

3.3.1 Density of Nesting Activity

The density of nesting activity at each survey location is shown in **Figure 3**. Note that for Thevenard Island, the south-west and south-east sections are not shown. This is due to the limited nesting activity (10 emergences) on the south-west section and the obscuring of marine turtle tracks from the DBCA-led flatback tagging program on the south-east section.

At Ashburton Island, the area of habitat with the highest density of nesting activity was situated on the southern side of the island, with nesting activity spread across the majority of the island's perimeter except for the western side which features a raised rock platform.

At Bessieres Island, the highest density nesting activity was situated to the north of a spit, on the eastern side of the island. There was also nesting activity concentrated on the north-east side and low-level activity on the southern side of the island. Note that the island's west coast features a raised rock platform which prevents any access to nesting habitat.

At Direction Island, nesting activity was recorded across the majority of the island's perimeter. The highest density nesting activity was recorded on the north-west side, with the north-east and south-east coasts recording a lower level of activity.

The highest density of nesting activity on the north-west section of Thevenard Island was situated in the middle of the surveyed area, with nesting activity spread across most of the monitored area.

J88006 MRL Adult Turtle Orientation 2022/23

Figure 3: Density of marine turtle nesting activity at each survey location. Areas with no monitoring are shown as a red line.

N

[redacted]
Date: 24/04/2023
Drawing File Ref:
PENV-J88006-1318-A
Coordinate System: GDA 2020 MGA Zone 50

PENDOLEY ENVIRONMENTAL

3.3.2 Pattern of Nesting Activity

At Ashburton Island, the mean bearing of nesting activity around the island's perimeter from the centre of the island was 128 ± 62° i.e. south-east direction (**Figure 4a**). The length of the mean vector ($\bar{r}$) was 0.56 which showed that nesting activity was neither spread evenly around the island or strongly clustered in one area (**Figure 4a**).

At Bessieres Island, the mean bearing of nesting activity around the island's perimeter from the centre of the island was 113 ± 63° i.e. east-south-east direction (**Figure 4b**). The length of the mean vector ($\bar{r}$) was 0.54 which showed that nesting activity was neither spread evenly around the island or strongly clustered in one area (**Figure 4b**).

At Direction Island, the mean bearing of nesting activity around the island's perimeter from the centre of the island was 210 ± 162° i.e. south-west direction (**Figure 4c**). The length of the mean vector ($\bar{r}$) was 0.02 which showed that nesting activity was spread evenly around the island (**Figure 4c**).

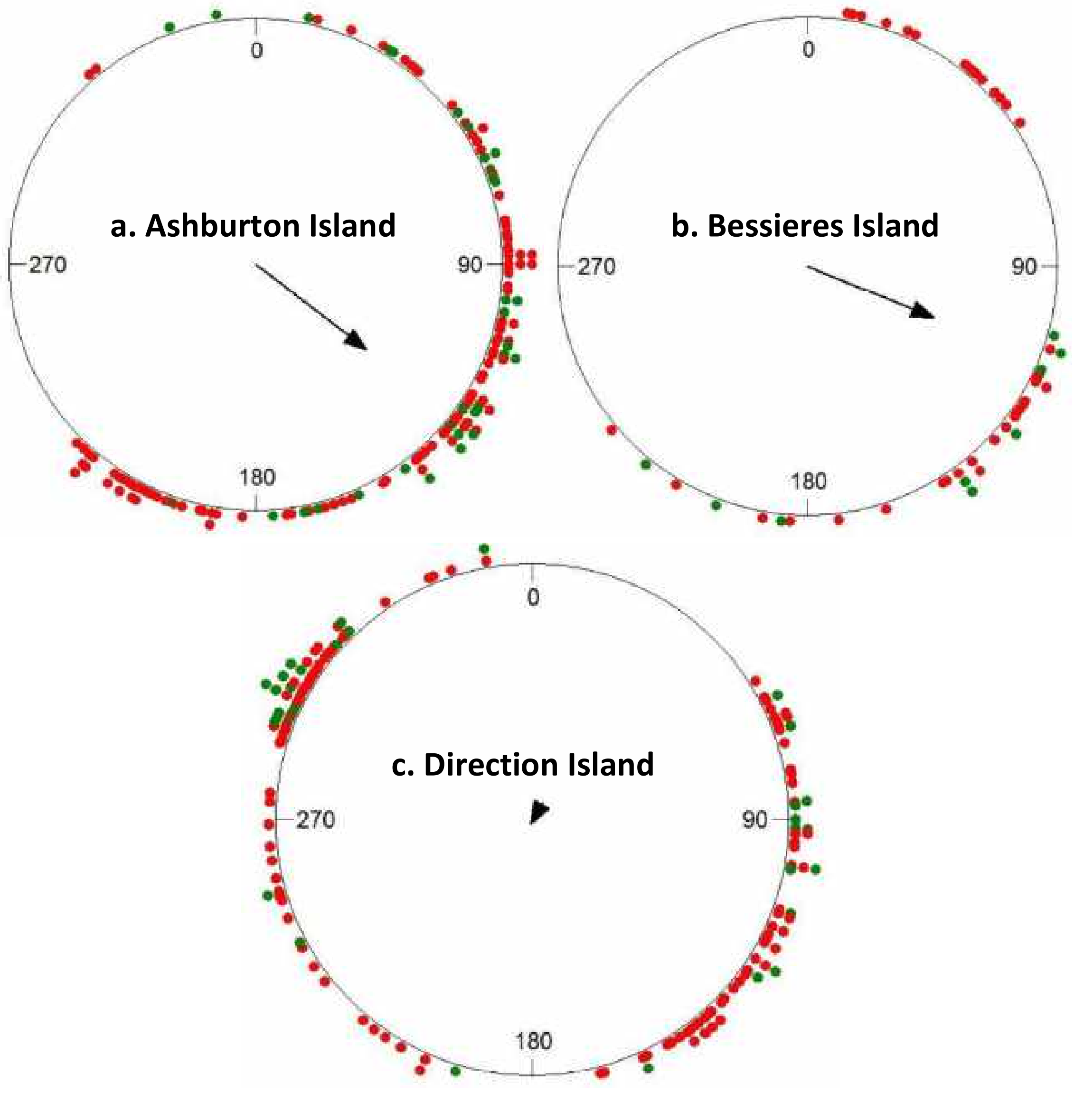


Figure 4: Direction of all nesting activity around the perimeter of the survey location from the centre of the island. Legend: Green dots = successful nests; red dots = false crawls/nesting attempts; black arrow shows the angle of the mean vector. Note that the length of the black arrow represents the length of the mean vector.

3.4 Post-baseline Trigger and Threshold Criteria

Trigger and threshold criteria were determined from the combined successful nest dataset recorded for all marine turtle species at all survey locations. This was on the basis that there was no significant difference in any track morphometric between species and survey locations.

3.4.1 Length Ratio

- **Trigger criteria**: The mean track length ratio at Ashburton, Direction, Thevenard, or Bessieres Island exceeds 1.64 (± 2StDev from the baseline mean). This would mean that when sea-finding, nesting turtles would crawl 1.64 times as far on its 'down' track to reach the ocean compared to the distance it crawled on its 'up' track from the ocean to reach its nest site.

- **Threshold criteria**: The mean track length ratio at Ashburton, Direction, Thevenard, or Bessieres Island exceeds 1.97 (± 3StDev from the baseline mean). This would mean that when sea-finding, nesting turtles would crawl 1.97 times as far on its 'down' track to reach the ocean compared to the distance it crawled on its 'up' track from the ocean to reach its nest site.

3.4.2 Offset Angle of the 'Down' Track

- **Trigger criteria**: The mean offset angle of the 'down' track at Ashburton, Direction, Thevenard, or Bessieres Island exceeds 60° (± 2StDev from the baseline mean). This would mean that during their initial sea-finding, nesting turtles would orient at an angle of 60° from their nest site away from the direction of the ocean.

- **Threshold criteria**: The mean offset angle of the 'down' track at Ashburton, Direction, Thevenard, or Bessieres Island exceeds 80° (± 3StDev from the baseline mean). This would mean that during their initial sea-finding, nesting turtles would orient at an angle of 80° from their nest site away from the direction of the ocean.

3.4.3 Sinuosity Index

- **Trigger criteria**: The mean sinuosity index at Ashburton, Direction, Thevenard, or Bessieres Island exceeds 1.15 (± 2StDev from the baseline mean). This would mean that when sea-finding, nesting turtles would crawl 15 % further than the straight-line distance to reach the ocean.

- **Threshold criteria**: The mean track length ratio at Ashburton, Direction, Thevenard, or Bessieres Island exceeds 1.20 (± 3StDev from the baseline mean). This would mean that when sea-finding, nesting turtles would crawl 20 % further than the straight-line distance to reach the ocean.

4 DISCUSSION

This is the first known marine turtle survey that considers the detection of change in adult nesting behaviour and habitat utilisation resulting from the potential impact of artificial light as part of a Project's impact assessment. The baseline survey was successful in utilising a UAV to capture imagery of adult nesting activity and the subsequent data analysis used the imagery to measure key track morphometrics of detected marine turtle emergences to describe adult nesting behaviour and the location of nesting activity to describe habitat utilisation in terms of density and pattern.

There was no significant difference in the track morphometrics used to describe adult nesting behaviour between species and survey locations. This justifies the decision to combine the baseline dataset when determining trigger and threshold criteria used to forewarn and indicate any significant impact on the adult turtle nesting behaviour. Furthermore, the data analysis for the track morphometrics accounts for bias in marine turtle nest site selection that may be introduced from varying beach morphology between each survey location e.g. different beach width, slope angle (see Maurer & Johnson 2017).

Following the successful laying of a clutch of eggs in a nest, a marine turtle will commence their sea-finding orientation and crawl directly towards the ocean (Miller 1997). The purpose of this direct and intended movement is to minimise their energy expenditure from crawling and their exposure to potential threats such as predators. The results of the sinuosity index (1.05 ± 0.05) and track length ratio (0.98 ± 0.33) recorded in this survey aligned with this expected behaviour; their return crawl to the ocean was close to being straight from the point they departed the nesting pit until they reached the ocean, with very little deviation, and was shorter than their initial crawl from the ocean to the nest site. This also highlights that the existing light horizon visible at the survey locations (see PENV 2022), including artificial light from the Wheatstone LNG Development and Onslow townsite, did not appear to influence the sea-finding behaviour and orientation of adult turtles after they successfully nest. This outcome aligns with the findings of Shimada et al. (2022) which found no evidence that artificial light visible as sky glow on the horizon influenced the orientation of nesting adult turtles.

During the survey, flatback turtles were the primary species recorded at Ashburton, Direction, and the south-east coast of Thevenard Island, green turtles were the primary species recorded at Bessieres and the north-west section of Thevenard Island, and hawksbill turtles were recorded in low levels at Bessieres Island (**Table 2**). From a marine turtle species perspective, this utilisation of nesting habitat at each survey location aligned with the expected species use prior to the survey which was informed by the outcomes of a regional assessment undertaken by DBCA in 2016 (Fossette et al. 2021) and a summary of marine turtle nesting activity recorded by PENV between 1992 and 2012 (Pendoley et al. 2016). Importantly, this also aligns with the description of adult marine turtle usage at these survey locations within the ALMP (PENV 2022).

5 REFERENCES

BERRY, M., BOOTH, D.T. & LIMPUS, C.J. (2013) Artificial lighting and disrupted sea-finding behaviour in hatchling loggerhead turtles (*Caretta caretta*) on the Woongarra coast, south-east Queensland, Australia. *Australian Journal of* Zoology, 61, 137 – 145.

COMMONWEALTH OF AUSTRALIA (2017) Recovery Plan for Marine Turtles in Australia 2017 - 2017. Available at: https://www.agriculture.gov.au/sites/default/files/documents/recovery-plan-marine-turtles-2017.pdf.

COMMONWEALTH OF AUSTRALIA (2020) National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds. January 2020. Available at: https://www.agriculture.gov.au/sites/default/files/documents/national-light-pollution-guidelines-wildlife.pdf.

EPA (2021) Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans, EPA, Western Australia. Available at: https://www.epa.wa.gov.au/sites/default/files/Forms_and_Templates/Instructions%20%20Preparing%20Environmental%20Protection%20Act%201986%2 0PIV%20Environmental%20Management%20Plans.pdf.

EPA (2023) Ashburton Infrastructure Project Assessment Report 1733, February 2023. Available at: https://www.epa.wa.gov.au/sites/default/files/EPA_Report/EPA%20Report%201733%20-%20Ashburton%20Infrastructure%20Project%20-%20assessment%20report.pdf.

FOSSETTE, S., LOWENTHAL, G., PEEL, L.R., VITENBERGS, A., HAMEL, M.A., DOUGLAS, C., TUCKER, A.D., MAYER, F. & WHITING, S.D. (2021) Using Aerial Photogrammetry to Assess Stock-Wide Marine Turtle Nesting Distribution, Abundance and Cumulative Exposure to Industrial Activity. *Remote Sensing*, 13(6), 116.

HAMANN, M., SHIMADA, T., DUCE, S., FOSTER, A., TO, A.T.Y. & LIMPUS, C. (2022) Patterns of nesting behaviour and nesting success for green turtles at Raine Island, Australia. Endangered Species Research, 47, 217 – 229.

KAMROWSKI, R.L., LIMPUS, C., PENDOLEY, K. & HAMANN, M. (2014) Influence of industrial light pollution on the sea-finding behavior of flatback turtle hatchlings. *Wildlife Research*, 41, 421 – 434.

LIMPUS, C.J. (1971) Sea turtle ocean finding behaviour. *Search*, 2, 385 – 387.

LIMPUS, C.J. & KAMROWSKI, R.L. (2013) Ocean-finding in marine turtles: The importance of low horizon elevation as an orientation cue, *Behaviour*, 150, 863 – 893.

MAURER, A.S. & JOHNSON, M.W. (2017) Loggerhead Nesting in the Northern Gulf of Mexico: Importance of Beach Slope to Nest Site Selection in the Mississippi Barrier Islands. *Chelonian Conservation and Biology*, 2017, 16(2).

MILLER, J.D. (1997) Reproduction in sea turtles. In The Biology of Sea Turtles (Vol. 1, pp. 51-81) Boca Raton, Florida: CRC Press

PENDOLEY, K.L., WHITTOCK, P.A., VITENBERGS, A. & BELL, C. (2016) Twenty years of turtle tracks: marine turtle nesting activity at remote locations in the Pilbara, Western Australia. *Australian Journal of Zoology*, 64, 217 – 226.

PENV (2022) Ashburton Infrastructure Project: Artificial Light Impact Assessment and Management Plan. Rev 6.

SHIMADA, T., LIMPUS, C.J., FITZSIMMONS, N.N., FERGUSON, J., LIMPUS, D. & SPINKS, R.K. (2022) Sky glow disrupts the orientation of Australian flatback turtles *Natator depressus* on nesting beaches. *Regional Environmental Change*, 23, 20.

APPENDIX E
BASELINE ADULT TURTLE AND BENCHMARK HATCHLING TURTLE ORIENTATION: TRIGGER AND THRESHOLD CRITERIA MEMO

MINERAL RESOURCES LIMITED (MINRES)

ASHBURTON INFRASTRUCTURE PROJECT: BASELINE ADULT TURTLE AND BENCHMARK HATCHLING TURTLE ORIENTATION: TRIGGER AND THRESHOLD CRITERIA MEMO

Prepared by

Pendoley Environmental Pty Ltd

For

Mineral Resources Limited (MinRes)

30 June 2023

DOCUMENT CONTROL INFORMATION

TITLE: ASHBURTON INFRASTRUCTURE PROJECT: BASELINE ADULT TURTLE AND BENCHMARK HATCHLING TURTLE ORIENTATION: TRIGGER AND THRESHOLD CRITERIA MEMO

Disclaimer and Limitation

This report has been prepared on behalf of and for the use of Mineral Resources Limited (MinRes). Pendoley Environmental Pty Ltd. takes no responsibility for the completeness or form of any subsequent copies of this Document. Copying of this Document without the permission of Mineral Resources Limited (MinRes) is not permitted.

Document History

Revision	Description	Date received	Date issued	Personnel
Draft	Report Draft		07/05/2023	[redacted]
Rev IA	Internal Review	08/05/2023	10/05/2023	
Rev A	Client review	23/05/2023	26/06/2023	
Rev 0	Final report issued	26/06/2023	30/06/2023	

Printed:	30 June 2023
Last saved:	30 June 2023 02:38 PM
File name:	P:\06 Projects\J88 MRL\J88005 Baseline Hatchling Orientation\04 Technical Reports\J88005 Trigger and Threshold Criteria Memo Rev0.docx
[redacted]	
Name of organisation:	Pendoley Environmental Pty Ltd
Name of Project:	N/A
Client	Mineral Resources Limited (MinRes)
[redacted]	
Report number:	N/A
Cover photo:	Ashburton Island (Credit: P. Whittock)

TABLE OF CONTENTS

LIST OF TABLES

1 BACKGROUND

The Ashburton Infrastructure Project (the Project) involves the mining of three iron ore deposits approximately 50 km south of Pannawonica and includes a 147 km long private haul road from the mine area to the Port of Ashburton with proposed additional nearshore and onshore port facilities, and offshore anchorage areas. The Project is located entirely within the Shire of Ashburton in the West Pilbara region of Western Australia and the Project proponent is Mineral Resources Limited (MinRes). MinRes expects the Project will deliver about 20 - 40 million tonnes per annum (Mtpa) of iron ore for export over about 30 - 40 years as a Direct Shipping Ore.

To address Environmental Protection Authority (EPA) conditions placed on the Project, MinRes engaged Pendoley Environmental (PENV) to undertake baseline surveys to capture adult turtle nesting behaviour and habitat utilisation, and hatchling orientation behaviour. The surveys were undertaken in December 2022 (adults), and January and March 2023 (hatchlings). The recommended conditions set out for the Project in February 2023 under Assessment No. 2320 (EPA 2023) included:

- *B3-1 The proponent must implement the proposal to meet the following environmental objectives:*
    - *(3) minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island.*
    - *(4) minimise the risk that the proposal increases the cumulative adverse impacts on regional populations of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate.*
- *B3-4 The proponent must update the Artificial Light Impact Assessment and Management Plan Revision 6 (Report number J88001), that satisfies the requirements of condition C5 and demonstrates how achievement of the marine fauna environmental objectives in condition B3-1(3) and condition B3-1(4) will be achieved and submit it to the CEO.*

This memo provides a summary of the survey methods and data analysis used to develop trigger and threshold criteria that satisfy these conditions.

1.1 Baseline Monitoring Limitations

MinRes received development approval for the Project in December 2022 and commenced construction of the Project in January 2023. Unfortunately, PENV were not informed of these activities until after they had already started, which resulted in inability to collect a pre-construction hatchling orientation baseline dataset as construction activities, including night-time dredging, occurred at the landside and nearshore facilities at the Port of Ashburton. No activities were situated at the Ocean Going Vessels (OGV) anchorage area.

Based on light modelling outputs, the Port Nearshore Marine Fauna Light Spill Impact Assessment (the assessment; PENV 2022) the assessment concluded that lighting associated with construction activities at the Port of Ashburton, including dredging, would have minimal visibility and be low in brightness when viewed from habitat at Bessieres and Thevenard islands and therefore present a lower risk of impact to hatchling turtles. This was primarily due to the significant distance (31 km and 25 km, respectively) between the islands and the light source, as well as the shielding provided by the islands' topography and vegetation. Instead, the assessment focused on lighting from vessels situated at the offshore OGV anchorage area which was highly visible in the light modelling outputs from the two islands and thus present a higher risk of impact to hatchling turtles. Therefore, due to the absence of any vessels at the OGV anchorage area during the monitoring period, any data captured at Bessieres and Thevenard islands in 2022/23 is considered as a suitable 'benchmark' for determining the influence of Project-related artificial light on hatchling sea-finding and for establishing trigger and threshold values.

Ashburton Island stands as an exception to the previous statement, as the assessment determined that lighting from the landside and nearshore facilities had a higher likelihood of being visible and brighter from the habitat compared to Bessieres and Thevenard islands. This is because the island is situated at a closer distance of 12 km from the light source. Therefore, any hatchling orientation data captured from this habitat during 2022/23 may have been influenced by Project-related artificial light.

Additionally, consideration of impacts to hatchling orientation at Direction Island was added to recommended conditions for the Project after PENV had been engaged to undertake baseline surveys. As such, while baseline data on light impacts to adult turtles were collected in 2022/23 for Direction Island, no baseline data are available for hatchling orientation at this island.

In light of the above baseline data limitations, hatchling orientation trigger and threshold criteria have been developed for Ashburton and Direction Islands using the criteria for Bessieres island (considered to be most conservative). These will be reviewed as future monitoring data are collected.

2 METHODS

2.1 Adult Nesting Behaviour and Habitat Utilisation

*A brief summary of methods is provided here. For a detailed methodology, see the complete technical report in **Appendix A**.*

Aerial images of overnight marine turtle nesting activity were recorded daily between 0700 and 1100 using an Unmanned Aerial Vehicle (UAV) over ten days between the 7th and 16th December 2022 for potential nesting habitat (sandy beaches) at Ashburton, Bessieres, Direction, and Thevenard Islands. Imagery was captured at a flight altitude of ca. 30 m above ground level with ca. 75 % forward and horizontal overlap. The survey timing was selected to coincide with the known peak nesting for flatback (*Natator depressus*) and green (*Chelonia mydas*) turtles for their respective genetic stocks and occurred prior to the commencement of any night-time construction activities.

The georeferenced aerial images recorded at each survey location were stitched into one daily orthomosaic using Pix4Dmapper Pro software (v4.6.3). Each generated orthomosaic was displayed in QGIS (v3.16.11) and visually screened for overnight marine turtle nesting activity. New overnight activity was identified by comparing the orthomosaic with the previous survey day's orthomosaic. Turtle species, GPS coordinate, and type of nesting activity (e.g., false crawl resulting in no nesting attempt, nesting attempt, or successful nest) were identified for each track. In addition, for each identified track with a successful nest, the occurrence of any prior nesting attempts along the same track was recorded.

Adult turtle nesting behaviour was then determined from specific track morphometrics measured using QGIS (v3.16.11) for each marine turtle emergence that featured a successful nest. Measured track morphometrics included:

- **Length Ratio:** The length of the 'up' (landward) and 'down' (seaward) tracks of each marine turtle emergence were compared as a ratio (i.e., length of 'down' track divided by length of 'up' track). Note that this ratio was only calculated for marine turtle emergences that featured no prior nesting attempts because the length of the 'up' track would be biased.
- **Offset Angle of the 'down' track:** The bearings from the nesting pit to the point the turtle's 'down' track intersected a 5 m distance buffer from the nesting pit, and from the nesting pit directly to the ocean, were measured. The offset angle between the two bearings was then calculated.
- **Sinuosity Index:** The sinuosity index is a measure of how much the 'down' track deviates from a straight line and is calculated by dividing the length of the 'down' track (as per the length ratio described above) by the straight-line distance between the nesting pit and the point the 'down' track intersects the delineated tide line on the beach. A sinuosity index of 1 indicates a perfectly straight line, while a value >1 indicates a more sinuous track.

The density and pattern of nesting activity were also analysed to determine utilisation of nesting habitat. However, as nesting activity can be spatially variable among seasons, these data will be used to qualitatively compare habitat use during construction and operations in examining any exceedance in trigger or threshold criteria associated with the adult turtle nesting behaviour metrics.

2.2 Hatchling Orientation

A brief summary of methods is provided here. For a detailed methodology, see the complete technical report in ***Appendix B****.*

Two field surveys were undertaken to measure hatchling fans over a total of 27 days from 17th January to 1st February 2023 (Field Survey 1; FS1), and 14th to 24th March 2023 (Field Survey 2; FS2) at Ashburton, Bessieres, and Thevenard Islands. This timing was selected to coincide with the peak hatching period for flatback and green turtles. During FS1, artificial light monitoring was also undertaken daily at each island.

A nest fan was recorded if five or more hatchling tracks were sighted from a hatched clutch. Hatchling tracks fan out from a localised depression in the sand which marks the point of emergence. A sighting compass was used to measure the bearing of the outermost tracks of the nest fan (vectors A and B) and the bearing of the most direct route to the ocean (vector X). Bearings were measured from the point where the track crossed the high tide line. Single hatchling tracks that were more than 30° from the outermost track of the main fan were recorded as outliers, as per monitoring guidance in Pendoley 2005.

Hatchling orientation data from each survey location was then analysed to determine:

- **Spread angle**: The range of dispersion of tracks from the emergence point, describing the degree of dispersion of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean finding bearings and may indicate disruption to natural hatchling sea finding ability.
- **Offset angle:** The degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e., less deviation from the most direct route) and a larger value demonstrates greater deviation from the most direct route which may indicate a disruption to natural hatchling sea finding ability.

The spread and offset angle data were analysed statistically using a Bayesian projected normal regression model (Markov Chain Monte Carlo algorithm used to fit a Bayesian regression model for circular data that is projected onto a normal distribution; see ***Appendix B***) to determine the **mean**, and a **lower** and **upper bound** for the mean based on a 95 % highest posterior density interval. These indices were then used to develop trigger and threshold criteria.

3 TRIGGER AND THRESHOLD CRITERIA

Outcome-based trigger and threshold criteria and associated contingency actions for each metric are outlined for adult nesting behaviour (**Table 1**) and hatchling orientation (**Table 2**). For a full description of each metric and their associated trigger and threshold values, refer to **Appendices A** and **B**.

Table 1: Outcome-based trigger and threshold criteria for adult marine turtle nesting behaviour.

EPA Factor: Marine Fauna – Adult marine turtles **Outcome:** There will be no significant increase in adult marine turtle misorientation, disorientation, or nesting habitat utilisation at Ashburton, Thevenard, Direction, and Bessieres Islands. **Key environmental values:** **Key impacts and risks:** Change in adult sea-finding ability, reduced survivability / fitness.				
Outcome-based				
• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold contingency actions**	**Monitoring**	**Timing / frequency of monitoring**	**Reporting**
Condition: B3-1 (3) minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island and Bessieres Island.				
Adult Nesting Behaviour: Length Ratio **Trigger criteria** • Mean track length ratio at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.64 (± 2 standard deviations from the baseline mean). **Threshold criteria** • Mean track length ratio at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.97 (± 3 standard deviations from the baseline mean).	**Trigger level action(s) (for length ratio or offset angle or sinuosity index):** • **If a single season of monitoring reports an exceedance in trigger criteria:** Undertake review of vessel movements, anchorage locations, and other light-producing activities. • **If two consecutive seasons of monitoring report an exceedance in trigger criteria:** Undertake review of artificial light monitoring, adult nesting	**Indicators: Length ratio, offset angle, or sinuosity index** Adult nesting behaviour monitoring will be conducted seasonally at Thevenard, Bessieres, Direction, and Ashburton Islands.	A 10-day period in the peak nesting season for flatback and green turtles. Monitoring will be undertaken each season during construction, and for two seasons during operations. If threshold criteria are exceeded, additional seasons of monitoring may be required	One annual report on results of the monitoring survey, including against trigger and threshold criteria.

EPA Factor: Marine Fauna – Adult marine turtles

Outcome: There will be no significant increase in adult marine turtle misorientation, disorientation, or nesting habitat utilisation at Ashburton, Thevenard, Direction, and Bessieres Islands.

Key environmental values:

Key impacts and risks: Change in adult sea-finding ability, reduced survivability / fitness.

Outcome-based

• Trigger criteria • Threshold criteria	Response actions: • Trigger level actions • Threshold contingency actions	Monitoring	Timing / frequency of monitoring	Reporting
Adult Nesting Behaviour: Offset Angle (Down Track) **Trigger criteria** • Mean offset angle of the 'down' track at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 60° (± 2 standard deviations from the baseline mean). **Threshold criteria** • The mean offset angle of the 'down' track ratio at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 80° (± 3 standard deviations from the baseline mean)	behaviour, and habitat utilisation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions. **Threshold contingency action(s) (for length ratio or offset angle or sinuosity index):** • **If any season of monitoring reports an exceedance in threshold criteria:** Undertake review of artificial light monitoring, adult nesting behaviour, and habitat utilisation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions.		pending the outcome of a desktop review.	
Adult Nesting Behaviour: Sinuosity Index **Trigger criteria** • Mean sinuosity index at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.15 (± 2 standard deviations from the baseline mean). **Threshold criteria**				

EPA Factor: Marine Fauna – Adult marine turtles

Outcome: There will be no significant increase in adult marine turtle misorientation, disorientation, or nesting habitat utilisation at Ashburton, Thevenard, Direction, and Bessieres Islands.

Key environmental values:

Key impacts and risks: Change in adult sea-finding ability, reduced survivability / fitness.

Outcome-based

• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold contingency actions**	**Monitoring**	**Timing / frequency of monitoring**	**Reporting**
• Mean sinuosity index at Ashburton Island, Direction Island, Thevenard Island, or Bessieres Island exceeds 1.20 (± 3 standard deviations from the baseline mean).				

Table 2: Outcome-based trigger and threshold criteria for hatchling marine turtle orientation.

EPA Factor: Marine Fauna – Hatchling marine turtles **Outcome:** There will be no significant increase in hatchling marine turtle misorientation or disorientation at Bessieres and Thevenard islands. **Key environmental values:** **Key impacts and risks:** Change in hatchling sea-finding ability, reduced survivability / fitness.				
Outcome-based				
• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold contingency actions**	**Monitoring**	**Timing / frequency of monitoring**	**Reporting**
Condition: B3-1 (3) minimise the risk of adult marine turtle and marine turtle hatchling misorientation, disorientation and associated increases in mortality rate, and to adult marine turtle nesting utilisation, at Ashburton Island, Direction Island, Thevenard Island, and Bessieres Island.				
Hatchling Orientation: Spread angle **Trigger criteria** • Bessieres Island: The mean spread angle exceeds 51° and the lower bound (95 % highest posterior density interval) is below 51°. • Thevenard Island: The mean spread angle exceeds 57° and the lower bound (95 % highest posterior density interval) is below 57°. • Ashburton and Direction Islands: The mean spread angle exceeds 51° and the lower bound (95 % highest posterior density interval) is below 51°. **Threshold criteria** • Bessieres Island: The lower bound spread angle (95 % highest posterior density interval) exceeds 51°.	**Trigger level action (for spread or offset angle at any monitoring location)** • **If a single season of monitoring reports an exceedance in trigger criteria:** Undertake review of vessel movements, anchorage locations, and other light-producing activities. • **If two or more consecutive seasons of monitoring report an exceedance in trigger criteria:** Undertake review of artificial light monitoring and hatchling orientation data to determine cause. The assessment will also	**Indicators: Spread angle, offset angle** Hatchling orientation monitoring will be conducted seasonally at Thevenard, Bessieres, Direction, and Ashburton Islands.	A 14-day period over a new moon in the peak hatching season for flatback and green turtles. Monitoring will be undertaken each season during construction, and for two seasons during operations. If threshold criteria are exceeded, additional seasons of monitoring may be required pending the outcome of a desktop review.	One annual report on results of the monitoring survey, including against trigger and threshold criteria.

EPA Factor: Marine Fauna – Hatchling marine turtles
Outcome: There will be no significant increase in hatchling marine turtle misorientation or disorientation at Bessieres and Thevenard islands.
Key environmental values:
Key impacts and risks: Change in hatchling sea-finding ability, reduced survivability / fitness.

Outcome-based

• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold contingency actions**	**Monitoring**	**Timing / frequency of monitoring**	**Reporting**
• Thevenard Island: The lower bound spread angle (95% highest posterior density interval) exceeds 57°. • Ashburton and Direction Islands: The lower bound spread angle (95 % highest posterior density interval) exceeds 51°.	rate the level of impact associated with this exceedance and recommend remedial actions. **Threshold criteria action (for spread or offset angle at any monitoring location)** • **If any season of monitoring reports an exceedance in threshold criteria:** Undertake review of artificial light monitoring and hatchling orientation data to determine cause. The assessment will also rate the level of impact associated with this exceedance and recommend remedial actions.		Additional surveys may be required in event adequate samples are not collected.	
Hatchling Orientation: Offset angle **Trigger criteria** • Bessieres Island: The mean offset angle exceeds 10.9° and the lower bound (95 % highest posterior density interval) is below 10.9°. • Thevenard Island: The mean offset angle exceeds 15.2° and the lower bound (95 % highest posterior density interval) is below 15.2°. • Ashburton and Direction Islands: The mean offset angle exceeds 10.9° and the lower bound (95 % highest posterior density interval) is below 10.9°. **Threshold criteria** • Bessieres Island: The lower bound offset angle (95 % highest posterior density interval) exceeds 10.9°.				

EPA Factor: Marine Fauna – Hatchling marine turtles

Outcome: There will be no significant increase in hatchling marine turtle misorientation or disorientation at Bessieres and Thevenard islands.

Key environmental values:

Key impacts and risks: Change in hatchling sea-finding ability, reduced survivability / fitness.

Outcome-based

• **Trigger criteria** • **Threshold criteria**	**Response actions:** • **Trigger level actions** • **Threshold contingency actions**	**Monitoring**	**Timing / frequency of monitoring**	**Reporting**
• Thevenard Island: The lower bound offset angle (95 % highest posterior density interval) exceeds 15.2°. • Ashburton and Direction Islands The lower bound offset angle (95 % highest posterior density interval) exceeds 10.9°.				

Mineral Resources Limited

20 Walters Drive
Osborne Park Perth 6017

Locked Bag 13, Osborne Park DC, WA 6916

P +61 8 9329 3600

E reception@mineralresources.com.au

W www.mrl.com.au