Mardie Salt and Potash Project

Illumination Plan

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DECLARATION OF ACCURACY

In making this declaration, I am aware that sections 490 and 491 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) make it an offence in certain circumstances to knowingly provide false or misleading information or documents. The offence is punishable on conviction by imprisonment or a fine, or both. I declare that all the information and documentation supporting this Monitoring Plan is true and correct in every particular. 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:	
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Position:	Manager Environment & Approvals
Organisation:	BCI Minerals
ABN 50 152 574 457	

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1. EXECUTIVE SUMMARY

This Illumination Plan is submitted by BCI Minerals in support of the Optimised Mardie Project (approvals pending) and aligns with the requirements of Condition 9 of Ministerial Statement 1175 and Condition 24 of EPBC 2018/8236, the current approvals for the 'original' Mardie Project. The Plan follows the format set out in the current Environmental Protection Authority (EPA) Instructions and Templates for Part IV Environmental Management Plans (EPA, 2021a).

Proposal name	Mardie Salt • Original Project • Optimised Project
Proponent name	Mardie Minerals Pty Ltd
Approval references	Original Proposal • Ministerial Statement 1175 • EPBC 2018/8236 Optimised Proposal • Ministerial Statement 1211 • EPBC 2022/9169 – approval pending
Purpose of the Illumination Plan	To avoid where possible, and otherwise minimise impacts of artificial light to fauna of conservation significance and their habitats.
Key environmental factor/s, outcome/s and objective/s	This Illumination Plan relates to the factors of Marine Fauna and Terrestrial Fauna, specifically fauna of conservation significance and their habitats. This Plan has both outcome-based and objective-based management strategies. The overarching outcome is to minimise significant impacts caused by artificial light to significant species and their habitats. The specific outcome-based indicators proposed to achieve this are: • The spatial distribution of marine turtle beach usage shows a statistically significant change in a single season compared to the baseline data for that site • Marine turtle hatchling behaviour (i.e. nest fan metrics) displays a variation in spread and/ or offset angles that exceed the 95th percentile when compared to the baseline data • A decline in abundance and diversity of migratory shorebirds >25% from baseline levels • An increase in light measured at Mardie Pool >15% from baseline levels (taken once the additional controls in Table 4-1 are implemented at Mardie Village) The specific objective-based indicators proposed to achieve this are: • Implement the project to ensure that the minimum number and intensity of lights are in use • Implement the Project to ensure that lighting is adapted for colour, intensity, and timing • Implement the Project to ensure only the area intended is illuminated (to avoid light spill) • Implement the Project using non-reflective, dark coloured surfaces
Condition clauses	Original Project • Ministerial Statement 1175 – Condition 9 • EPBC 2018/8236 - Condition 24

	Optimised Project • Ministerial Statement 1211 - Condition B5-3 • EPBC 2022/9169 – approval pending
Key components in the Plan	This Plan covers management and monitoring commitments for significant fauna across the Original and Optimised Project Areas.
Proposed construction date	Construction of the Original Proposal commenced in February 2022
Plan required pre-construction?	Approval sought from EPA Services (WA) by BCI (via email) for an extension to the timeframe for provision of the Illumination Plan, based on the staged construction of the Project and associated delays to light modelling and noting a commitment to no night works until the Illumination Plan has been approved. This approach was approved, in accordance with Condition 9-1, by EPA Services (WA) on 16 February 2022. The approval of this approach stated that there will be no construction or operation activities at night during the turtle nesting and hatchling seasons (October to May), until such a time as the Illumination plan has been approved by the CEO. Until such a time as the illumination plan has been approved, no construction or operation activities are to be undertaken at night.

2. CONTEXT, SCOPE AND RATIONALE

2.1 Proposal

The Mardie Salt and Potash Project (the Project), currently being constructed by BCI Minerals Limited (BCI) is located on the north-west coast of Western Australia in the Pilbara region, approximately 135 km south-west of Karratha (Figure 1). The Project involves development facilities to produce, process and export high purity industrial grade salt and fertiliser grade sulphate of potash (SOP) from seawater via solar evaporation, crystallisation, raw salt purification and SOP conversion.

The Project was originally referred to the Environmental Protection Authority (EPA) in April 2018 and approved with conditions under Ministerial Statement 1175 in 2021 (EPA, 2021b). Significant amendments to the original proposal have since been outlined within the Optimised Mardie Salt Proposal, which was submitted to the EPA in March 2022 (Preston Consulting, 2022) and approved under Ministerial Statement 1211 in October 2023 (EPA, 2023b). Ministerial Statement 1211 supersedes Statement 1175.

The updated Project Area consists of three parts: the Original Proposal Area, the Optimisation Area and the Quarry Area (located 18.5 km south-east of the Optimisation Area) (Figure 2). This includes the expansion of concentrator and crystalliser ponds, an increased salt and SOP production rate, new secondary seawater intake option, a port facility laydown area, a quarry and minor changes to the dredge channel.

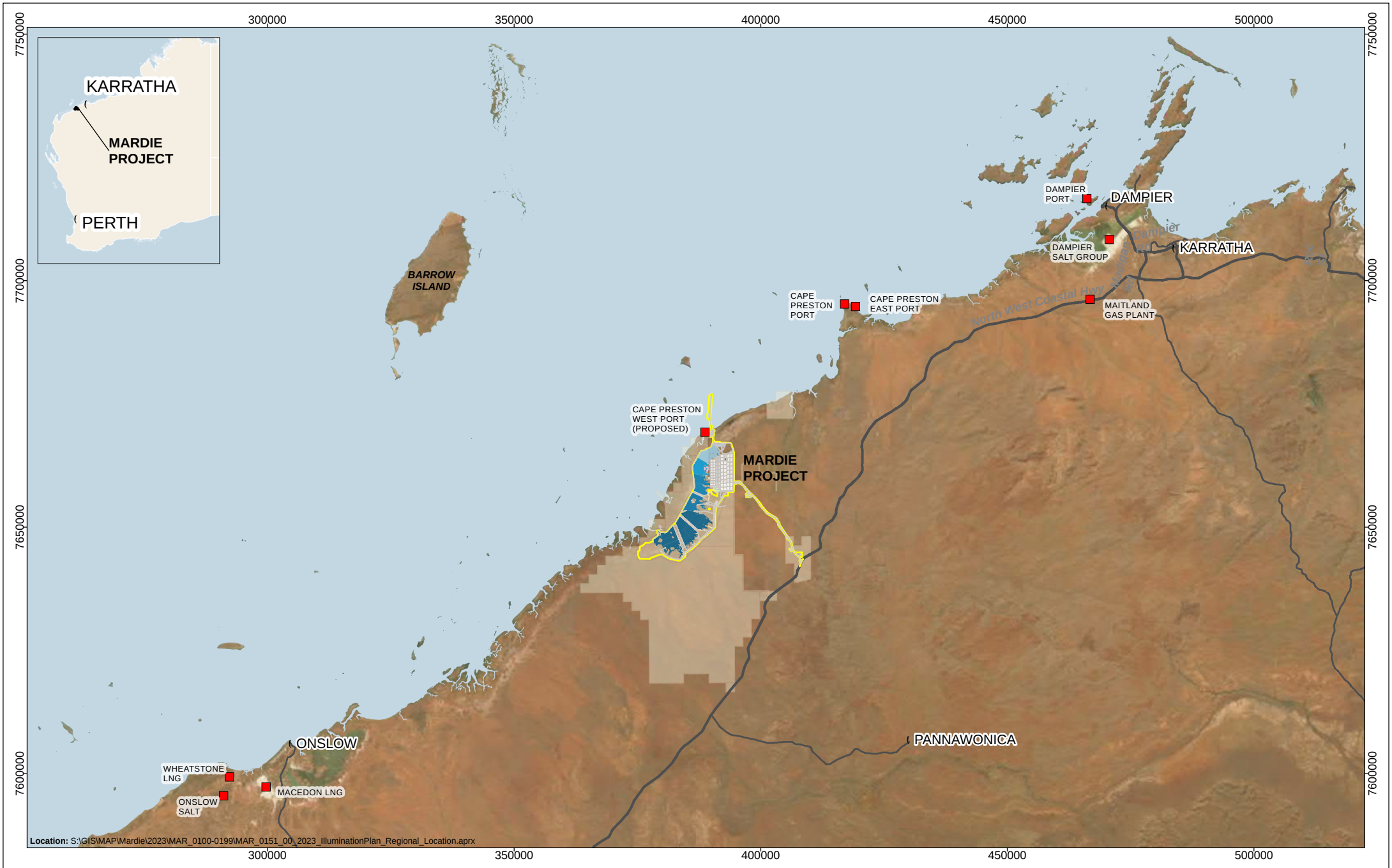
Artificial light will be generated by Project infrastructure and associated sea-going vessels which has the potential to impact marine turtles and other terrestrial fauna. This plan addresses the potential impacts of artificial lighting associated with the construction and operation of all three aspects of the Project (Original, Optimised and Quarry Areas) combined. An overview of Project lighting is provided in Section 4.

In order to minimise and manage potential impacts, BCI has developed this Illumination Plan, with due regard given to the *National Light Pollution Guidelines for Wildlife* (DCCEEW, 2023) and EPA Assessment Guideline No. 5 (EPA, 2010). The Illumination Plan:

- Includes measures to avoid, reduce and minimise any potential environmental impacts from the Project's lighting on marine and terrestrial fauna
- Includes details of the monitoring and management measures (as per the Conditions from EPA Report 1740 for the 'Optimised Project' (EPA, 2023a) and Ministerial Conditions in MS 1211) to minimise impacts to marine and terrestrial fauna
- Specifies timing and responsibilities for implementation of these measures
- Specifies monitoring and reporting procedures to provide for continuous improvement, consistent with an adaptive management approach
- Follows instructions developed by the Western Australian Environmental Protection Authority (2021c), *How to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans*

With the implementation of this Illumination Plan, it is expected that light impacts will be minimised and the EPA's objective for marine and terrestrial fauna will be met. This plan must be approved by the CEO of the Department of Water and Environmental Regulation (DWER) prior to night-time

construction works, and the commencement of operations, to ensure that environmental outcomes relating to marine and terrestrial fauna will be met. The Plan may be updated in accordance with new information from ongoing monitoring programs, updated/ new lighting designs or on request by DWER or DCCEEW.



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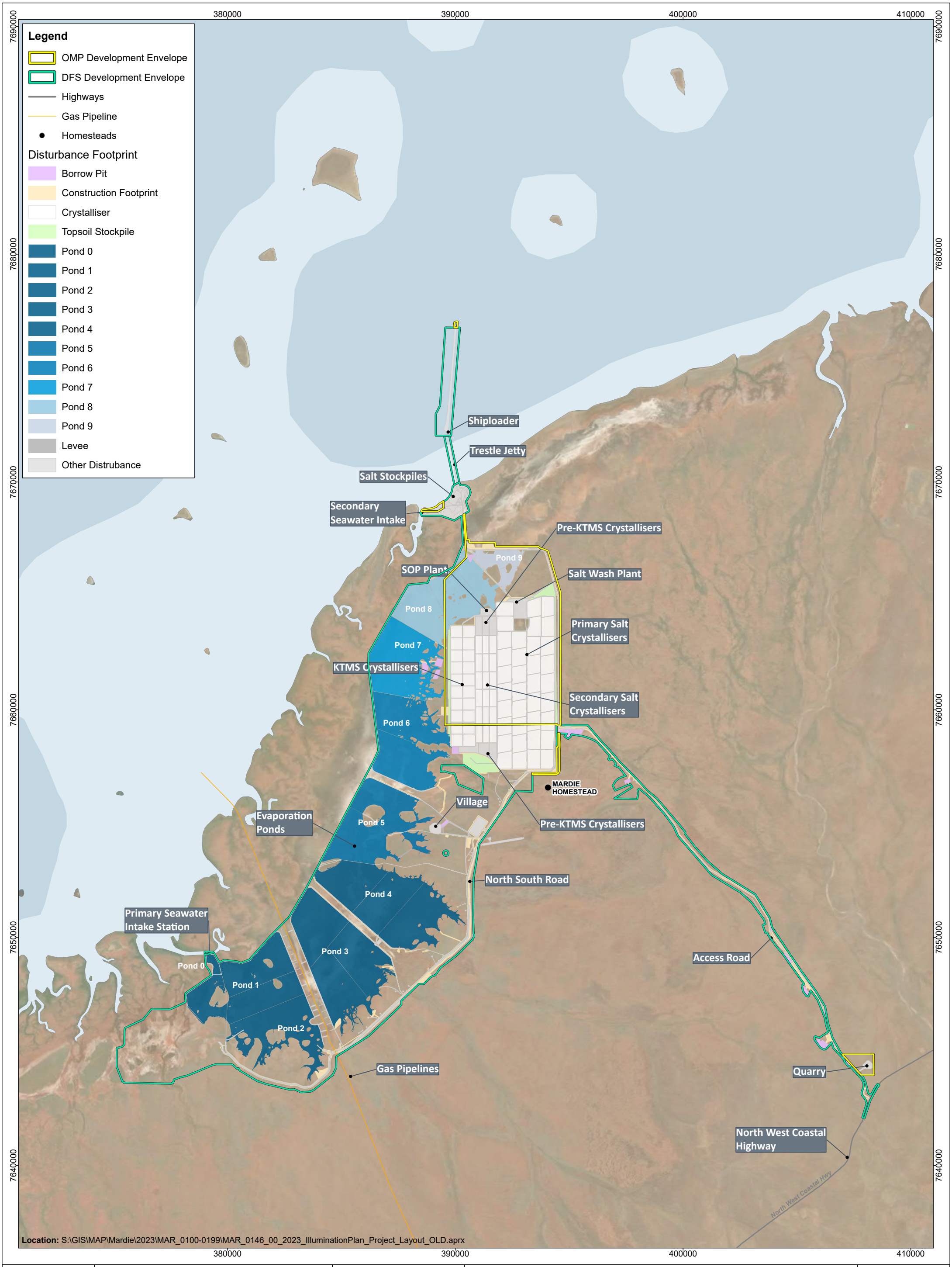
Mardie Project
Regional Location

Figure: 1



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Optimised Mardie Project Layout

Figure: 2

2.2 Key Environmental Factors

The key environmental factors considered in this Illumination Plan are marine fauna and terrestrial fauna, specifically 'fauna of conservation significance and their habitats'.

2.3 Condition Requirements

The Original Mardie Salt Project was approved under the EPBC Act in January 2022 (EPBC 2018/8236) and the EP Act (Ministerial Statement 1175) in November 2021. The key conditions of EPBC 2018/8236 relevant to the Illumination Plan are shown in Table 2-1. The Optimised Mardie Salt Proposal is currently being assessed under the EPBC Act and has recently been approved under the EP Act. The conditions in Ministerial Statement 1211 (Optimised Proposal) supersede those under the Original Proposal and are shown in Table 2-1.

Table 2-1: Key Conditions of EP and EPBC Acts relating to this Illumination Plan

No.	Condition Text	Plan Section
EPBC	**2018/8236**	
14	The approval holder must implement the following measures during any construction or clearing and until all terrestrial construction has been completed:	
	a. Any construction and/or clearing within 1 kilometre from the nearest part of Mardie Pool must only occur in daylight hours to minimise noise, vibration and artificial lighting impacts on terrestrial fauna.	5.3.2 6.1
24	The approval holder must comply with **condition 9 of the WA Approval** to minimise impacts due to artificial illumination and light spill on **migratory shorebirds and marine fauna.**	5.2.1 6.1
	a. The approval holder must develop the **Illumination Plan** according to condition 9-1 of the WA Approval. The **Illumination Plan** must also include methods of monitoring the light impacts from the action on **marine turtles and migratory shorebirds**.	7.1 7.2
	b. The plan must be submitted and approved by the Minister prior to the commencement of the operation. The **Illumination Plan** must be implemented once the **Illumination Plan** is approved.	6.0
	c. The approval holder may review and submit a revised **Illumination Plan** to the Department for the Minister's approval at any time, but the Illumination Plan must be reviewed every 5 years starting after the commencement of the action. The review must consider the monitoring data collected through the Marine Turtle Monitoring Program (condition 19(c)), the Migratory Shorebird Monitoring and Management Plan (condition 22) to adapt the operational lighting to further minimise impacts.	6.1 7.1/7.2 8.3
	d. The approval holder shall continue to implement the **Illumination Plan**, or any subsequent revisions, as approved by the Minister for the life of the project.	6.0

EP Act Ministerial Statement 1211		
B5-1	The proponent shall implement the proposal to achieve the following environmental outcomes:	
	(1) no mortality, injury, disturbance or displacement of humpback whales (Megaptera novaeangliae) within the migration of the **biologically important area**;	2.4.1
	(2) no change in marine turtle orientation (i.e. misorientation or disorientation) nesting beach utilisation, nesting success or hatchling survivorship as a result of artificial light emissions at both sandy beach habitat adjacent to the development and Long Island, Sholl Island and the Passage Islands (Angle, Middle and Round); and	6.0 7.1 8.2.1
	(3) **significant marine fauna** are not prevented/deterred from undertaking critical behaviours in **biologically important areas**.	6.0 7.2 8.2.2
B5-3	The proponent must in consultation with DWER:	
	(1) develop and implement a Mardie **Illumination Plan** environmental management plan that satisfy the requirements of condition C4 and demonstrates how achievement of the **significant marine fauna** outcomes in B5-1(2-3) will be monitored and substantiated, and submit it to the CEO.	6.0 8.3
B6-5	The proponent must develop and implement the Mardie **Illumination Plan** with the purpose of ensuring that **Terrestrial Fauna** environmental outcomes in condition B6-1(1) (no change in migratory shorebirds abundance and diversity), B6-1(2) (no change in nesting density of grey falcons) are achieved, monitored and substantiated and that condition B5-3(1) is met.	6.0 7.2/7.3 8.2.2 8.2.4
C4-1	The environmental management plans required under condition B1-4, condition B2-2, condition B3-2, condition B4-3, condition B5-3, condition B5-4, condition B6-4, condition B6-6 and condition B8-3 must contain provisions which enable the substantiation of whether the relevant outcomes of those conditions are met, and must include:	6.1
	(1) **threshold criteria** that provide a limit beyond which the environmental outcomes are not achieved;	6.1
	(2) **trigger criteria** that will provide an early warning that the environmental outcomes are not likely to be met;	6.1
	(3) monitoring parameters, sites, control/reference sites, methodology, timing and frequencies which will be used to measure threshold criteria and trigger criteria. Include methodology for determining alternative monitoring sites as a contingency if proposed sites are not suitable in the future;	6.1 7.0
	(4) baseline data;	3.1.3
	(5) data collection and analysis methodologies;	6.0

EP Act Ministerial Statement 1211		
	(6) adaptive management methodology;	8.2
	(7) contingency measures which will be implemented if threshold criteria or trigger criteria are met; and	6.1
	(8) reporting requirements.	6.1
C4-2	The environmental management plan required under condition B5-3 is also required to:	
	(1) 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 (i.e. misorientation or disorientation), and nesting beach utilisation as described in condition B5-1(2).	6.0 8.2
	(2) include a commitment to annually compare cumulative results against the baseline assessment (Pendoley Environmental 2019, Mardie Salt Project Marine Turtle Monitoring Program 2018/2019. Rev 0, Report No. RP-59001);	8.3
	(3) Include a monitoring plan that is in accordance with the recommendations published in the National Light Pollution Guidelines (2020);	7.0
	(4) provide criteria for when the Mardie **Illumination Plan** required by condition B6-5 will be revised in response to outcomes of the monitoring required by condition B5-3; and	8.3
	(5) Continue to be implemented until the CEO has confirmed by notice in writing, on advice from DBCA and DWER, that the outcome of condition B5-1(1-3) has been, and will continue to be met.	8.3

2.4 Rationale and Approach

The development and implementation of an Illumination Plan for the Mardie Salt Project is a direct condition of both EPBC 2018/8236 (condition 24b) and MS 1211 (condition B5-3(1)) for the Optimised Proposal. DWER and DCCEEW have advised that the scope of this Plan should cover the implementation of both the Original and the Optimised Mardie Salt Proposals. In accordance with this advice, the Illumination Plan has been developed to include both the Original and Optimised Project footprints and covers assessment of both marine and terrestrial fauna of conservation significance. This Plan is designed to meet the mitigation and monitoring requirements of both Proposals.

The specific objective of this Plan is to avoid, where possible, and otherwise minimise direct and indirect impacts to conservation significant fauna and their habitat. The Illumination Plan incorporates best practice lighting principles to minimise artificial light spill/ glow impacts to significant fauna, by reducing light spill. The management practices outlined will also benefit other marine and terrestrial species present within and surrounding the Project Area.

The Plan has been prepared with reference to the *'Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans'* (EPA, 2021c) and the '*Environmental*

Management Plan Guidelines, Commonwealth of Australia 2014' (DoE, 2014). The fauna of conservation significance that are the focus of the Illumination Plan are those which the Project has the most potential to impact (consistent with EPA Reports 1704 and 1740), namely marine turtles (including green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and flatback turtles (*Natator depressus*), migratory birds, the northern quoll (*Dasyurus hallucatus*), Pilbara leaf-nosed bat (*Rhinonicteris aurantius*) and grey falcon (*Falco hypoleucos*).

2.4.1 Risk Assessment

Risk assessments were undertaken to assess the risk of impacts of Project lighting on marine turtles (Section 5.1); migratory shorebirds and seabirds (Section 5.2); and terrestrial species (northern quoll, Pilbara leaf-nosed bat and grey falcon) (Section 5.3). It should be noted that the coast adjacent to the Project Area is also known to be a Biologically Important Area for the humpback whale (*Megaptera novaeangliae*). However, a risk assessment was not undertaken for the humpback whale as artificial light has not been demonstrated to affect the behaviour, survivorship, or reproduction of this species. The humpback whale is not discussed further in this Illumination Plan.

The risk matrix and assessment used for these risk assessments was developed by Pendoley Environmental Pendoley (2022) and modified by Phoenix (2022b) to suit migratory shorebirds and Biologic to suit terrestrial species. The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures.

2.4.2 Key Assumptions and Uncertainties

The key elements within the Illumination Plan (including trigger criteria, threshold criteria, response actions, monitoring indicators, timing/ frequency of monitoring and management actions) have been based upon best available expert knowledge and opinion.

General uncertainties applicable to the Illumination Plan include:

- The nature of natural fluctuations of the individuals/ populations of key species, which makes it more difficult to determine whether measured changes are due to natural causes or Project impacts.
- Difficulty determining whether any impacts to species are due to artificial lighting associated with the Project or another development/ operator in the region.

The key assumptions and uncertainties specific to key species considered in the Illumination Plan are discussed below.

Grey Falcon

- The grey falcon was recorded in the centre and south-eastern corner of the Optimised Project Development Envelope and it is possible that the grey falcon recorded was nesting on the communications tower close to Mardie Homestead (Phoenix, 2022a). However, the current whereabouts of the grey falcon pair that are reported to use the nest on the communications tower is uncertain. If the pair of grey falcons are located and do move away from this nesting site, it will be difficult to determine the cause of their relocation (i.e. artificial lighting associated with the Project or other natural causes).
- Recent research has shown that the grey falcon is a 'reluctant nomad' - only if conditions become a risk to their survival are they likely to move on and then, when they do, they move no further than necessary (Schoenjahn, 2018).

Marine turtles

- Natural interannual fluctuations in marine turtle nesting effort or natural occurrences such as cyclones, heavy rain events inundating beaches, El Nino/ La Nina impacts, or global warming and sea level rise) can occur, which makes it more difficult to determine whether changes in marine turtle nesting effort are due to natural causes or in response to the Project.
- Difficulty determining whether any impacts to species are due to artificial lighting associated with the Project or other operators in the region contributing light to the night-time environment.

Migratory shorebirds and seabirds

- The nature of natural fluctuations of the populations of migratory shorebird and seabird species makes it difficult to determine whether population changes are due to natural causes or the Project. Baseline studies and ongoing monitoring will help mitigate against this uncertainty.

2.4.3 Management Framework

To ensure that management provisions are proportionate to the risk, BCI has developed an **outcome-based** management framework and an **objective-based** framework. This Illumination Plan contains both outcome-based and objective-based elements.

Outcome-based elements are performance-based. They focus on monitoring and evaluating specific measurable outcomes, usually driven by trigger and threshold criteria. Objective-based elements relate to monitoring and management actions that are required to achieve an objective. Table 2-2 briefly lists the key elements of these two frameworks.

Table 2-2: Overview of Management Frameworks in this Illumination Plan

Management Framework	Key Elements of Framework
Outcome-based	Trigger criteria, threshold criteria, response actions (trigger level actions and threshold contingency actions), monitoring (including indicators), timing/ frequency of monitoring, and reporting.
Objective-based	Management actions, management targets, monitoring and reporting.

2.4.4 Rationale for Choice of Indicators and/or Management Actions

BCI recognises that the EPA prefers outcome-based provisions, and use of these have been maximised. The Objective-based provisions have been created to align light management with the National Light Pollution Guidelines for Wildlife (DCCEEW, 2023) and the EPA's Environmental Assessment Guidelines for Protecting Marine Turtles from Light Impacts (EPA, 2010).

Monitoring data (references for turtles, migratory shorebirds/ seabirds and artificial light) has been used to inform the triggers and thresholds for the outcome-based provisions. The key assumptions, monitoring data, and management actions of this Plan will be reviewed regularly and adapted where necessary to meet the environmental objectives and outcomes, this is discussed further in Section 8.

The Management objectives are designed to meet the EPA's environmental objectives for the Marine Fauna and Terrestrial Fauna factors, with the overall objective of no significant impact of artificial lighting on marine (EPA, 2016a) or terrestrial fauna (EPA, 2016b). The management actions have been

designed to meet the overall objective, with the management targets designed to assess the effectiveness of management actions.

This Plan also describes the monitoring and reporting approach that will be undertaken to assess the effectiveness of the management actions in meeting the environmental outcomes and management-based objectives.

a. Indicators for Outcome-based Provisions of this Plan

Indicators are the measurable or quantifiable characteristics which are selected for specific purposes to indicate the health or condition of the environment (EPA, 2020). The indicators used in this Illumination Plan were selected as they were best available, practical measures to determine whether or not the outcome was being achieved. Two levels of indicators are used in this plan; a) criteria relating to trigger levels and b) criteria relating to threshold levels.

Indicators were developed specifically for the species of conservation significance with the potential to be impacted by the Project (specifically three marine turtles (green, hawksbill and flatback) and migratory shorebirds/seabirds) and levels of artificial light. Furthermore, indicators were developed to address, where applicable, conditions set for the Project (Section 2) and best management practice for species of conservation significance in the Pilbara region. This includes:

- Condition B5-3 of Ministerial Statement 1211
- Condition 24 of EPBC 2018/8236 relating to the Illumination Plan
- EPA (2010) Environmental Assessment Guidelines for Protecting Marine Turtles from Light Impacts
- DCCEEW (2023) National Light Pollution Guidelines for Wildlife, Department of Climate Change, Energy, the Environment and Water
- TSSC (2016) Conservation Advice *Rhinonicteris aurantia* (Pilbara form)
- Bat Call (2021) A Review of Pilbara Leaf-nosed Bat Ecology, Threats and Survey Requirements
- ‘Recovery Plan for Marine Turtles in Australia, Commonwealth of Australia 2017’ (DoEE, 2017b)
- EPBC Act Policy Statement 3.21 — Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species, Department of the Environment and Energy (DoEE, 2017a)
- Wildlife Conservation Plan for Migratory Shorebirds, Department of Environment (DoE, 2015)

Given that there are no defined light intensity impact thresholds for any of the listed receptors (species), it was not appropriate to set triggers and thresholds based on absolute light levels or changes in light. Furthermore, such thresholds would likely be different for different receptors and would be site specific. Instead, triggers and thresholds have been chosen which focus on receptors, to identify whether adverse changes in behaviour (if detected) have occurred due to changes in light. Light will be assessed at island and mainland sites using sky brightness metrics, with these data assessed in response to a recorded adverse behaviour or impact. Similarly, lighting audits will assess lighting design in terms of direction,

shading, screening, timing and wavelength, in accordance with the National Light Pollution Guidelines for Wildlife (DCCEEW, 2023) rather than light levels.

The **outcome-based** provisions of this Plan are set out in Table 6-1.

b. Management Actions for Objective-based Provisions of the Illumination Plan

Management actions are targeted at addressing the identified potential impacts, which includes key threats. The potential impacts addressed here are those specifically recognised and assessed within the Mardie Minerals Development: Artificial Light Assessment and Management Plan (Draft) (Pendoley Environmental, 2023b) and the Long-term migratory shorebird monitoring program for the Optimised Mardie Project (Phoenix, 2023b). Artificial light modelling has also been undertaken (Pendoley Environmental, 2023a). These plans have been developed in consideration of the conservation significant species present or potentially present in and surrounding the Project Area and potential impacts of the Project, specialist advice and industry best practices.

The **objective-based** provisions of this Plan are set out in Table 6-2.

3. WILDLIFE

3.1 Survey and Study Findings

Since 2017, a total of 11 field assessments have been undertaken within or including the Mardie Salt Project Area (including Original and Optimised Projects). Seven of these focussed on terrestrial fauna (including migratory shorebirds/seabirds) (Phoenix, 2020, 2021a, 2021b, 2022a, 2023a, 2023b, 2022c) and four focussed on marine turtles (Pendoley Environmental, 2018, 2019, 2022, 2023c). In addition, two impact assessments have been completed for the Project, one for shorebirds and migratory shorebirds (Phoenix, 2022b) and one for marine turtles (draft) (Pendoley Environmental, 2023b). Artificial light modelling has also been undertaken (Pendoley Environmental, 2023a). All field assessments and impact assessments were undertaken to inform the assessment of the Project.

3.1.1 Habitat

Fourteen broad habitat types have been identified and mapped over the Project Area as listed in Table 3-1 and shown on Figure 5. The Shrubland over Spinifex Grassland habitat is the only habitat present in the Quarry Area. Spinifex Grassland on Rocky Hills habitat is present approximately 1 km to the north of the Quarry Area.

Table 3-1: Habitats Present in Project Area

Habitat Type	TFSA* (Phoenix, 2020)	Optimisation Area (Phoenix, 2022a)	Quarry Area (Phoenix, 2022a)
Mangal Community	Yes	Yes	No
Mudflat or Saltflat	Yes	Yes	No
Low Shrubland	Yes	Yes	No
Shrubland over Spinifex Grassland	Yes	Yes	Yes
Shrubland over Tussock Grassland	No	Yes	No
Spinifex Grassland	Yes	Yes	No
Spinifex Grassland on Rocky hills	Yes	No	No (only to north of Quarry Area)

Habitat Type	TFSA* (Phoenix, 2020)	Optimisation Area (Phoenix, 2022a)	Quarry Area (Phoenix, 2022a)
Tidal Channel and Ocean	Yes	Yes	No
Tidal Samphire Mudflat	Yes	Yes	No
Tussock Grassland	Yes	Yes	No
Open Woodland (riparian)	Yes	No	No
Beach/ Dune	Yes	No	No
Freshwater Pool	Yes	No	No
Cleared/ None	Yes	Yes	No

* Terrestrial Fauna Survey Area

3.1.2 Habitat Features

Two water features have been confirmed in the Project Area, namely Mardie Pool (Figure 5) and a permanent pool by the old shearing quarters located approximately 300 m south of Mardie Pool. Two other pools/ soaks are thought to occur within the Project Area but have not been verified (Phoenix, 2020). Mardie Pool is an important permanent freshwater resource for terrestrial fauna including the Pilbara leaf-nosed bat, which has been previously recorded foraging there on one occasion. Mardie Pool has been excluded from the development envelope of the Project Area.

There is no roosting habitat (i.e. caves) for the Pilbara leaf-nosed bat within the Project Area or nearby. The Pilbara leaf-nosed bats recorded in the Project Area are likely to have travelled from a roost site in the ranges, approximately 20 km to the east of the Project Area (Phoenix, 2020).

3.1.3 Conservation Significant Species

The conservation significant vertebrate species recorded within or considered likely to occur within the Project Area include six mammals and five reptiles, three of which are marine turtles (Preston Consulting, 2022). In addition, three significant bird species (grey falcon, fairy tern and night parrot), seven migratory terns (shaded below) and at least 22 migratory shorebirds are likely to be present (Table 3-2).

Table 3-2: Conservation Significant Species confirmed or likely to be present in Project Area (Preston Consulting, 2022)

Common Name (Species Name)	Conservation Status		Recorded in Project Area
	EPBC Act	In WA	
Northern quoll (*Dasyurus hallucatus*)	Endangered	Endangered	Recorded
Bilby (*Macrotis lagotis*)	Vulnerable	Vulnerable	Possible
Black-flanked rock wallaby (*Petrogale lateralis subsp. lateralis*)	Endangered	Endangered	Possible
Western pebble-mound mouse (*Pseudomys chapmani*)	-	Priority 4	Recorded
Pilbara leaf-nosed bat (*Rhinonicteris aurantius*)	Vulnerable	Vulnerable	Likely
Northern coastal free-tailed bat (*Ozimops cobourgianus*)	-	Priority 1	Recorded
Pilbara olive python (*Liasis olivaceus barroni*)	Vulnerable	Vulnerable	Possible
Lined soil-crevice skink (Dampier) (*Notoscincus butleri*)	-	Priority 4	Recorded

Common Name (Species Name)	Conservation Status		Recorded in Project Area
	EPBC Act	In WA	
Green turtle (*Chelonia mydas)*	Vulnerable	Vulnerable	Recorded nearby
Hawksbill turtle (*Eretmochelys imbricata*)	Vulnerable	Vulnerable	Recorded nearby
Flatback turtle (*Natator depressus*)	Vulnerable	Vulnerable	Recorded nearby
Night parrot (*Pezoporus occidentalis*)	Endangered	Critically Endangered	Possible
Fairy tern (*Sterna nereis*)	-	Vulnerable	Possible
Grey falcon (*Falco hypoleucos*)	Endangered	Vulnerable	Recorded
Ruddy turnstone (*Arenaria interpres*)	Migratory	Migratory	Likely
Sharp-tailed sandpiper *(Calidris acuminata)*	Migratory	Migratory	Likely
Sanderling (*Calidris alba*)	Migratory	Migratory	Likely
Red knot (*Calidris canutus*)	Endangered/Migratory	Migratory	Likely
Curlew sandpiper (*Calidris ferruginea*)	Critically Endangered/Migratory	Vulnerable/Migratory	Likely
Pectoral sandpiper (*Calidris melanotos*)	Migratory	Migratory	Possible
Red-necked stint (*Calidris ruficollis*)	Migratory	Migratory	Likely
Great knot (*Calidris tenuirostris*)	Critically Endangered/Migratory	Vulnerable/Migratory	Possible
Greater sand plover (*Charadrius leschenaultia*)	Vulnerable/Migratory	Migratory	Likely
Lesser sand plover (*Charadrius mongolus*)	Endangered/Migratory	Endangered/Migratory	Possible
Oriental plover (*Charadrius veredus*)	Migratory	Migratory	Likely
White-winged black tern (*Sterna leucoptera*)	Migratory	Migratory	Possible
Oriental pratincole (*Glareola maldivarum)*	Migratory	Migratory	Likely
Bar-tailed godwit (*Limosa lapponica*)	Migratory	Migratory	Likely
Black-tailed godwit (*Limosa limosa*)	Migratory	Migratory	Possible
Eastern curlew (*Numenius madagascariensis*)	Critically Endangered/Migratory	Vulnerable/Migratory	Likely
Little curlew (*Numenius minutus*)	Migratory	Migratory	Possible
Whimbrel (*Numenius phaeopus*)	Migratory	Migratory	Likely
Pacific golden plover (*Pluvialis fulva*)	Migratory	Migratory	Likely
Grey plover (*Pluvialis squatarola*)	Migratory	Migratory	Possible
Little tern (*Sternula albifrons*)	Migratory	Migratory	Likely
Lesser crested tern (*Sterna bergalensis*)	Migratory	Migratory	Likely
Caspian tern (*Hydroprogne caspia*)	Migratory	Migratory	Likely
Roseate tern (*Sterna dougallii*)	Migratory	Migratory	Likely
Common tern (*Sterna hirundo*)	Migratory	Migratory	Likely
Crested tern (*Thalasseus bergii*)	-	Migratory	Likely
Grey-tailed tattler (*Tringa brevipes*)	Migratory	Migratory	Possible
Terek sandpiper (*Tringa cinerea*)	Migratory	Migratory	Possible
Wood sandpiper (Tringa glareola)	Migratory	Migratory	Possible

- not stated by DCCEEW (2023)

Of the conservation significant vertebrate fauna, three marine fauna species (green, hawksbill, and flatback turtles), three terrestrial fauna (northern quoll, Pilbara leaf-nosed bat, grey falcon) and a number of migratory shorebirds/seabirds were recorded within or in close proximity to the Project Area

(Preston Consulting, 2022) and have the potential to be impacted by Project lighting. This Plan focuses on these conservation significant fauna that may be potentially impacted as a result of Project light spill/ glow. However, other native fauna will also benefit from the management of project lighting and reduction of artificial light spill through the implementation of this Plan.

Marine fauna

Biologically Important Areas (BIAs) are areas and times used by protected marine species (listed threatened and migratory species under the EPBC Act) for carrying out critical life functions, such as reproduction, feeding, migration or resting (DCCEEW, 2023). The island chain from Mangrove Islands to Cape Preston, located to the west of the Project Area, is recognised as a BIA for green, hawksbill and flatback turtles (Pendoley Environmental, 2019). These three species of turtle were consistently recorded during turtle monitoring surveys associated with the Project (Figure 3) (Pendoley Environmental, 2019, 2022, 2023c). Pendoley (2019) reported that the offshore islands adjacent to the Project Area, particularly Long and Sholl Islands, provide suitable and viable habitat for turtle nesting rookeries and low density nesting was recorded on the mainland (Pendoley Environmental, 2019). Nesting and inter-nesting are the main considerations for BIAs for these three turtle species. The greatest potential for impact of artificial lights on turtles is associated with nesting beaches and nearshore waters (including inter-nesting areas) through which hatchlings travel to reach the ocean (DCCEEW, 2023). Therefore the Project has the potential to impact these BIAs which provide habitat critical to the survival of green, hawksbill and flatback turtles (DCCEEW, 2023).

*Green Turtle (*Chelonia mydas*) - (Vulnerable, Migratory - EPBC Act, Vulnerable - BC Act)*

Green turtles have been recorded nesting at offshore islands only, predominantly Long, Sholl and Passage Islands (Pendoley Environmental, 2023c). Green turtle activity was not recorded on the mainland during any of the monitoring (Pendoley Environmental, 2023c).

*Hawksbill Turtle (*Eretmochelys imbricate*) - (Vulnerable, Migratory - EPBC Act, Vulnerable - BC Act)*

Sholl Island is recognised as habitat critical to the survival of hawksbill turtles, including a 20 km zone around the island for inter-nesting (DCCEEW, 2023). Hawksbill turtles were recently recorded nesting on all the islands except Solitary. Nesting was recorded predominantly on Sholl, Round, Long and Middle Passage. Hawksbill turtles were also recorded nesting on the mainland at both Mardie Creek East and Mardie Creek West (Pendoley Environmental, 2023c).

*Flatback Turtle (*Natator depressus*) - (Vulnerable, Migratory - EPBC Act, Vulnerable - BC Act)*

The nearshore islands in the vicinity of the project site (particularly Long and Sholl islands) are recognised as habitat critical to the survival of flatback turtle for nesting, in addition to the waters 60 km around the islands which are used for nesting (DCCEEW, 2023). During recent monitoring, flatback turtles were recorded nesting at offshore islands, and nests or nesting attempts were recorded on mainland beaches to the east and west of Mardie Creek (Pendoley Environmental, 2022, 2023c).

Migratory shorebirds and seabirds

Surveys targeting migratory shorebirds/seabirds have been undertaken within the Migratory Shorebird Survey Area (MSSA), Terrestrial Fauna Survey Area (TFSA) and Mardie Project Area (Phoenix, 2020, 2021b, 2023a, 2023b, 2022c). These surveys identify a contiguous shorebird habitat unit, that extends 100 km from the Fortescue River mouth south-west to just north of the town of Onslow (Phoenix, 2021a). The Project Area intersects part of this nationally significant wetland habitat (Figure 4). The tidal samphire mudflats and mangal communities found within the Project Area have been identified as being of high importance to migratory shorebirds (Preston Consulting, 2022). This Plan considers

migratory shorebirds/seabirds as a group that may potentially be negatively affected by artificial light at night.

Terrestrial fauna

Northern Quoll (Endangered – EPBC Act; Vulnerable – BC Act)

The northern quoll has been recorded (three records) from spinifex grassland on rocky hills habitat, approximately 1 km north of the Quarry Area (QA) (Phoenix, 2022a) (Figure 5). This type of habitat is considered potential denning/ shelter habitat (Figure 5) (Phoenix, 2022a). Although this habitat is not present within, but nearby the QA, it is considered significant foraging habitat for northern quoll and as such is included in the Plan (Phoenix, 2021a, 2022a).

Grey Falcon (Vulnerable – EPBC Act / BC Act)

The grey falcon was recorded in the centre and south-eastern corner of the Optimisation Area (Phoenix, 2022a) (Figure 5). As there does not appear to be any natural nesting sites within the Optimisation Area, it is likely that the grey falcon recorded was nesting in a communications tower close to Mardie homestead (Phoenix, 2022a). Suitable habitat for the grey falcon, such as shrubland over tussock grassland, occurs extensively immediately outside the Project Area. The grey falcon has a wide foraging range and is only restricted by habitat in relation to suitable roosting sites such as inland drainage lines, grasslands sparse wooded lowlands and building infrastructure (i.e. communication towers).

Pilbara leaf-nosed bat (Vulnerable - EPBC Act / BC Act)

The Pilbara leaf-nosed bat has been recorded in the vicinity of Mardie Pool (Figure 5) (Phoenix, 2020) which has been excised from the Project Area. Mardie Pool has been identified as a likely water source for this species. The Project Area is thought to provide foraging habitat for Pilbara leaf-nosed bat; however it does not provide roost sites due to the absence of caves. The Pilbara leaf-nosed bats are likely to have travelled from a roost site, approximately 20 km to the east of the Project Area (Phoenix, 2020).

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Legend

- Development Envelope
- Disturbance Footprint
- Light Monitoring Sites

Marine Turtle Nesting Habitat

- Flatback Turtle
- Green Turtle
- Hawksbill Turtle
- Mainland Turtle Survey Area
- Biologically Important Area
- Homesteads
- Gas Pipeline
- Highway

Stewart Island
Fortescue Island
Scholl Island
Mardie Island
Round Island
Long Island
Middle Passage Island
Angle Island
Passage Island
Solitary Island
South Passage Island
Mardie Creek East
Mardie Creek West
Shiploader
Trestle Jetty
Salt Stockpiles
Secondary Seawater Intake
SOP Plant
Salt Wash Plant
Pre-KTMS Crystallisers
Crystallisers
Pond 9
Pond 8
Pond 7
Pond 6
Pond 5
Pond 4
Pond 3
Pond 2
Pond 1
Pond 0
Pre-KTMS Crystallisers
Mardie Pool
Mardie Homestead
Evaporation Ponds
Village
North South Road
Primary Seawater Intake Station
Access Road
Quarry
Quarry
Gas Pipelines
North West Coastal Highway

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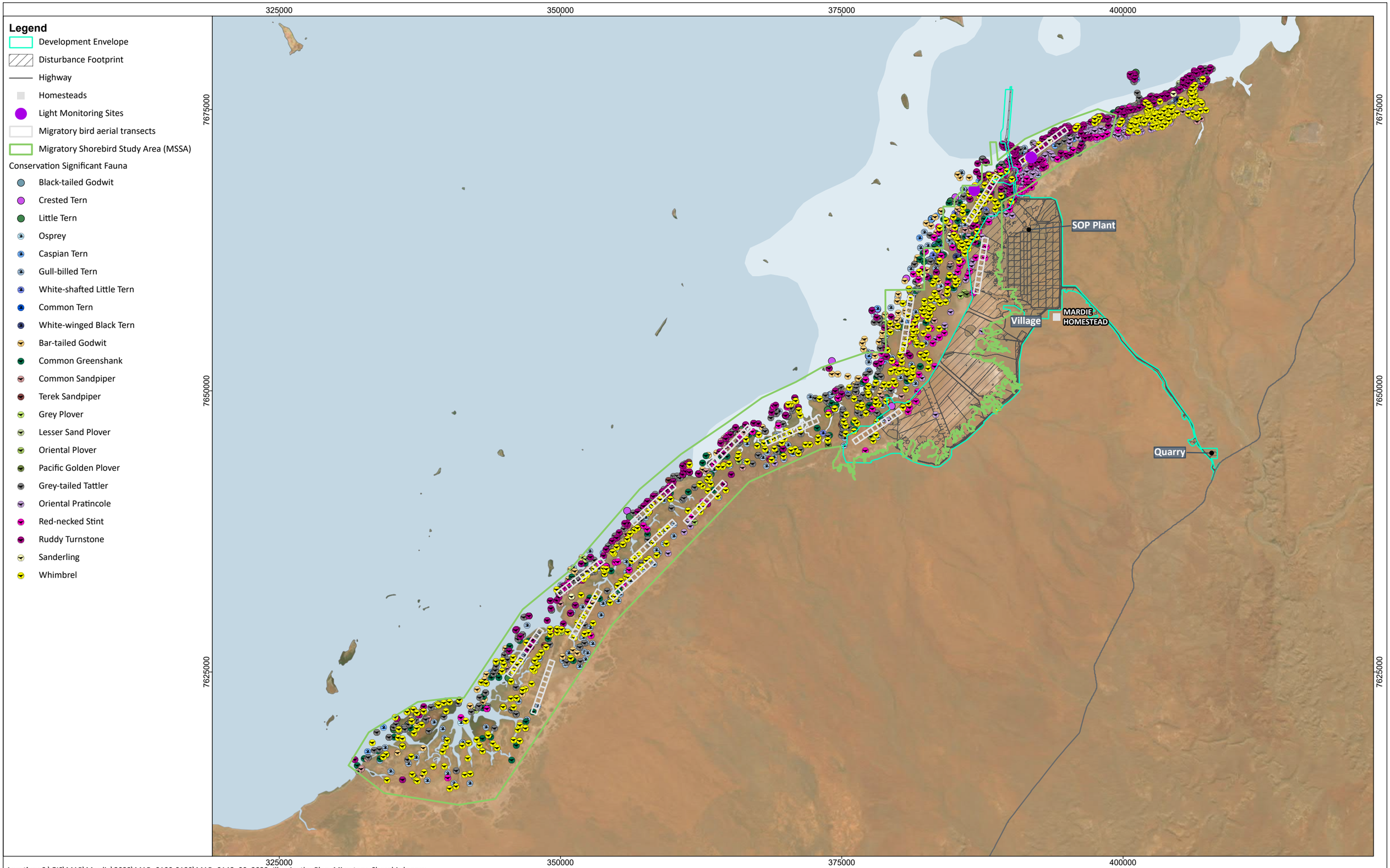
Marine Turtle Nesting Locations

Figure: 3



Legend

- Development Envelope
- Disturbance Footprint
- Highway
- Homesteads
- Light Monitoring Sites
- Migratory bird aerial transects
- Migratory Shorebird Study Area (MSSA)

Conservation Significant Fauna

- Black-tailed Godwit
- Crested Tern
- Little Tern
- Osprey
- Caspian Tern
- Gull-billed Tern
- White-shafted Little Tern
- Common Tern
- White-winged Black Tern
- Bar-tailed Godwit
- Common Greenshank
- Common Sandpiper
- Terek Sandpiper
- Grey Plover
- Lesser Sand Plover
- Oriental Plover
- Pacific Golden Plover
- Grey-tailed Tattler
- Oriental Pratincole
- Red-necked Stint
- Ruddy Turnstone
- Sanderling
- Whimbrel

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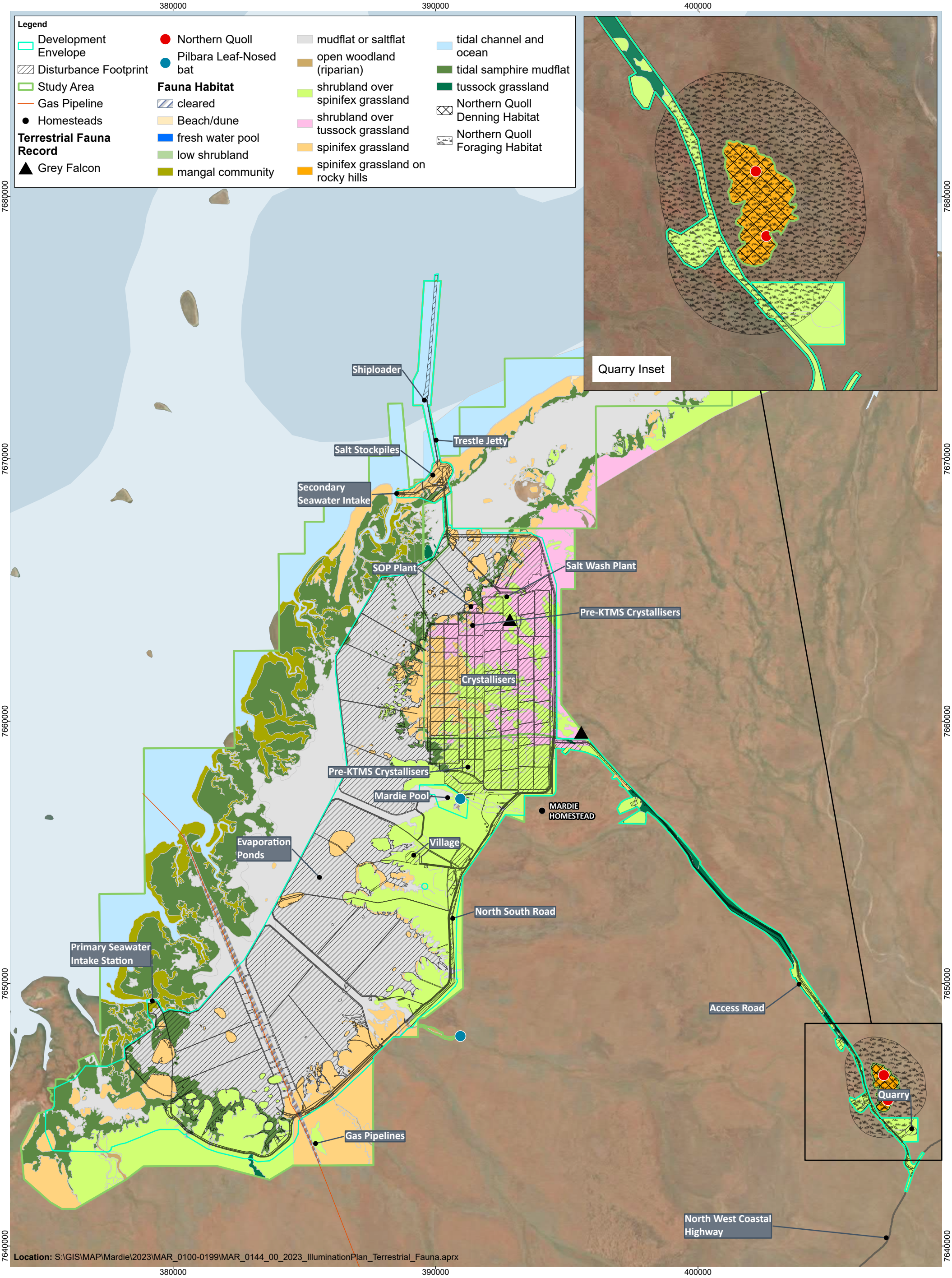
Migratory Shorebird Records and Seabirds

Figure: 4



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Terrestrial Fauna Habitats and Significant Fauna Records

Figure: 5

4. PROJECT LIGHTING

4.1 Existing Light Environment

The existing (as at 2022) light sources present within 20 km of the Project Area are shown on Figure 7. These light sources, ranked from greatest to least, include:

- Citic Pacific Sino Iron Ore facilities and camp
- Santos Devils Creek camp
- BCI camp, Mardie Village

Light emissions are most visible from the Citic Pacific Sino Iron facilities located northeast of the Project Area and from the Devils Creek camp site (also in the north-east). These facilities are likely to include lighting for streets and walkways, laydown and work areas, security, administration and service facilities (Pendoley, 2022). These facilities were constructed prior to the release of the Commonwealth Light Pollution Guidelines (DoEE, 2020) and so are unlikely to be consistent with current technology and light management policy and guidance.

4.2 Description of Project Lighting

The lighting to be used for the Project is located in the following facilities:

- **Mardie Village** contains a total of 404 lights, with a mix of colour temperatures ranging from 2350K to 6000K, for a total power of 1,680,163 lumens. BCI is currently undertaking a review and replacement programme to align the lighting used at Mardie Village with this Illumination Plan
- **The Jetty** contains lighting in three sub-inventories:
    - **Jetty Traveller** (construction phase) containing 191 lights with a total power of 824,770 lumens
    - **Barge** (construction phase) containing 32 lights with a total power of 1,326,040 lumens
    - **Onshore Facilities** (construction phase) containing 70 lights with a total power of 3,569,430 lumens
    - **Jetty** (operational lighting) The lighting of the outdoor areas of the Jetty and walkways is Amber colour 1970k LED with low level of filtered blue, violet and ultra-violet wavelengths (bulkheads on the walkways-3000mm above walkway level) and LED floodlights (jetty head end). The Jetty Head floodlights are installed at or above 8000mm above the deck on a hinged pole or fixed. Solar lighting on the Jetty crossovers uses a colour temperature of 1800k lighting. Lighting at the land end of the conveyor uses 4000k temperature colour lighting. Bulkhead light fixtures at the Jetty head end have been selected with a walkway lens optic which provides a long narrow strip of light rather than light being dispersed radially around the light fitting. This allows light to be directed at the intended walkway and minimised light spill from the structure.
- **Primary Seawater Intake** facility which contains 29 Amber lights with a total power of 211,800 lumens
- **Pond Transfer Stations (3)** which contain 54 Amber lights with a total power of 152,790 lumens

- **Rock Haul and Stock Piling** which will have up to 17 Amber lighting towers with a total power 1,819,000 lumens
- **Secondary Seawater Intake** facility (yet to be constructed), detailed lighting designs not available)
- **Salt Wash Plant** (yet to be constructed) will have up to 84 Amber lights (pole mounted) with a total power 1,251,520 lumens and 40 LED lights with total power 378,000 lumens, totalling 1,629,520 lumens.
- **SOP Plant** (yet to be constructed, detailed lighting designs not available)
- **Quarry** (yet to be constructed, daylight operations only, detailed lighting designs not available)
- **Dredges** (one operational 24 hours per day, a second operational 12 hours per day, detailed lighting designs not available)
- **Trans-shipment Vessel** operations phase, operating between the jetty head and an anchorage located approximately 27 km from coast

The trans-shipment vessel (TSV) operates between the jetty and anchorage, with two trips per day (24 hrs). The Ocean-going vessel (OGV) will remain anchored approximately 27 km of the coast. During operations deck lighting will be required for both the TSV and OGV at anchorage (27 km from the coast) and at the jetty (TSV only). The TSV will remain with maximum lighting at either the jetty or anchorage for a maximum of four hours each. Minimum (navigation) lighting will be used on the TSV when transiting between jetty and anchorage. These lights will be coloured sector lights for navigational interactions only, not for illuminating the vessel. All accommodation and bridge lighting will not be in use during navigation.

The Secondary Seawater Intake facility, SOP Plant and Quarry are yet to be constructed and detailed lighting designs for these facilities were not available at the time of preparing this Plan. The quarry will operate during daylight hours only, so no lighting will be used at night apart from minimal lighting in the early morning when personnel arrive at work. The crystallisers associated with the Salt Wash Plant and SOP Plant have minimal planned lighting which is only used during salt harvesting. No operational lighting would be used at evaporation ponds, gas pipelines, North South Road, and the Mardie Access Road.

The lights for use at each of the Project facilities are provided in the lighting inventory (provided by BCI) which includes the details of each of these lights (e.g. light type and number to be used as well as power) where designs are known (Table 4-1). For any facilities which do not yet have detailed lighting designs, BCI commits to ensuring that all future lighting designs align with the National Light Pollution Guidelines for Wildlife (DCCEEW, 2023).

BCI has committed to further reducing the light spill at Mardie Village by implementing the additional controls proposed in Table 4-1. The implementation of additional controls is to be completed within six months (i.e. by 30 April 2024).

Lighting at all construction sites, including on the jetty, barge and dredges, will be subject to routine inspections. Non-compliant light sources identified by these routine inspections will be raised as a non-compliance issue for prompt rectification. In general, lights will be switched off when not required.

Table 4-1: Lighting Inventory (provided by BCI)

Light Type	Power (Lumens)	Number	Total Power (Lumens)	Current		Proposed	
				Colour	Average Height (m)	Colour	Average Height (m)
Mardie Village							
ETG-MCSL30	4,200	23	96,600	3000K	2.83	True amber or PC amber	NA
Pierlite BWPECO202E4 20W	2,000	183	366,000	3000K	2.20	True amber or PC amber	NA
90 G2 Solar Maxi Series Lighting Tower 6m	9,800	3	29,400	4000K	6.00	2700k	3.00
91 G2 Solar Maxi Series Lighting Tower 6m	9,800	1	9,800	4000K	6.00	2700k	3.00
ETG-ZLB60W-CCT	2,400	20	48,000	3000K	3.00	True amber or PC amber	NA
SLA7102BK	1,200	15	18,000	6000K	1.00	True amber or PC amber	NA
Recessed Downlight APEX0145_TW40_W-PC070001	2,470	23	56,810	4000K	4.00	True amber or PC amber	3.00
ETG-VSFL80-G2	12,100	16	193,600	3000K	8.00	2700k	3.00
Pierlite BWPECO202E4CS 20W	2,000	14	28,000	3000K	2.26	True amber or PC amber	N/A
SOL SL9726TC (SL9726/20TC/DP)	2,040	17	34,680	3000K	3.00	True amber or PC amber	N/A
ETG-VSFL100-G2	14,100	5	70,500	3000K	8.00	2700k	3.00
ETG-VSFL300-G2	44,100	4	176,400	3000K	8.00	2700k	3.00
ETG-VSFL200-G2	31,300	10	313,000	3000K	8.00	2700k	3.00
SE7169/200TC/BK"	21,000	3	63,000	3000K	8.00	True amber or PC amber	3.00
Melec Titan X4 ML-TN20X4-Y	2,191	13	28,483	Yellow	2.19	True amber or PC amber	N/A
Clipsal TPWPLED1 20W 5000k IP65	1,900	2	3,800	5000K	2.20	True amber or PC amber	N/A

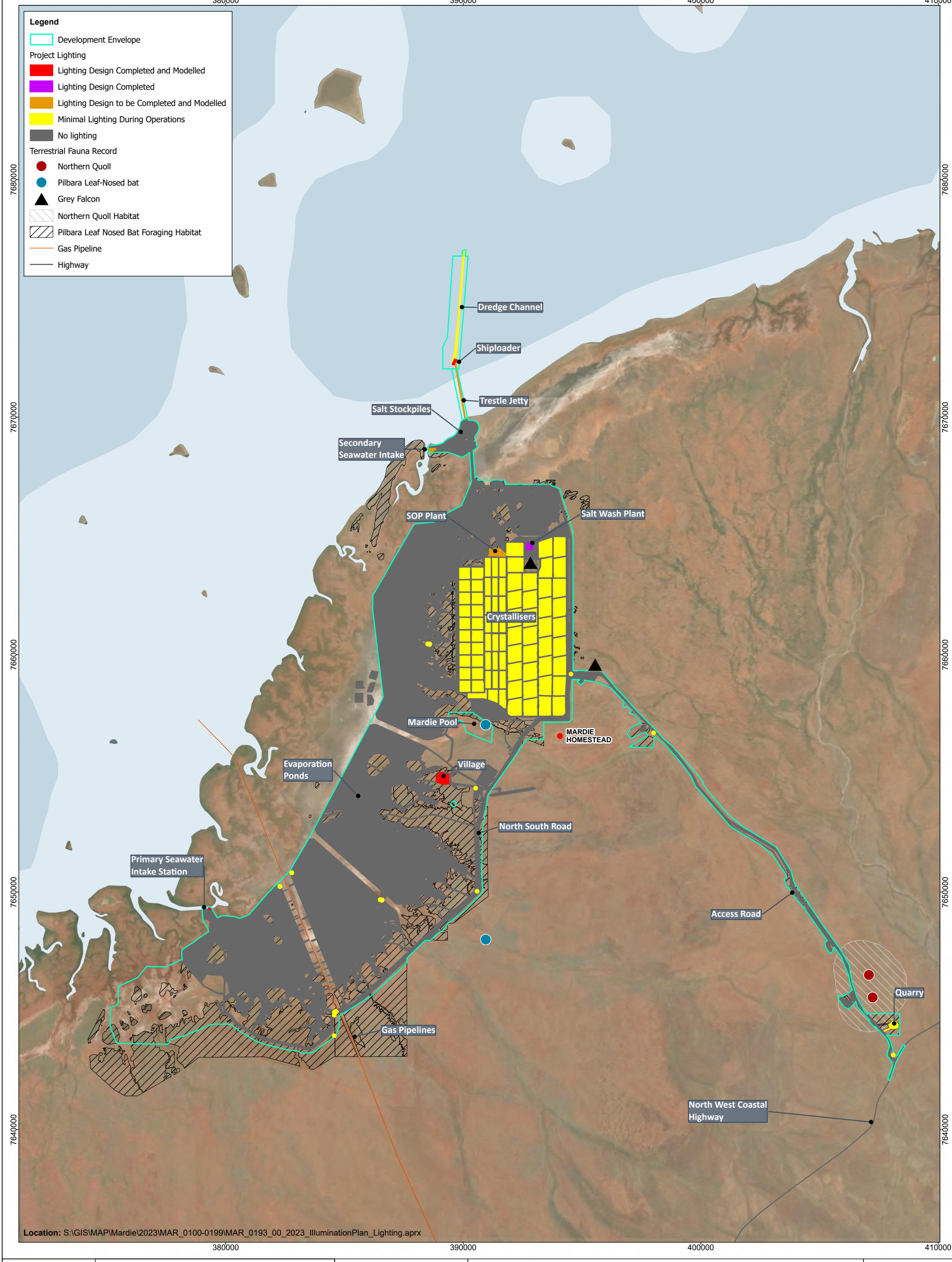
Light Type	Power (Lumens)	Number	Total Power (Lumens)	Current		Proposed	
				Colour	Average Height (m)	Colour	Average Height (m)
Unknown	3,000	15	45,000	4000K	2.20	True amber or PC amber	N/A
SOL SL9726/40TC/DP	4,370	4	17,480	3000K	3.00	True amber or PC amber	N/A
ETG-ZLB120-CCT	4,000	3	12,000	4000K	2.20	True amber or PC amber	N/A
Pierlite Maxi Master LED MML50S	5,250	1	5,250	4000K	2.20	2700k	N/A
Unknown flourescent tube lighting	3,000	11	33,000	4000K	2.20	True amber or PC amber	N/A
Pierlite Maxi Master LED MML100S	12,000	2	24,000	4000K	3.00	2700k	N/A
HPM LA6001BUGES LED Globe	460	16	7,360	2350K	2.20	N/A	N/A
Jetty Traveller							
Versalux TitanSS1200TFEMGF	2,510	65	163,150	2200K	0.92	N/A	N/A
Versalux TitanSS1200TFGF	2,510	112	281,120	2200K	0.92	N/A	N/A
Versalux Next 8TF P34053TF	47,000	8	376,000	2200K	0.80	N/A	N/A
Spinefex LG15TSL25	750	6	4,500	2200K	1.16	N/A	N/A
Barge							
Versalux Next 8TF P34053TF	47,000	28	1,316,000	2200K	3.25	N/A	N/A
Versalux TitanSS1200TFGF	2,510	4	10,040	2200K	2.10	N/A	N/A
Onshore Facilities							
Versalux Nautilus.12FO	4,525	42	190,050	2500K	2.70	N/A	N/A
Versalux Next 3 P34089	21,800	10	218,000	2500K	2.70	N/A	N/A

Light Type	Power (Lumens)	Number	Total Power (Lumens)	Current		Proposed	
				Colour	Average Height (m)	Colour	Average Height (m)
Versalux Challenge ST 45596	11,350	2	22,700	2500K	6.00	N/A	N/A
Versalux Vantage VTG.MAX.4080.2	40,670	4	162,680	2500K	6.00	N/A	N/A
JLG LED-4 Series II	248,000	12	2,976,000	2500K	8.00	N/A	N/A
Jetty (operational lighting)							
BHE-4BA2-5NFN-VGN	4,200	4	16,800	-	-	Amber	N/A
BPE-4BAG-5NNN-VGF	4,200	1	4,200	-	-	Amber	3
BPE-4UAG-5NNN-VGF	3,900	45	175,500	-	-	Amber	3
BPE-4UA2-5NNN-VGN	3,900	7	27,300	-	-	Amber	3
BPE-4UAG-5NNN-VGF	3,900	16	62,400	-	-	Amber	3
BPE-4UA2-5NNN-VGN	3,900	14	54,600	-	-	Amber	3
BHE-4UAG-5NFN-VGF	3,900	4	15,600	-	-	Amber	N/A
F1E-7FA2-BDEN-VGN	11,700	4	46,800	-	-	Amber	N/A
F1E-7FA2-BDEN-VGN	11,700	2	23,400	-	-	Amber	3
F2E-7FA2-EDEN-VGN	23,800	3	71,400	-	-	Amber	N/A
BPE-6BGG-3NNN-VGG	2,600	2	5,200	-	-	Green	3
BPE-4UNG-6NNN-VGF	6,400	17	108,800	4000K	3	Amber	N/A
BPE-4UN2-6NNN-VGN	6,400	6	38,400	4000K	3	Amber	N/A
F1E-7FL2-FDEN-VGN	29,200	2	58,400	4000K	3	Amber	N/A
BPE-4BN2-6NNN-VGN	6,700	3	20,100	4000K	3	Amber	N/A
MOSLX-20W 1800k	2,240	26	58,240	-	-	1800	N/A
Primary Seawater Intake							
LED T1	4,200	17	71,400	Amber	3.18	N/A	N/A
LED T2	11,700	12	140,400	Amber	8.00	N/A	N/A

Light Type	Power (Lumens)	Number	Total Power (Lumens)	Current		Proposed	
				Colour	Average Height (m)	Colour	Average Height (m)
Pond Transfer Stations							
EYE CONV2 40W AMBER LED	2,680	48	128,640	2200K	2.63	N/A	N/A
EYE L-LINE 35W	4,025	6	24,150	2200K	2.00	N/A	N/A
Rock Haul							
Minespec LED 200K-9	107,000	17	1,819,000	Amber	5.00	N/A	N/A
Secondary Seawater Intake (yet to be constructed)							
-	-	-	-	-	-	-	-
Salt Wash Plant (yet to be constructed)							
EYE CONV2 40W AMBER LED 40W Amber LED Pole mount	2,680	49	131,320	-	-	Amber	2.4
EYE CONV2 40W AMBER LED 40W Amber LED structure mount	2,680	15	40,200	-	-	Amber	3
Rapid LED HERO-400 R3070 400W Amber LED Flood light Pole mount	54000	6	324,000	-	-	Amber	3
Rapid LED HERO-400 R3070 400W Amber LED Flood light structure mount	54000	14	756,000	-	-	Amber	3
Rapid LED Matrix-70 R3240-070 70W LED Bollard Light Pole mount	9450	40	378,000	-	-	5000k	3
SoP Plant (yet to be constructed)							
-	-	-	-	-	-	-	-

Light Type	Power (Lumens)	Number	Total Power (Lumens)	Current		Proposed	
				Colour	Average Height (m)	Colour	Average Height (m)
Quarry (yet to be constructed)							
-	-	-	-	-	-	-	-
Dredges							
-	-	-	-	-	-	-	-
Trans-shipment Vessel							
To be confirmed			67,760	3000K	N/A	N/A	N/A
Ocean going vessel							
To be confirmed			101,920	3000K	N/A	N/A	N/A

"-" has not yet been determined



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Project Locations of Lighting and Significant Fauna and Habitat

Figure: 6

4.3 Artificial Light Modelling

Artificial light modelling was undertaken for various components of the Project by Pendoley Environmental (2023a) and is provided in Appendix 1. The available lighting design for the Project was used to predict the:

- Overall contribution to sky glow
- Visibility to turtle nesting beaches using a landscape scale light model

It should be noted that this modelling did not include the Secondary Seawater Intake facility, Salt Wash Plant, SOP Plant or Quarry. These Project facilities have not yet been constructed and detailed lighting designs were not available at the time of modelling. However, each of these components will either have no lighting (Quarry), minimal lighting (Secondary Seawater Intake facility) and/ or lighting designed to align with the National Light Pollution Guidelines for Wildlife (DCCEEW, 2023) (Salt Wash Plant, SOP Plant).

Further light modelling will be undertaken prior to any element involving significant lighting being constructed. If the artificial light modelling outcomes change, the revised modelling and subsequent lighting design changes will be submitted to DCCEEW for approval prior to the installation of new lighting infrastructure. Regular audits will also be undertaken, and specific lighting design details will be documented in future revisions of the Illumination Plan.

An updated version of the Illumination Plan, which includes the lighting designs for the Secondary Seawater Intake facility, Salt Wash Plant, SOP Plant and Quarry, and the new artificial light modelling including these elements, once completed, will be submitted to the DCCEEW for approval prior to any installation of lighting at each of these elements commencing[1]. The updated version of the Illumination Plan will also include an updated risk assessment to include consideration of the new artificial light modelling.

4.3.1 Sky Glow

Light modelling of the Project predicted the greatest change in sky brightness occurring at Mardie Creek East (Pendoley Environmental, 2023a). This monitoring site is shielded from existing major light sources in the region (i.e. Sino Iron), however has direct line of sight to the jetty developments and onshore facilities associated with the Project. Artificial light modelling for Long, Middle Passage, and Sholl Islands indicated a smaller increase in brightness relative to Mardie Creek East (Pendoley Environmental, 2023a).

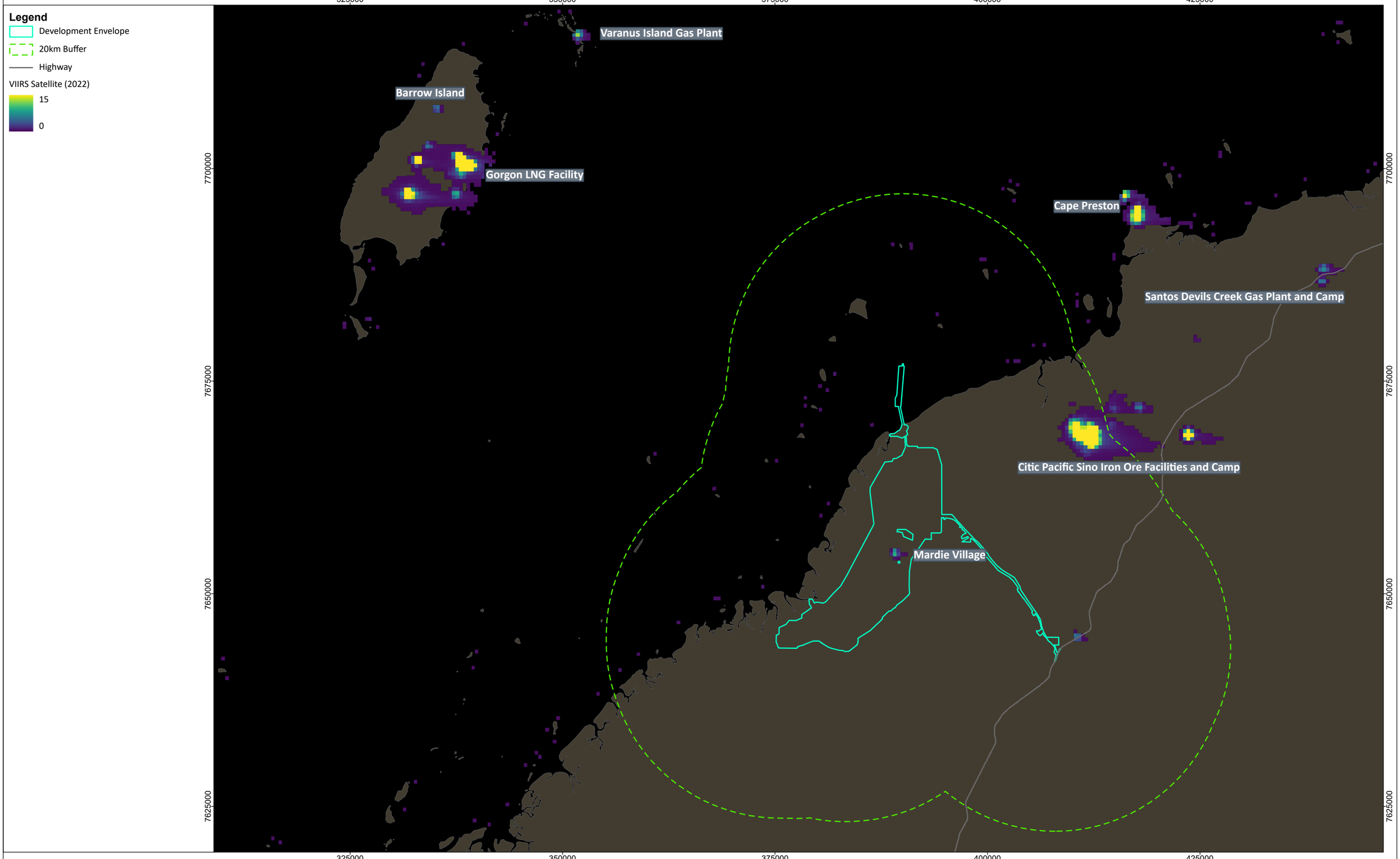
4.3.2 Visibility to Turtle Nesting Beaches

Across the Project, the brightest new sources of light associated with the turtle nesting beaches are the jetty traveller and onshore facilities (Pendoley Environmental, 2023a). It should be noted that the barge and night-operating dredge (not included in the modelling) will further contribute to the artificial light levels in this area. The other facilities included in the modelling, including the accommodation at Mardie Village, rock haul, transfer pump stations and primary seawater intake, are visible from the beaches but as much smaller sources on the horizon (Pendoley Environmental, 2023a). Lighting

[1] As noted above, the Quarry will have no lighting and the Secondary Seawater Intake facility minimal lighting. Further, the construction periods for the Salt Wash Plant and SOP Plant are extensive, with lighting being one of the last elements to be completed. Thus, the commitment to complete lighting design, light modelling and submission of the revised modelling within an updated Illumination Plan has been made a prerequisite to the installation of any lighting at these elements.

associated with the Salt Wash Plant, while not included in the current modelling, is also likely to be visible from the beaches but as much smaller sources on the horizon.

When comparing the modelled worst and base case scenarios, there is a decrease in cumulative modelled sky brightness for whole-of-sky, horizon, and zenith (Pendoley Environmental, 2023a). The greatest change is recorded at Mardie Creek East and the smallest change at Sholl Island. In both scenarios, Mardie Creek East, Long Island and Sholl Island maintain their classification as rural/ suburban transition skies, and Middle Passage Island is reclassified from a typical dark sky to a rural sky (Pendoley Environmental, 2023a). Further detail is provided in Appendix 1.



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Artificial light Sources in the Mardie Salt Project Area and Surrounds

Figure: 7

5. RISK ASSESSMENT

The risk assessments were based on the most recent light modelling (Appendix 1:) as well as a qualitative consideration of the likely impact of lighting from those facilities that did not have detailed lighting designs at the time of original modelling (Secondary Seawater Intake facility, Salt Wash Plant, and SOP Plant). An updated version of the Illumination Plan, which includes the lighting designs for the Secondary Seawater Intake facility, Salt Wash Plant, SOP Plant and Quarry, and the new artificial light modelling including these elements, once completed, will be submitted to the DCCEEW for approval prior to any installation of lighting at each of these elements commencing. The updated version of the Illumination Plan will also include an updated risk assessment to include consideration of the new artificial light modelling.

5.1 Marine Turtles

To assess the impacts of Project lighting on marine turtles, the risk assessment matrix developed by Pendoley Environmental (Pendoley, 2022) was used. This risk assessment matrix (Table 5-1), as well as definitions for the likelihood and consequence ratings (Table 5-2 and Table 5-3) are provided below. As there were two distant monitoring locations (coastal islands and mainland) and three different turtle groups (turtle hatchlings onshore, turtle hatchlings offshore and nesting adults), six risk assessments were completed (Table 5-4).

Table 5-1: Risk assessment matrix for marine turtles

			Consequence (see Table 5-3 for definition)				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
Likelihood (see Table 5-2 for definition)	Almost Certain (95-100%)	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	Medium 4	Medium 6	Medium 8	High 10
	Rare (0-5%)	1	Low 1	Low 2	Low 3	Medium 4	Medium 5

Table 5-2: Definition of likelihood (Pendoley, 2022)

Description	Frequency	Probability
Almost certain	• Expected to occur continuously throughout a year (e.g. more than 250 days per year) • Lights are directly visible from the nesting beach	96 – 100 %
Likely	• Expected to occur once or many times in a year (e.g. 1 to 250 days per year)	71 – 95 %

Description	Frequency	Probability
	• Sky glow is visible from the nesting beach	
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 • No lights are visible from the nesting beach	0 – 5 %

Table 5-3: Definition of consequence (Pendoley, 2022)

Description	Definition
Insignificant	Little to no impact on the overall ecosystem. Very small levels of impact on turtles, 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 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 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 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 habitat is irretrievably compromised. Mass mortality of turtles and local extinction of species. Recovery over several decades for habitat values and centuries for turtle populations.

Impacts of artificial light on marine turtle behaviour are well recognised (Witherington & Martin, 2003). 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) (Pendoley, 2005). The attractiveness to light differs by species, however, green, flatback, and hawksbill turtles all show increased sensitivity to wavelengths <600 nm (Pendoley, 2005). Cooler, whiter lights are more likely to attract turtles in comparison to warmer, amber lights (Pendoley, 2022).

Although longer wavelengths of light are less attractive than shorter wavelengths, long wavelengths can still disrupt the ability of hatchlings to locate the sea (Pendoley, 2005), and if bright enough, can elicit a similar response to shorter wavelength light. The disruptive effect of light on hatchlings is also strongly correlated with light intensity. In the absence of competing light sources, if the intensity is great enough, there is potential for artificial light to result in behavioural impacts to marine turtles, even if spectral output of light sources is outside the peak sensitivity of marine turtles (i.e. >600 nm).

Little is known about the impact of artificial light on adult and juvenile turtles when they are at sea (i.e. offshore). Some studies have described the attraction of marine turtles to lights associated with commercial fishing operations (Witzell, 1999), however, these marine turtles may instead be attracted to their prey which, in turn, is attracted to the light source. In contrast, other studies have suggested that turtles may not be attracted to light sources at sea (Ortiz et al., 2016). As such, there is no

consistent evidence that artificial light attracts foraging turtles. Similarly, there is no evidence that migrating turtles are attracted to lights. As 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 (Pendoley, 2022). Therefore, as there is no clear evidence to suggest that adult and juvenile marine turtles are negatively impacted by artificial light at sea, these life stages have not been considered in the following risk assessment.

The risk assessment for lighting from the Project on marine turtles is presented in Table 5-4. The greatest risk from Project lighting is to hatchling marine turtles emerging on the mainland and offshore islands. These lights are associated with the jetty construction, primarily from the barge, dredges, jetty traveller, onshore facilities and the Secondary Seawater Intake. Although the detailed lighting design of the Secondary Seawater Intake are not yet known, light emissions from this facility are likely to be similar to the Primary Seawater Intake (only a small amount of glow). However, the Secondary Seawater Intake is located near marine turtle nesting habitat so it is likely to present higher risk to hatchling marine turtles emerging on the mainland and offshore islands.

Lights from Mardie Village, transfer stations, and the Primary Seawater Intake are less likely to have any detectable impact on hatchling turtles due to the distance from sensitive habitat on the mainland or the offshore islands, and the results of the modelling which show only a small amount of glow from these facilities. Although modelling has not yet been done for the Salt Wash Plant, lighting from this facility is also unlikely to have any detectable impact on hatchling turtles due to the distance from sensitive habitat on the mainland and the offshore islands. The crystallisers associated with the Salt Wash Plant and SOP Plant would have minimal lighting and would only be used during salt harvesting. The additional impact on marine turtles from these facilities is likely to be minimal.

The temporary nature of the construction activity (1 – 2 nesting seasons) reduces the long-term impacts on the local marine turtle populations. However, it is important to note that the brightness and high visibility of the lights used in construction can potentially generate impact over large areas (> 20 km) and so management and mitigation of construction light is necessary. Lights associated with the jetty construction and dredging are mobile and would only be used when necessary. This would reduce impacts of Project lighting on hatchlings as according to Mrosovsky (1978) they are more influenced by permanent cues and continuous sources of light than lights that may go on and off.

Hatchling marine turtles on the nearshore islands are most at risk of a negative impact from Project lighting, while hatchling marine turtles on the mainland, nesting adult turtles and hatchlings offshore are at lower risk (Table 5-4).

Table 5-4**:** Risk assessment for marine turtles in the Study Area (Pendoley, 2022)

Turtle Group and Location	Impact*	Consequence	Likelihood	Ranking
Hatchling: Onshore *Coastal Islands*	Inherent	Minor (2)	Almost certain (5)	High (10)
	Residual	Insignificant (1)	Possible (3)	Low (3)
Hatchling: Onshore *Mainland*	Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
	Residual	Insignificant (1)	Possible (3)	Low (3)
Hatchling: Offshore *Coastal Islands*	Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
	Residual	Insignificant (1)	Possible (3)	Low (3)
Hatchling: Offshore *Mainland*	Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
	Residual	Insignificant (1)	Possible (3)	Low (3)
Adult: Nesting	Inherent	Insignificant (1)	Almost certain (5)	Medium (5)

Turtle Group and Location	Impact*	Consequence	Likelihood	Ranking
Coastal Islands	Residual	Insignificant (1)	Possible (3)	Low (3)
Adult: Nesting	Inherent	Insignificant (1)	Almost certain (5)	Medium (5)
Mainland	Residual	Insignificant (1)	Unlikely (2)	Low (2)

**The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures*

5.2 Migratory Shorebirds and Seabirds

To assess the impacts of Project lighting on migratory shorebirds and seabirds, the risk assessment matrix developed by Pendoley Environmental (Pendoley, 2022) was adapted to suit shorebirds and seabirds by Phoenix (2022b). This risk assessment matrix (Table 5-5), as well as definitions for the likelihood and consequence ratings (Table 5-6 and Table 5-7) are provided below.

Table 5-5: Risk assessment matrix for migratory shorebirds

			Consequence (see Table 5-7 for definition)				
			Insignificant 1	**Minor 2**	**Moderate 3**	**Major 4**	**Catastrophic 5**
Likelihood (see Table 5-6 for definition)	**Almost Certain (95-100%)**	**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	Medium 4	Medium 6	Medium 8	High 10
	Rare (0-5%)	**1**	Low 1	Low 2	Low 3	Medium 4	Medium 5

Table 5-6: Definition of likelihood (Phoenix, 2022b)

Description	Frequency	Probability
Almost certain	Expected to occur 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 5-7: Definition of consequence (Phoenix, 2022b)

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

5.2.1 Migratory Shorebirds

Artificial light at night has the potential to affect shorebirds foraging and roosting habits, such as causing collisions or disorientations, and potentially making them more susceptible to predation. Light intensity (artificial and natural) influences optimal foraging decisions, perceived predation risk and the costs of taking flight for shorebirds (Jolkkonen *et al.*, 2023).

There is no risk of the Project impacting the migratory shorebirds during their breeding period as this does not occur in Australia. Instead, the potential risks are associated with foraging and roosting while the birds recover from their southern migration and prepare for their northern migration. Migratory shorebirds are likely to be most vulnerable to these impacts during their peak migratory periods during March-April and August-November (Phoenix, 2022b). This is when migratory shorebirds undertake major coastal movements, and when their foraging requirements are the greatest.

It is possible that Project lighting may have an impact on some migratory shorebird species. The most disruptive Project lights would likely be at the Primary and Secondary Seawater Intakes, due to their location within important coastal habitat for shorebirds. The Primary Seawater Intake facility contains 29 Amber lights with a total power of 211,800 lumens. The Secondary Seawater Intake facility is yet to be constructed but is likely to have similar illumination to the Primary Seawater Intake facility.

Saltworks can provide valuable feeding habitat for migratory shorebirds. The initial intake evaporation ponds (where invertebrate density is very high) is anticipated to create new foraging habitat for migratory shorebirds. Project lighting near the ponds (i.e. from the Primary Seawater Intake facility) may result in increased predation on shorebirds if predators (e.g. cats or dogs) are attracted to the lights.

Mitigation measures will be undertaken to reduce the impact of Project lighting on migratory shorebirds. These measures would include:

- All fixed and mobile light towers to be positioned facing away from the mainland coast and offshore islands

- Light sources to be modified or shielded so they are not directly visible from foraging or nocturnal roost habitats
- Mobile light sources (e.g. headlamps, vehicle headlights) should not be directed into foraging or nocturnal roost habitats
- Fixed light sources which may permanently reduce habitat usage and provide a vantage point for aerial predators should not be installed
- Window screens or window tinting to be used to prevent any indoor lighting from reaching the outdoor environment
- The appropriate wavelength (most birds are sensitive to blue light) and appropriate commercial luminaries (Appendix 2:) to be used
- Lighting intensity to be kept as low as possible, particularly in areas adjacent to foraging or roosting habitat
- Lighting to be used only as required; motion-activated lighting may be suitable in some cases
- Works during peak migratory shorebird abundance (August-April) to be limited unless all appropriate mitigation measures have been implemented

The inherent impact of Project artificial lighting on shorebirds was considered *medium*, given the high value migratory shorebird habitat which occurs within 20 km of proposed operation and construction areas. Unmitigated, it is likely that any night lighting would impact migratory shorebird species, and the impacts would be *minor*. However, if appropriate management actions are taken, the residual impact to migratory shorebirds is considered *low* (Table 5-8).

Table 5-8: Risk assessment for migratory shorebirds in the Project Area

Impact*	Consequence	Likelihood	Ranking
Inherent	Minor (2)	Likely (4)	Medium (8)
Residual	Insignificant (1)	Unlikely (2)	Low (2)

**The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures*

5.2.2 Seabirds

Artificial light at night may negatively affect seabirds, particularly those which display nocturnal behaviour. Seabirds within Order Procellariiformes (e.g. shearwaters and petrels) have been documented as particularly affected by artificial light (Rodríguez et al., 2019). Artificial light at night has the potential to cause collisions or disorientations. It may also cause entrapment, stranding, grounding and interference with navigation (i.e. being drawn off course from their migration route) (DCCEEW, 2023). Migratory seabird species that are active at night are vulnerable, as artificial light (including light from seagoing vessels) can disrupt their ability to orientate towards the sea (DCCEEW, 2023). It should be noted that there are limited records of shearwater and petrel species within 20 km of the Project Area.

Fledging petrels and shearwaters can be attracted to and disoriented by artificial lights when leaving their nests for first time, resulting in mass groundings (Imber, 1975; Reed *et al.*, 1985; Rodríguez *et al.*, 2014; Rodríguez *et al.*, 2015). As a result, fledglings become vulnerable to predation, motor vehicle collisions or starvation (Le Corre *et al.*, 2002; Miles *et al.*, 2010). Fledglings originating from dark islands

can be affected by light pollution once they reach the sea (Rodríguez *et al.*, 2015). Some adult petrels and shearwaters demonstrate aversion to artificial light, which may cause decreased usage of artificially lit areas (Syposz *et al.*, 2021).

Wedge-tailed shearwaters begin preparing burrows in early July, lay eggs in mid to late November, and fledge in the middle of May (Burbidge & Fuller, 1998; Marchant & Higgins, 1990). As such, April-May is the period where the birds are most vulnerable to artificial light and should be considered the period of greatest biological importance.

Diurnal seabird species, such as frigatebirds, terns, noddies, and boobies, in contrast, are less vulnerable to the impacts of artificial light at night. However, artificial lighting may still impact their usage of foraging or roosting habitat.

Direct light and skyglow would be most visible to islands offshore of the northern portion of the Project Area where the jetty and Secondary Seawater Intake facility is proposed to be located. Fledgeling petrels and shearwaters originating from offshore rookeries are the most likely to be affected by Project lighting from this area. Project lighting from the barge and the dredge that operates at night may have an impact on seabird species that are active at night (petrels and shearwaters). Examples of potential ways seabirds may be impacted include:

- Seabirds avoiding the night-operating dredge and barge due to bright lights
- Individual birds colliding with the night-operating dredge and barge
- Seabirds becoming disorientated due to the lights on the night-operating dredge and barge

Mitigation measures will be undertaken to reduce the impact of Project lighting on seabirds. These measures would include:

- All fixed and mobile light towers to be positioned facing away from the mainland coast and offshore islands
- Light sources to be modified or shielded so they are not directly visible from foraging or nocturnal roost habitats
- Mobile light sources (e.g. headlamps, vehicle headlights) should not be directed into foraging or nocturnal roost habitats
- Fixed light sources which may permanently reduce habitat usage and provide a vantage point for aerial predators should not be installed
- Window screens or window tinting to be used to prevent any indoor lighting from reaching the outdoor environment
- The appropriate wavelength (most birds are sensitive to blue light) and appropriate commercial luminaries (Appendix 2:) to be used
- Lighting intensity to be kept as low as possible, particularly in areas adjacent to foraging or roosting habitat
- Lighting to be used only as required; motion-activated lighting may be suitable in some cases
- Works during peak seabird fledging (April/ May) to be limited unless all appropriate mitigation measures have been implemented

The inherent impact to shearwater and petrel species was considered *medium* (Table 5-8). It is *possible* that project lighting could impact fledging and result in grounding; however, there were limited records

of these species within 20 km of the Project Area, so the consequences were considered *minor*. If appropriate management actions are taken, the residual impact to shearwater and petrel species would be *low*. Both the inherent and residual impact to diurnal seabirds (terns, boobies, frigatebirds, noddies) was considered *low*, due to their lack of night-time activity (Table 5-8).

Table 5-9: Risk assessment for seabirds in the Project Area

Seabird Group	Impact*	Consequence	Likelihood	Ranking
Petrels, shearwaters	Inherent	Minor (2)	Possible (3)	Medium (6)
	Residual	Insignificant (1)	Unlikely (2)	Low (2)
Terns, boobies, frigatebirds, noddies	Inherent	Insignificant (1)	Unlikely (2)	Low (2)
	Residual	Insignificant (1)	Unlikely (2)	Low (2)

**The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures*

5.3 Terrestrial Fauna

To assess the impacts of Project lighting on terrestrial fauna (northern quoll, Pilbara leaf-nosed bat and grey falcon), the risk assessment matrix developed by Pendoley Environmental (Pendoley, 2022) was adapted by Biologic. The impact assessment matrix (Table 5-10), as well as definitions for the likelihood and consequence ratings (Table 5-11 and Table 5-12) are provided below.

The impacts of Project lighting on terrestrial species are assessed both prior to (inherent) and after (residual) the implementation of mitigation measures.

Table 5-10: Risk assessment matrix for northern quoll, Pilbara leaf-nosed bat and grey falcon

			Consequence (see Table 5-12 for definition)				
			Insignificant	Minor	Moderate	Major	Catastrophic
			1	2	3	4	5
Likelihood (see Table 5-11 for definition)	Almost Certain (95-100%)	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	Medium 4	Medium 6	Medium 8	High 10
	Rare (0-5%)	1	Low 1	Low 2	Low 3	Medium 4	Medium 5

Table 5-11: Definition of likelihood

Description	Frequency	Probability
Almost certain	Expected to occur 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 5-12: Definition of consequence

Description	Definition
Insignificant	Little to no impact on the overall ecosystem. Very small levels of impact on the northern quoll, Pilbara leaf-nosed bat or grey falcon and their habitats. Only occasional injury to, or mortality of, northern quoll, Pilbara leaf-nosed bat or grey falcon.
Minor	Impacts are present, but not to the extent that the overall condition of northern quoll, Pilbara leaf-nosed bat or grey falcon populations or their habitats are impaired in the long term. Low levels of mortality of northern quoll, Pilbara leaf-nosed bat or grey falcon and habitat loss. Recovery would generally be measured in years for habitats.
Moderate	Northern quoll, Pilbara leaf-nosed bat or grey falcon and their habitats are significantly affected. Recovery at the habitat level would take at least a decade, with recovery of northern quoll, Pilbara leaf-nosed bat or grey falcon populations taking several decades.
Major	Significant impact on northern quoll, Pilbara leaf-nosed bat or grey falcon 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 to recover.
Catastrophic	Northern quoll, Pilbara leaf-nosed bat or grey falcon habitat is irretrievably compromised. Mass mortality of northern quoll, Pilbara leaf-nosed bat or grey falcon and local extinction of species. Recovery over several decades for habitat values and centuries for northern quoll, Pilbara leaf-nosed bat or grey falcon populations.

5.3.1 Northern Quoll

The impact of artificial light on northern quolls is largely unknown. It is possible that artificial light may fragment foraging habitat if northern quolls avoid artificial light. Northern quolls are known to occur around mine sites and human dwellings, and to shelter amongst mine infrastructure such as vehicles, machinery and laydown areas (Oakwood, 2008) where there are enhanced levels of light. Higher concentrations of prey items (e.g. insects) may congregate around lights (Oakwood, 2008), affecting normal behaviour and movements of northern quolls.

The northern quoll has been recorded from spinifex grassland on rocky hills habitat (which provides potential denning/ shelter habitat) approximately 1 km north of the QA. The QA contains foraging habitat for northern quoll so any light in this area may impact foraging if it fragments suitable habitat. However, the quarry will be operated during daylight hours only therefore no lighting will be used at night in this area. Minimal lighting will be used in the early morning when personnel arrive for work with 40 km/hr speed limits in place during this time.

The inherent impact was considered *low* (Table 5-13), given that there is likely to be very little light impact near the northern quoll foraging habitat in the QA and surrounds, as well as the tendency of northern quolls to co-occur around mine sites. The general light management strategies that will be

put in place to reduce impacts on marine turtles and migratory shorebirds are also expected to benefit the northern quoll by minimising any impacts of artificial lighting on normal behaviour and movements. The residual impacts on northern quolls (i.e. impacts after general light management strategies are in place) would be considered *low*.

Table 5-13: Risk assessment for the northern quoll in the Project Area

Impact*	Consequence	Likelihood	Ranking
Inherent	Insignificant (1)	Unlikely (2)	Low (2)
Residual	Insignificant (1)	Unlikely (2)	Low (2)

**The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures*

5.3.2 Pilbara Leaf-nosed Bat

There is no roosting habitat (i.e. caves) for the Pilbara leaf-nosed bat within the Project Area or nearby. The Pilbara leaf-nosed bats recorded in the Project Area are likely to have travelled from a roost site in the ranges, approximately 20 km to the east (Phoenix, 2020). This roost would not be affected by Project lighting, other than perhaps a very small amount of sky glow.

Pilbara leaf-nosed bats display a curiosity for light sources (TSSC, 2016). Foraging Pilbara leaf-nosed bats have been recorded being attracted to artificial lights (car headlights, head torches and mine site lights) (Cramer et al., 2016), which may make them more susceptible to vehicle strike or predation. Changes to prey item aggregation caused by Project lighting may result in changes to foraging behaviour for the Pilbara leaf-nosed bat.

The Pilbara leaf-nosed bat has been observed to tolerate lighting associated with mining (MWH, 2014). However, there is uncertainty surrounding the light thresholds that the Pilbara leaf-nosed bat will tolerate with respect to artificial lighting.

The following mitigation measures will be undertaken to reduce the impact of Project lighting on foraging Pilbara leaf-nosed bats.

- Firstly, the general light management strategies that will be put in place to reduce impacts on marine turtles and migratory shorebirds are also expected to benefit the Pilbara leaf-nosed bat.
- Secondly, Mardie Pool is an important freshwater resource for Pilbara leaf-nosed bats and as such has been excluded from the development envelope. The intent is for this area to be retained as a dark refuge for Pilbara leaf-nosed bats. Dark refuges are one of the most effective measures for mitigating the impact of artificial lights on bats (DCCEEW, 2023). Mardie Pool is currently naturally screened (to some extent) by vegetation from Project lighting emanating from Mardie Village (approximately 2.7 km to the south-west) and the crystallisers (approximately 1 km to the north) (Figure 8). The crystallisers are planned to have minimal lighting and only during salt harvesting. The maximum height of lighting at the Salt Wash Plant is 3 m. As this is about the same height as the existing vegetative screening around Mardie Pool, lighting from the Salt Wash Plant is not expected to impact Mardie Pool. This vegetative screening provides a dark corridor for Pilbara leaf-nosed bats to commute to Mardie Pool from the east and west. North South Road does intersect this dark corridor; however, it should not significantly impact the use of the dark corridor by Pilbara leaf-nosed bats as it will not have street lighting. Additionally, traffic along North South Road is also expected to be minimal. North South Road is currently being used in the early mornings by construction work crews driving to their work areas for 6am pre-starts. During the operation phase, vehicle traffic associated with the night shift at the Salt Wash Plant will be required.

- Thirdly, the vehicle speed has been limited to 40 km/hr within 2 km of Mardie Pool. This is enforced during day and night to protect ecological (and heritage) values. Any Pilbara leaf-nosed bats that are attracted to vehicle headlights may be less likely to be struck by vehicles travelling at this lower speed.

The inherent and residual impacts of Project lighting were both considered *low* (Table 5-14). Unmitigated, it is *possible* that any night lighting would impact Pilbara leaf-nosed bats, and the impacts would be *insignificant*. The residual impacts to Pilbara leaf-nosed bats would be considered *low*.

Table 5-14: Risk assessment for the Pilbara leaf-nosed bat in the Study Area

Impact*	Consequence	Likelihood	Ranking
Inherent	Insignificant (1)	Possible (3)	Low (3)
Residual	Insignificant (1)	Possible (3)	Low (3)

**The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures*

Figure 8: Vegetation surrounding Mardie Creek (side view and aerial view)

5.3.3 Grey Falcon

Recent estimates suggest the grey falcon comprises a single, freely interbreeding population (Mullin et al., 2020). Modelling by Runge et al. (2014) estimated the minimum range size for this species as 882,558 km^2. Despite this very large range, recent research has shown that the grey falcon is a 'reluctant nomad'; only if conditions become a risk to their survival are they likely to move on and then, when they do, they move no further than necessary (Schoenjahn, 2018). The grey falcon tends to stay and forego breeding rather than search for more favourable conditions (Schoenjahn, 2018).

The grey falcon is restricted by habitat in relation to suitable roosting sites such as inland drainage lines, grasslands sparse wooded lowlands and building infrastructure (i.e. communication towers). Notwithstanding, TSSC (2020) lists 'nest shortage' as a high threat.

Grey falcons frequently roost on bare ground, exposing them to predation (e.g. by cats) as documented by Schoenjahn (2018). Project lighting may exacerbate the likelihood of predation if individuals roost on the ground. However, the effects of artificial light on predator-prey relationships have been little explored (Jolkkonen *et al.*, 2023) so this is not a certain impact.

The grey falcon was recorded in the centre and south-eastern corner of the Optimisation Area (Phoenix, 2022a) and is likely that the grey falcon recorded was nesting in a communications tower close to Mardie homestead (Phoenix, 2022a). The most likely impact of Project lighting on this species would be that individuals forego breeding but remain in the Project Area. The least likely impact would be displacement (i.e. individuals move into nearby suitable habitat).

The inherent and residual impacts of Project lighting on this species were both considered *low* (Table 5-15). Unmitigated, it is *unlikely* that any night lighting would impact grey falcons, and the impacts would be *insignificant*. Nonetheless management measures will be implemented. If grey falcons are observed nesting within the Project Area or nearby, they will be monitored, and actions will be taken to ensure they are not impacted by Project lighting. This would exclude light that existed prior to when any grey falcons commence nesting. The general light management strategies that will be put in place to reduce impacts on marine turtles and migratory shorebirds are also expected to benefit the grey falcon. The residual impacts to the grey falcon would be considered *low*.

Table 5-15: Risk assessment for the grey falcon in the Project Area

Impact*	Consequence	Likelihood	Ranking
Inherent	Insignificant (1)	Unlikely (2)	Low (2)
Residual	Insignificant (1)	Rare (1)	Low (1)

**The Project lighting impacts were assessed both prior to (inherent) and after (residual) the implementation of mitigation measures*

6. PROVISION OF THE ILLUMINATION PLAN

The outcome-based provisions of this Illumination Plan are set out in Table 6-1 while the objective-based provisions of this Plan are set out in Table 6-2.

6.1 Outcome-based Provisions

Table 6-1: Outcome-based Provisions of the Illumination Plan

EPA Factors: Marine Fauna and Terrestrial Fauna.

EPA Objectives:

- to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
- to protect marine fauna so that biological diversity and ecological integrity are maintained.

Outcome: no significant impact of artificial lighting on marine or terrestrial fauna.

Key Environmental Values: conservation significant fauna and their habitats.

Key impacts and risks: increased light.

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
1	**Trigger***: The spatial distribution of marine turtle beach usage shows a statistically significant change in a single season compared to the baseline data for that site **Threshold****: The spatial distribution of marine turtle beach usage shows a statistically significant change in two or more consecutive seasons compared to the baseline data for that site	**Trigger level actions**: • Undertake review of the marine turtle monitoring data, artificial light data, and other data as relevant, to determine if this change could be due to natural variability in nesting behaviour or artificial light impacts • Consider whether change could be due to natural influences (e.g. cyclones, heavy rain events inundating beaches, El Nino/ La Nina impacts, or global warming and sea level rise) • Assess Project lighting together with the light audit results to identify any problem lighting • Identify individual lights that are directly visible or poorly shielded	**Indicator**: The spatial distribution of marine turtle nesting activity (i.e. location along the beach) (refer Figure 3) Artificial light monitoring (refer Figure 3) **Methods**: Refer to the Marine Turtle Monitoring Program (Pendoley Environmental, 2023c) for detailed method (using nearest neighbour spatial analysis) and locations **Locations**: Track census will be routinely conducted throughout the	Marine turtle monitoring will be undertaken annually, commencing in the 2023/24 marine turtle nesting season Surveys will be conducted over a 14-day period in the peak nesting season for hawksbill (October), green (December) and flatback (December) turtles If trigger criteria are exceeded, additional seasons of monitoring may be required to determine cause and monitor remedial	Performance against criteria to be reported annually in EPBC compliance report Notify DCCEEW if marine turtle monitoring data identifies impacts due to artificial lighting and within three months of identifying or predicting exceedance, submit either a revised and additional avoidance and mitigation measures to reduce impacts to marine turtles or an Offset Strategy. The Illumination Plan will be updated if any	MS 1175, EPBC 2018/8236

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		• Modify light fixtures to include additional shielding and/ or re-orientate light fixtures, if required • Reduce the colour temperature or intensity of light sources, if required • Eliminate lights that are surplus to operational needs **Threshold contingency actions**: • Undertake review of the marine turtle monitoring data, and other data as relevant, to determine if this change could be due to natural variability in nesting behaviour or artificial light impacts • If determined likely to be the result of project lighting impacts, undertake lighting audit within one month and implement measures to reduce light spill/ glow levels at impacted site(s) • An additional survey should be undertaken after implementation of any proposed actions to determine whether the actions have been successful. This additional survey would be conducted at the beginning of the next turtle nesting season. If engineering solutions fail, then intervention at the nesting beach may be required (individuals	marine turtle nesting season at mainland beaches near Mardie Creek, as well as Long and Sholl Islands Artificial light monitoring will be undertaken at mainland beaches (Mardie Creek East and West), as well as Long and Sholl Islands Opportunistic surveys of nesting activity will also be undertaken at other monitoring sites, including Round, Middle Passage, Angle, Passage, South Passage, Mardie, Stewart, and Fortescue Islands	actions, pending the outcome of the review An additional survey at the beginning of the next turtle season should be undertaken after implementation of any proposed actions (e.g. mitigation measures) to determine whether the actions have been successful.	adverse impacts are detected The Illumination Plan must be reviewed every 5 years by an independent SME. Any changes to the Illumination Plan to be submitted for approval by DWER and DCCEEW The Illumination Plan will be implemented for the life of the Project Inform DCCEEW within 7 days if an impact is found to be caused by artificial lighting	

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		returned to nearest beach) in consultation with and under recommendations from an appropriate subject matter expert consistent with the Turtle Monitoring Plan (Pendoley Environmental, 2023c). • Review the implementation of lighting management actions within this plan				
2	**Trigger**: Marine turtle hatchling behaviour (i.e. nest fan metrics) displays variation in spread and/or offset angles that exceed the 95th percentile[#] when compared to the baseline data. **Threshold**: Marine turtle hatchling behaviour (i.e. nest fan metrics) displays variation in spread and/or offset angles that exceed the 99th percentile[#] when compared to the baseline data.	**Trigger level actions**: • Undertake review of Project lighting to determine if artificial lighting is the likely cause of the variation • Identify individual lights that are directly visible or poorly shielded • Modify light fixtures to include additional shielding and/ or re-orientate light fixtures, if required • Reduce the colour temperature or intensity of light sources, if required • Eliminate lights that are surplus to operational needs **Threshold contingency actions**: • Undertake review of artificial light monitoring and hatchling orientation data to determine cause	**Indicator**: Spread and offset angles of marine turtle hatchling fans **Methods**: Refer to the Marine Turtle Monitoring Program (Pendoley Environmental, 2023c) for detailed method and locations **Locations**: Hatchling orientation metrics will be routinely monitored at mainland beaches near Mardie Creek, and at Long and Sholl Islands. Artificial light monitoring will be undertaken at mainland beaches (Mardie Creek East and West), as well as Long and Sholl Islands Hatchling orientation data will also be opportunistically	Marine turtle monitoring will be undertaken annually, commencing in 2023/24 marine turtle nesting season. Surveys will be conducted over a 14-day period over a new moon in the peak hatching season for hawksbill (December), flatback and green turtles (February). An additional survey should be undertaken after implementation of any proposed actions to determine whether the actions have been successful	Performance against criteria to be reported annually in EPBC compliance report. Notify DCCEEW if marine turtle hatchling data identifies impacts due to artificial lighting and within three months of identifying or predicting exceedance, submit revised and additional avoidance and mitigation measures to reduce impacts to marine turtles or an Offset Strategy. The Illumination Plan will be updated if any adverse impacts are detected. Inform DCCEEW within	MS 1175, EPBC 2018/8236,

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		• The review will also rate the level of impact associated with this exceedance and recommend remedial actions to reduce light spill on the impacted site(s) • Remedial actions will be implemented and monitored for success • Additional engineering and/ or operational solutions will be implemented where practicable to control or modify the 'problem light(s)' (see Section 8.2.1) • Review the implementation of lighting management actions within this plan	recorded at other monitoring sites, including Round, Middle Passage, Angle, Passage, South Passage, Mardie, Stewart and Fortescue Islands.		7 days if an impact is found to be caused by artificial lighting The Illumination Plan must be reviewed every 5 years by an independent SME. Any changes to the Illumination Plan to be submitted for approval by DWER and DCCEEW. The Illumination Plan will be implemented for the life of the Project. The trigger and threshold criteria may be reviewed at the end of each season to ensure that they remain suitable.	
3	**Trigger***: A decline in abundance and diversity of migratory shorebirds >25% from baseline levels **Threshold****: A decline in abundance and diversity of migratory shorebirds >25% from baseline	**Trigger level actions**: • Identify whether the likely cause is artificial lighting • Identify whether trigger criteria exceedance is due to sampling variability • Compare results with control sites to determine if decline may be attributable to the Project	**Indicator**: Migratory shorebird presence, recorded via: • Aerial (helicopter) surveys • Ground-based bird counts **Methods**: Refer to the Long-term migratory shorebird monitoring program (LMSMP) (Phoenix,	Annual migratory shorebird monitoring surveys to be conducted in summer (repeated at both high and low tide over 4 consecutive days in late January or early February) Migratory shorebird monitoring to continue for a minimum of five	Details of any incidence of seabird interaction with the dredges or barge as well as any mis-orientated or disorientated migratory seabirds will be recorded in the BCI Incident Reporting System, and the Fauna	MS 1175, EPBC 2018/8236

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	levels over two consecutive years	• Review migratory shorebird monitoring methods and refine, if necessary • Project lighting will be assessed together with the light audit results to identify any likely problem lighting • Within seven days of becoming aware of the impact, implement management actions to remove the most likely cause of the impact and implement management actions that will mitigate the impact • Within two months of becoming aware of the impact, complete investigation of the likely cause(s) of the impact(s) • Review the implementation of lighting management actions within this Plan • Review employee guide/ handbook on good lighting practices **Threshold contingency actions**: • Review and implement trigger level actions where applicable • Investigate the likely cause • Compare results with control areas to determine if decline may be attributable to the Project. If triggered, but the change is	2022c) for detailed methods and locations **Locations**: Monitoring sites - Impact Area (nine sites) and Control Area (nine sites) Artificial light monitoring will be undertaken at mainland beaches (Mardie Creek East and West) Additional ground-based surveys (e.g. around Karratha, approximately 100 km east of the Project) to provide regional data to be used to calibrate for annual variation in migratory shorebird numbers	years to capture shorebird assemblage during construction and post construction phases of the Project.	Management Procedure would be implemented Within four months of becoming aware of impact(s), submit report to DCCEEW Performance against criteria – annually in EPBC compliance report. Annual Shorebird Monitoring Survey for the Project, as per the LMSMP The Illumination Plan will be implemented for the life of the Project Results of each completed monitoring survey to be submitted to the ‘Shorebirds 2020’ initiative, DCCEEW and DBCA Inform DCCEEW within 7 days if an impact is found to be caused by artificial lighting	

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		recorded regionally (across both impact and non-impact/ control sites) and found to be indicative of a regional rather than Project related change/ impact (e.g. influencing environmental factor) no further corrective action is required • Additional engineering and/or operational solutions will be implemented where practicable to control or modify the 'problem light(s)'				
4	**Trigger***: An increase in light measured at Mardie Pool >15% from baseline levels (taken once the additional controls in Table 4-1 are implemented at Mardie Village) **Threshold****: An increase in light at Mardie Pool >25% from baseline levels (taken once the additional controls in Table 4-1 are implemented at Mardie	**Trigger level actions**: • Identify whether the likely cause is artificial lighting • Project lighting will be assessed together with the light audit results to identify any likely problem lighting • Review the implementation of lighting management actions within this Plan • Review employee guide/ handbook on good lighting practices **Threshold contingency actions**: • Review and implement trigger level actions where applicable • Investigate the likely cause	**Indicator**: Data from the light monitoring site at Mardie Pool **Methods**: Light will be measured in conjunction with the Marine Turtle Monitoring Program. See Pendoley Environmental (2023c) for detailed light data collection methods **Locations**: Mardie Pool	Light monitoring will be undertaken annually, commencing in 2024	Any injured or disorientated Pilbara leaf-nosed bats would be opportunistically recorded in the BCI Incident Reporting System, and the Fauna Management Procedure would be implemented Performance against criteria – annually in EPBC compliance report. The Illumination Plan will be implemented for the life of the Project Inform DCCEEW within 7 days if an impact is	MS 1175, EPBC 2018/8236

No.	Indicators: **Trigger Criteria** **Threshold Criteria**	Response actions: **Trigger Level Actions** **Threshold Contingency Actions**	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
	Village) over two consecutive years	• Additional engineering and/or operational solutions will be implemented to control, modify or screen the 'problem light(s)'			found to be caused by artificial lighting	

Notes:

 # The 95% and 99% limits are based on a control chart approach for analysing circular data that was developed by a statistics expert from Pendoley Environmental. Any post-baseline value that falls outside of these limits will 'trigger' the trigger level actions and/or threshold contingency actions. The 95% and 99% limits were chosen as an initial, conservative (i.e. highly sensitive) guide to detect change. If the triggers and thresholds are often exceeded, these criteria may need to be reviewed.

**Trigger levels are set to reveal any significant change from baseline levels. This activates the trigger level actions which are designed to identify whether the impact is due to artificial lighting and, if so, to allow for early remediation measures to be undertaken.*

***Threshold levels are set so that natural interannual fluctuations are less likely to cause the threshold to be reached*

6.2 Objective-based Provisions

Table 6-2: Objective-based Provisions of the Illumination Plan

EPA Factors: Marine Fauna and Terrestrial Fauna.

EPA Objectives:

- to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
- to protect marine fauna so that biological diversity and ecological integrity are maintained.

Objective: no significant impact of artificial lighting on marine or terrestrial fauna.

Key environmental values: fauna species of conservation significance and their habitats.

Key impacts and risks: light emissions and subsequent habitat loss or degradation.

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
1	Implement the project to ensure that the minimum number and intensity of lights are in use	The following actions/ controls will be implemented to minimise the number and intensity of lights to meet the objective: • No lights used when practicable • All non-essential lighting to be switched off when not in use • Reduce unnecessary lighting at sea • All construction lighting to be switched off when not in use • Construction or and/or clearing within 1 km from the nearest part of Mardie Pool to only occur during daylight hours to minimise lighting impacts on terrestrial fauna • Night-time vehicle movements will be minimised to minimise potential vehicle strikes of Pilbara leaf-nosed	**Indicator**: Lights used are the minimum number and intensity practicable **Method:** A comparative assessment of lighting design to identify the minimum number and intensity of lights required to meet lighting objectives while addressing human health and safety There may be a trade-off between the number of lights and intensity of each light (explore with modelling using conventional lighting design software) **Location**: Mardie Project Area, Optimisation Area and Quarry Area	An annual external audit will be undertaken at least six weeks prior to every marine turtle nesting season which begins in October. This timing also coincides with the beginning of the arrival of migrating shorebirds to the area (around September). Recommendations for modifications/upgrading of components will then be undertaken prior to nesting season. Additional audits to be scheduled as necessary (e.g. following major weather	Performance against management target – annually in the MS1175 Compliance Assessment Report (CAR) and the EPBC compliance reports Exceedance of management target – annually in the CAR and EPBC compliance reports Reporting on the review and revision of management actions – annually in the CAR and the EPBC compliance report The Illumination Plan will be implemented	MS 1175, EPBC 2018/8236

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		bats (which are attracted to vehicle headlights) • Vehicle speed limited to 40 km/ hr within 2 km of Mardie Pool, during day and night to minimise potential vehicle strikes of Pilbara leaf-nosed bats. • Limit traffic along North South Road during the night to minimise potential vehicle strikes of Pilbara leaf-nosed bats. • If grey falcons are observed nesting within the Project Area or nearby, they will be monitored, and actions will be taken to ensure they are not exposed to light. This would exclude light that existed prior to when any grey falcons commence nesting • Minimal lighting will be used at the Quarry Area (only in the early morning) to minimise potential impact on the northern quoll • Consider redesigning activities that require lighting so that they can be done elsewhere (e.g. fabrication or maintenance), in daylight, automated, out of turtle nesting season, or with task lighting only (e.g. head torches) • Only the minimum number and intensity of lights needed to provide safe and secure illumination required		events or major changes in Project facilities or buildings)	for the life of the Project	

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		to meet the lighting objectives, including health and safety requirements, to be installed • Intensity of light should be measured in lumens, not wattage, when comparing intensity between different lighting design options • No works to be inside the exclusion zone around Mardie Pool, which will provide a dark refuge for the Pilbara leaf-nosed bat • An employee guide/ handbook on good lighting practices will be developed and implemented				
2	Implement the project to ensure that lighting is adapted for colour, intensity, and timing	• Identification of, and measures taken, to reduce impacts of problem lights (as identified during light audits) • Intensity should be reduced to as low as possible, regardless of the type, colour, and planned operation of the light • White lights should be replaced with amber/ orange lights, where practicable • High-pressure sodium vapour lights will not be used near bat habitat. • If white lights are required, filters to block green, blue, violet, and ultra-violet wavelengths should be applied • For lights that are not required to be continuously lit, smart LED technology	**Indicator**: Lights used are to reflect the requirements of the management actions **Method:** Ensure compliance with control measures and approved lighting design **Location**: Mardie Project Area, Optimisation Area and Quarry Area	An annual external audit will be undertaken at least six weeks prior to every marine turtle nesting season which begins in October. This timing also coincides with the beginning of the arrival of migrating shorebirds to the area (around September). Recommendations for modifications/upgrading of components will then be undertaken prior to nesting season. Additional audits to be scheduled as	Performance against management target – annually in the CAR and the EPBC compliance reports Exceedance of management target – annually in the CAR and EPBC compliance reports Reporting on the review and revision of management actions – annually in the CAR and the EPBC compliance report The Illumination Plan will be implemented	MS 1175, EPBC 2018/8236

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		(switches off when not in use) or intermittent flashing lights to be used • The suitability of different commercial lights, with respect to reducing impacts to marine turtles, is summarised in Appendix 2 • Accommodation buildings, outdoor lighting to utilise amber LED emitters (~585 nm 'true amber', 'phosphor-coated (PC Amber') • Outdoor public areas, high mast floodlighting to be minimised and to use reduced blue LED (≤ 2700K (Kelvin) CCT (colour temperature) light at a minimum, < 2200K CCT is ideal) • Walkway/ pathways to use amber LED emitters (~585 nm 'true amber' emitters, 'phosphor-coated amber') • Portable Lighting Towers will use ~590 nm able filter, shrouds, and interchangeable mast heights • Streetlights to utilise LEDs with a CCT equal to or lower than 2200 K • If specific, intermittent tasks require a brighter white light for better colour rendition (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,		necessary (e.g. following major weather events or major changes in Project facilities or buildings)	for the life of the Project	

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		put on a timer, or can be manually switched off • Intermittent/ flashing lights, or reflectors will be used in areas for purposes that do not require continuous light (e.g. to identify an entrance or delineate a pathway) • All non-essential lighting (e.g. tennis court/ playing field lighting) to be automatically switched off at a predetermined curfew hour (9 pm) • Identification of any new information regarding potential impact pathways between artificial light associated with the Project and marine turtles, and any adaptive management measures that could further reduce potential impacts				
3	Implement the Project to ensure only the area intended is illuminated (to avoid light spill)	To avoid light spill, light fittings will be designed, located, and directed to avoid lighting anything but the target area by: • 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 (e.g. low bollard lighting for pathways and walkways, low wall mounted lights around buildings and on decks, banister mounted lights on	**Indicator**: Areas not intended to be illuminated are exposed to light **Method:** Visual observation of selected indicators **Location**: The Project Area – including Mardie Project Area, Optimisation Area and Quarry Area	An annual external audit will be undertaken at least six weeks prior to every marine turtle nesting season which begins in October. This timing also coincides with the beginning of the arrival of migrating shorebirds to the area (around September). Recommendations for modifications/upgrading of components will then	Performance against management target – annually in the CAR and the EPBC compliance reports Exceedance of management target – annually in the CAR and EPBC compliance reports Reporting on the review and revision of management actions – annually in the CAR	MS 1175, EPBC 2018/8236

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		stairs or embedded in risers and focussed downwards, where practicable) • Streetlights to only be used where necessary (e.g. in high traffic areas such as road junctions) and pole heights should be as low as possible. Bollard lighting used instead of light poles/ masts, where practicable. Pole height should be capped at 3 m • The existing vegetation between the Project Area boundary and adjacent bushland, dunes, and beaches to be maintained and enhanced where feasible • No unshielded wall mounted bulkhead lighting to be used on buildings, including balconies • Project lights to be directed away from turtle nesting beaches. Lights required to be directed towards the nesting beaches should be placed so that buildings provide shielding • Mobile light sources not to be oriented towards nesting habitat or seaward and the height of these kept to a minimum. If this is not possible, these lights will be shielded to prevent light spill		be undertaken prior to nesting season. Additional audits to be scheduled as necessary (e.g. following major weather events or major changes in Project facilities or buildings)	and the EPBC compliance report The Illumination Plan will be implemented for the life of the Project	

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		• 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, and by using the light housing which prevents horizontal light above a 45-degree angle • Glass (windows/ doors) of buildings to have opaque (block-out) blinds/ curtains/ shutters fitted • Building and vessel window blinds will be shut during hours between sunset and sunrise • Lighting to be confined to essential purposes only. Decorative lighting (e.g. upward facing lights to illuminate building facades or gardens) not to be used • All service and laydown areas to be illuminated only when required and lights will be shielded to prevent light spill. Mast lighting to be mounted at a maximum height of 3 m • Maintain a dark zone between turtle nesting beach and Project infrastructure • Limit number of beach access areas or construct beach access such that				

No.	Management Target	Management Actions	Monitoring Indicators, Methods and Locations	Monitoring Timing and Frequency	Reporting	Applicable Approvals
		artificial light is not visible through the access point • Avoid significantly increasing whole of sky brightness at Long and Sholl Islands • Maintain Mardie Pool as a dark refuge for Pilbara leaf-nosed bats				
4	Implement the Project using non-reflective, dark coloured surfaces	To reduce reflectance and scattering of light that contributes to sky glow: • Exterior finishes on all buildings will be matte and have a maximum reflective value of 30% • Surfaces of main structures and ground coverings to be matte and have a maximum reflective value of 30%, where practicable • There will not be any shiny bright white painted surfaces on buildings, on wastewater treatment tanks or facilities	**Indicator**: Exterior surfaces will be checked for reflective value **Method:** Visual observation of selected indicators **Location**: Mardie Project Area, Optimisation Area and Quarry Area	An annual external audit will be undertaken at least six weeks prior to every marine turtle nesting season which begins in October. This timing also coincides with the beginning of the arrival of migrating shorebirds to the area (around September). Recommendations for modifications/upgrading of components will then be undertaken prior to nesting season. Additional audits to be scheduled as necessary (e.g. following major weather events or major changes in Project facilities or buildings)	Performance against management target – annually in the CAR and the EPBC compliance reports Exceedance of management target – annually in the CAR and EPBC compliance reports Reporting on the review and revision of management actions – annually in the CAR and the EPBC compliance report The Illumination Plan will be implemented for the life of the Project	MS 1175, EPBC 2018/8236

7. MONITORING

Monitoring of light will be undertaken and compared to data collected from marine turtle monitoring (Section 7.1) and shorebird and seabird monitoring (Section 7.2). Light will be monitored at Mardie Pool to ensure levels are minimised to ensure a dark refuge for the Pilbara leaf-nosed bat (Section 7.3).

General monitoring of light in relation to the grey falcon and northern quoll is not considered necessary. However, if grey falcons are observed nesting within the Project Area or nearby, they will be monitored. A new light monitoring site would also be located near the nest (providing access is not constrained) to ensure that lighting levels do not increase due to the Project.

If monitoring for other species triggers mitigation measures to be undertaken, these measures are also likely to benefit grey falcon and northern quoll.

The baseline light data (already collected at sites relevant to marine turtles and shorebirds) will be compared to monitoring data gathered during the ongoing construction phase, and through operations, to determine if:

- There is any change in marine turtle behaviour or shorebird numbers
- Whether any changes (if relevant) can be attributed to Project lighting

7.1 Marine Turtle Monitoring

All monitoring data (marine turtle and light data) required to monitor the impacts of Project lighting on marine turtles for this Illumination Plan will be collected through the Marine Turtle Monitoring Program (Pendoley Environmental, 2023c).

Hatchling marine turtles onshore on coastal islands are most at risk of a negative impact from Project lighting (Section 5.1). Hatchling marine turtles onshore on the mainland, nesting adult turtles and hatchlings offshore are at lower risk. Given this, proposed marine turtle monitoring will focus on:

- Measuring the orientation of hatchlings (i.e. nest fan metrics) at the nesting habitat to determine the influence of Project light on their orientation
- Monitoring nesting females to determine if there is a change in habitat use over time that could potentially be due to Project lighting

Locations proposed for marine turtle monitoring include Long and Sholl Island (due to its area of critical marine turtle habitat, multi-species use, and the high number of nesting turtles recorded during baseline surveys) and on the mainland (due to it being in closest proximity to the Project Area).

Light monitoring to collect measurements on the intensity and extent of light sources visible from nesting beaches will be undertaken. Light monitoring locations will be within the defined hatchling fan monitoring zones on Long and Sholl Island, and on the mainland (Figure 3).

Hatchling orientation data and information on female habitat use was gathered during the 2018/19, 2021/22 and 2022/23 surveys to understand hatchling behaviour and nesting patterns. The baseline data will be compared to data gathered throughout construction and operation to monitor any change in marine turtle behaviour that may be attributed to the Project lighting.

The methods used to undertake both light monitoring and marine turtle monitoring are detailed in the Marine Turtle Monitoring Program (Pendoley Environmental, 2023c).

7.2 Shorebird and Seabird Monitoring

The monitoring data required to monitor the impacts of Project lighting for this Illumination Plan will be collected through other programs undertaken for the Project as follows:

- Light monitoring data will be collected through the Marine Turtle Monitoring Program (Pendoley Environmental, 2023c)
- Shorebird monitoring data will be collected through the Annual Shorebird Monitoring Surveys (Phoenix, 2023b)

Light monitoring data will be collected from two light monitoring sites situated north and south of Mardie Creek as well as north and south of the jetty (Figure 4).The sites near the jetty are expected to be exposed to the most Project lighting, therefore are anticipated to provide a good indication of light levels to compare to the shorebird and seabird monitoring data.

The shorebird and seabird monitoring data will comprise the results from avifauna aerial surveys. The aerial surveys are conducted in impact areas (up to 5 km from the development envelope of the Project) and control areas (10 – 40 km south) of the Project (Figure 4). Aerial surveys may also be completed around Karratha (approximately 100 km north-east of the Project) to provide regional data to calibrate for annual variation in migratory shorebird numbers. Following the collection of aerial survey data each year, the average counts by species per detection will be compared to the previous years' data to determine whether there are any changes to the population of shorebirds present within the Study Area (Study Area shown in Figure 4). Ground surveys will also be undertaken at the Evaporation Ponds to provide information on any changes to habitat use by migratory birds in response to the Project. While completing these surveys, any evidence of predation pressure from cats and/ or dogs or disturbances caused by humans will also be recorded. This data will be used to determine whether the artificial lighting near the Evaporation Ponds (i.e. from the Primary Seawater Intake facility) has contributed to increased predation.

The results of the aerial surveys will be compared against the light monitoring data. It is important to note that five years of annual monitoring data is needed before statistically valid population trends can be assessed (Phoenix, 2023a). So far two annual monitoring surveys have been undertaken.

Further details of the methods used to undertake shorebird monitoring as well as baseline data are provided in Phoenix (2023b). The methods used to undertake light monitoring are comprehensively explained in Pendoley Environmental (2023c).

In addition to the above, the details of any incidence of seabird interaction with the dredges or barge as well as any mis-orientated or disorientated migratory seabirds will be recorded in the BCI Incident Reporting System, and the Fauna Management Procedure would be implemented. Details will include the species of seabird, time of incident and outcome of the interaction.

7.3 Pilbara Leaf-nosed Bat

A light monitoring site will be situated at Mardie Pool (Figure 5). Baseline light monitoring data will be collected from the Mardie Pool light monitoring site once the additional controls in Table 4-1 are implemented at Mardie Village. This will give an indication of Mardie Pool's quality as a dark refuge once the lighting in Mardie Village is improved for use near fauna. If light levels subsequently increase at Mardie Pool over time, management actions will be undertaken to reduce the penetration of Project lighting into Mardie Pool (e.g. screening with a timber barrier if the ability for vegetation to screen light deteriorates). Following any substantial mitigation measures, monitoring of Pilbara leaf-nosed bats

would be undertaken to ensure that individuals of this species were still using Mardie Pool. Any injured or disorientated Pilbara leaf-nosed bats would be opportunistically recorded in the BCI Incident Reporting System, and the Fauna Management Procedure would be implemented. Details will include the time of incident and outcome of the interaction.

8. ADAPTIVE MANAGEMENT AND REVIEW OF THE ILLUMINATION PLAN

8.1 Audit Process

An artificial light audit will be undertaken across the Project Area after construction or modification/ upgrading of each major component of the project (as identified in Table 4-1) to confirm compliance with this Illumination Plan and the National Guidelines (DCCEEW, 2023). The audit will be conducted by an appropriately qualified environmental practitioner/ technical specialist (Subject Matter Expert). An artificial light audit will involve the following:

- Review of the latest version of the Illumination Plan
- Review of light management in the context of approval conditions and best practice light management (DCCEEW, 2023)
- Review as-built drawings for the lighting design
- Check for compliance with the approved lighting design
- An inspection of the Project Area both during the day and at night to visually check and measure the placement, number, intensity, spectral power output, orientation and management of each lamp and lamp type
- A visual inspection of the facility lighting from the location of fauna habitat and, where possible, the perspective of the wildlife (i.e. sand level for a marine turtle)
- measurements appropriate for indicating impacts to fauna (in accordance with Table 6.1 and 6.2), noting limitations for measurement
- Record, collate and report on the findings and include any nonconformances. Consider any differences between baseline and post-construction observations. For aspects of the Project yet to have detailed lighting design, that are considered to pose a risk of impact to fauna (such as the SoP), model lighting at design phase and adjust design accordingly if it does not meet fauna impact objectives. Where lighting outputs were modelled as part of the design phase, compare actual output with modelled scenarios
- Provide recommendations for any improvements or modifications to the lighting design that will decrease the risk of impact on conservation significant fauna

BCI have also committed to a minimum of one annual internal light audit at least six weeks prior to every marine turtle nesting season (October) and the arrival of migrating shorebirds to the area (around September).

8.2 Adaptive Management

In general, adaptive management in relation to the Illumination Plan will include the following:

- Monitor and evaluate performance against the outcome-based triggers and thresholds (Section 6.1)
- Monitor and evaluate the effectiveness of the management actions against the management targets (Section 6.2)

- Specifying monitoring and reporting procedures to provide for continuous improvement, consistent with an adaptive management approach
- In the event one or more of the triggers, thresholds or management targets has not been met, or is considered at risk of not being met, review and adjust the management measures and monitoring to ensure the objectives are met, based on what is learned from evaluation of the monitoring data, or any new data that becomes available
- Review any assumptions considering the monitoring data or any new data that becomes available

Species-specific adaptive management measures for marine turtles, shorebirds and seabirds as well as Pilbara leaf-nosed bats are given below.

8.2.1 Marine Turtles

If marine turtle monitoring identifies misorientation in hatchlings after they leave the nest or if monitoring shows a shift in the usage of nesting habitat by adult females compared to the baseline data, and this is associated with an increase in light levels at the monitoring sites, the Project lighting will be assessed together with the light audit results to identify the likely problem lighting.

Additional engineering and/or operational solutions will be implemented where practicable to control or modify the 'problem light(s)', such as:

- Changing wavelength of light for marine turtles
- Reducing the brightness of the light
- Changing orientation and direction of light fittings
- Erecting additional shielding
- Considering whether activities requiring illumination of problem lights can be undertaken during daylight hours only or used outside of turtle nesting season

An additional survey should be undertaken after implementation of any proposed corrective actions to determine whether the actions have been successful in reducing light levels. This additional survey would be conducted at the beginning of the next turtle nesting season.

8.2.2 Shorebirds and Seabirds

If shorebird and seabird monitoring identifies a decline in abundance of birds near the Project Area (impact sites) relative to the control sites (or regional reference sites) and this decline is associated with an increase in light levels at the monitoring sites, the Project lighting will be assessed together with the light audit results to identify the likely problem lighting.

Additional engineering and/or operational solutions will be implemented where practicable to control or modify the 'problem light(s)', such as:

- Changing wavelength of light to be suitable for shorebirds
- Additional shielding.
- Reducing the brightness of the light.
- Changing orientation and direction of light fittings.

- Erecting additional shielding
- Consideration to whether activities requiring illumination of problem lights can be undertaken during daylight hours only or used outside of turtle nesting season
- If artificial lighting near the Evaporation Ponds (i.e. from the Primary Seawater Intake facility) has contributed to increased predation, measures to control the predators (e.g. cats or dogs) will be undertaken

An additional survey should be undertaken after implementation of any proposed corrective actions to determine whether the actions have been successful in reducing light levels.

8.2.3 Pilbara Leaf-nosed Bats

If light monitoring at Mardie Pool identifies an increase from baseline levels (taken once the additional controls in Table 4-1 are implemented at Mardie Village), the Project lighting will be assessed together with the light audit results to identify whether the increase is due to the lights themselves or the 'screen' provided by existing vegetation becoming less effective over time. Additional engineering and/ or operational solutions will be implemented to control or modify the issue, such as:

- Changing wavelength of light
- Reducing the brightness of the light
- Changing orientation and direction of light fittings
- Screening with a timber barrier

An additional survey should be undertaken after implementation of any proposed corrective actions to determine whether the actions have been successful in reducing light levels.

8.2.4 Grey Falcon

If grey falcons are observed nesting within the Project Area or nearby, they will be monitored, and actions will be taken to ensure they are not exposed to increased levels of light as a result of the Project. This would exclude light that existed prior to when any grey falcons commence nesting.

8.3 Review

The Illumination Plan will be reviewed every 12 months, as required following significant amendments (for example in response to the adaptive management process outlined above), or in response to outcomes of the monitoring required by condition B5-3 of Ministerial Statement 1211 (EPA, 2023b).

The Illumination Plan will also be reviewed following the finalisation of the lighting design for the Secondary Seawater Intake facility, Salt Wash Plant, SOP Plant and Quarry, with the subsequent revision(s) to be approved by the DCCEEW prior to the installation of any lighting at these elements.

The Plan will continue to be implemented until the CEO has confirmed in writing, on advice from DBCA and DWER, that the outcome of condition B5-1(1-3) has been and will continue to be met (EPA, 2023b). In addition, the Illumination Plan will be reviewed every 5 years by an independent Subject Matter Expert (SME).

Regional and cumulative impacts will be considered against the baseline assessments (i.e. Pendoley Environmental 2019, Mardie Salt Project Marine Turtle Monitoring Program 2018/2019.) during the Reporting on the review and revision of management actions – annually in Ministerial Statement

Compliance Assessment Report (CAR) and the EPBC compliance reports. Additionally, regional and cumulative impacts will be considered as part of the 5-year review of the Illumination Plan. All reviews will consider:

- Outcomes of monitoring programs (i.e. Marine Turtle Monitoring Program (Pendoley Environmental, 2023c), Annual Shorebird Monitoring Surveys (Phoenix, 2023b)).
- Implementation and effectiveness of management measures and monitoring programs.
- Threshold/trigger criteria and threshold/trigger level actions.
- Changes to relevant legislation, policy, guidelines, management plans and industry practices.
- Changes to operational activities.
- Changes to approval conditions.
- Changes to the conservation status of fauna species.
- The identification of a conservation significant fauna species not previously confirmed within the Project area.
- Recurring incidents of death/injury to a conservation significant fauna species.
- Regional and cumulative impacts.
- Specialist advice.
- Stakeholder consultation.

8.4 Roles and Responsibilities

As outlined in the Environmental Policy, BCI is committed to fully complying with applicable environmental laws and regulations and will strive to carry out all activities in a manner that minimises impacts to the environment. Further, BCI commits to the sustainable management and efficient use of natural resources, and to the research, development and management of the surrounding ecosystems.

8.4.1 Compliance with Implementation of Plan and the Monitoring Data

BCI's roles and responsibilities relevant to the implementation of the Illumination Plan are outlined in Table 8-1.

Table 8-1: Roles and Responsibilities for Illumination Plan Implementation

Role	Responsibility
Manager Environment and Approvals	Ensure monitoring and management actions are implemented in accordance with this Plan. Ensure reporting to regulatory agencies is undertaken in accordance with this Plan.
Environmental Advisor	Support the implementation of monitoring programs and maintain monitoring records. Support reporting, and the provision of data, to regulators as required under this plan.

	Deliver awareness training programs to personnel, contactors, and visitors. Ensure all personnel involved in fauna surveys are appropriately licensed and qualified.

8.4.2 Compliance with Submission of Plan and the Monitoring Data

BCI's roles and responsibilities relevant to the submission of the Illumination Plan and the informing monitoring data from the Marine Turtle Management Plan are outlined in Table 8-2.

Table 8-2: Roles and Responsibilities for Compliance with Submission requirements

Role	Responsibility
Manager Environment and Approvals	Ensure the annual submission of the Ministerial Statement Compliance Assessment Report (CAR) and the annual EPBC compliance report. Ensure other reporting is undertaken in accordance with this Plan (including the reporting/submission of documents and data (as required) under EPBC 2018/8236 conditions 19e, 35 and 36).
Environmental Advisor	Support the implementation of monitoring programs and maintain monitoring records. Support reporting, and the provision of data, to regulators as required under this plan. Ensure all personnel involved in fauna surveys are appropriately licensed and qualified.

9. STAKEHOLDER CONSULTATION

BCI has consulted extensively with and will have ongoing consultation with all stakeholders who are affected by the proposal. This includes (but not limited to):

- Indigenous community groups (Wirrawandi Aboriginal Corporation (WAC), Robe River Kuruma Aboriginal Corporation (RRKAC);
- Neighbouring pastoral lease owners (Pastoral Management Pty Ltd (PMPL));
- Government agencies (EPA, DMIRS, DWER; DBCA, Department of Planning, Lands and Heritage (DPLH); Main Roads Western Australia (MRWA); Pilbara Ports Authority; Department of Climate Change, Energy, the Environment and Water (DCCEEW));
- Local Government (Shire of East Pilbara and Town of Port Hedland); and.
- Community / Special interest Groups (Hampton Harbour Boat and Sailing Club, Nickol Bay Sporting Fishing Club, Wildflower Society, Rangelands Natural Resource Management WA, Birds Australia / Birdlife Australia.

Consultation regarding the Mardie Salt Project has included both the Original and the Optimised Proposals. In addition to the consultation completed in relation to the Proposals, additional consultation has more recently been undertaken with key stakeholders in relation to the Illumination Plan and will continue throughout the life of the Project. A summary of the stakeholder consultation undertaken in relation to the management of impacts to marine and terrestrial fauna is provided in Table 9-1.

Table 9-1: Stakeholder Consultation in relation to the Illumination Plan

Stakeholder	Date	Issues/Topics	BCI Response
DCCEEW	19/08/2019 May-August 2022 21/07/2023	Site familiarisation. Ensuring requirements under EPBC Act and MS 1175 are met The plan needs to clearly link to the monitoring and outcomes outlined in the Marine Turtle Management Plan The plan needs to align to the National Light Pollution Guidelines (NLPG), and include information on how BCI will respond and adapt in the event of impacts being detected in biological receptors The plan needs to include consideration of potential impacts to bats	Ensure relevant groups and plans are consulted Ensure Illumination Plan is submitted within identified timeframes

Stakeholder	Date	Issues/Topics	BCI Response
		Adoption of the EPA's Environmental Management Plan (EMP) template was supported, with detail on the development of triggers and thresholds, in accordance with the NLPG, able to be presented in an Appendix.	
EPA Services	Numerous between 19/08//2019 and 21/07/2023	Site visit Ensure the Illumination Plan is being updated to ensure it meets all requirements of the current (MS 1175 & EPBC 2018/8236) and pending (EPA Report 1740) conditions, for submission in August 2023. Extension to the timeframe for provision of the Illumination Plan	Ensure relevant groups and plans are aligned with this Plan Approach approved by EPA Services on 05/08/2022

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ABBREVIATIONS

Abbreviation	Definition
BCI	BCI Limited
BC Act	*Biodiversity Conservation Act 2016*
CAR	Compliance Assessment Report
DAWE	Department of Agriculture, Water and Environment
DBCA	Department of Biodiversity, Conservation and Attractions
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DMIRS	Department of Mines, Industry Regulation and Safety
EP Act	*Environmental Protection Act 1986*
EPA	Western Australian Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
MSSA	Migratory Shorebird Study Area
SME	Subject Matter Expert
TFSA	Terrestrial Fauna Survey Area
QA	Quarry Area

GLOSSARY

Abbreviation	Definition
Daylight hours	Extends from 30 minutes after sunrise until 30 minutes prior to sunset
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Plan	Illumination Plan
Project Area	The area encompassing both the Original and Optimised Proposal

APPENDICES

The following appendices are referenced (or included) in this Section.

Appendix	Document Number/Author/Source
Appendix 1	Pendoley Environmental (2023a)
Appendix 2	D. Gleeson (DCCEEW, 2023)

Appendix 1: Mardie Artificial Light Modelling Stage 1 Report

BCI MINERALS

MARDIE ARTIFICIAL LIGHT MODELLING STAGE 1 REPORT

Prepared by

Pendoley Environmental Pty Ltd

For

BCI Minerals

9 October 2023

ARTIFICIAL LIGHT ASSESSMENT SERVICES

PENDOLEY ENVIRONMENTAL

PENDOLEY ENVIRONMENTAL

DOCUMENT CONTROL INFORMATION

TITLE: MARDIE ARTIFICIAL LIGHT MODELLING STAGE 1 REPORT

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1 INTRODUCTION

1.1 Project Description

BCI Minerals (BCI) is building the Mardie Project (the Project), a greenfield high-quality salt and Sulphate of Potash (SoP) project, and associated export facility, approximately 80 kilometres south-west of Karratha, in the Pilbara region of Western Australia (WA). The location is in proximity to several documented rookeries for green, hawksbill and flatback turtles. Under the National Light Pollution Guidelines for Wildlife ("the guidelines"; Commonwealth of Australia 2020), any action or activity that includes externally visible artificial lighting should use best practice lighting design and assess the potential impact on listed species and their important habitat(s) if they are present within a 20 km radius. Consequently, for this Project there is a recognised pathway for a potential impact from artificial lighting to listed threatened and migratory marine turtles that nest on the mainland and nearshore islands in the vicinity of the Project.

1.2 Scope

Due to the planned timeline of the development, BCI have separated their modelling scope into different stages as constructions progresses, this report contains the work for stage one of modelling which includes:

- Mardie village camp
- Jetty construction
    - Jetty traveller (situated at the end of the jetty)
    - Jetty onshore facilities
    - Jetty Barge
- Primary seawater intake
- Pond transfer stations
    - Transfer 2/3
    - Transfer 3/4
    - Transfer 6/7
- Rock haul and stock piling.

The modelling does not include the proposed salt wash plant, SoP plant, or the quarry.

2 METHODOLOGY

2.1 Light Monitoring

2.1.1 Field Survey

Monitoring was undertaken at four locations during two field surveys in February 2022 and February 2023, coinciding with new moon periods. (**Table 1** and **Figure 1**). The Long Island, Sholl Island and Middle Passage Island (MPI) monitoring locations had benchmark data captured during the 2022 survey. The mainland location at Mardie Creek East (MCE) had benchmark data captured during the 2023 survey.

Table 1: Latitude and longitude of all light monitoring locations.

Survey Year	Location	Latitude	Longitude
2021/22	Long Island	-21.020256	115.854185
	Middle Passage Island (MPI)	-21.049457	115.842692
	Sholl Island	-20.955115	115.901677
2022/23	Mardie Creek East (MCE)	-21.061038	115.958972

2.1.1 Data Capture

Artificial light data was captured at each monitoring location using a Sky42 light monitoring camera. The camera features 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.

Sky42 light monitoring cameras were deployed on tripods (~60 cm high) on areas of sandy beach suitable for turtle nesting and were programmed to capture one long-exposure image every 10 minutes between sunset and sunrise. Cameras were deployed overnight at all locations and images were downloaded every other day.

2.1.1 Data Analysis

All suitable images were processed using specialised software to determine 'whole-of-sky' (WOS) and 'horizon' sky brightness. WOS is the mean value of light (including direct light and sky glow, natural and artificial) in the entire image, and horizon brightness is the mean value of light within the 60 – 90° outer band, considered most relevant to marine turtle vision (**Figure 2**). All images have been quantified in units of visual magnitudes per square arc second (Vmag/arcsec^2), 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 or turtle eye, or a Sky42 camera.

J59005 Maride Light Modelling - Observer and Stage 1 Package Locations

Figure 1: Map of observer and stage one package locations.

Figure 2: 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.

2.1.2 Measurement Units

All images have been quantified in units of visual magnitudes per square arc second (Vmag/arcsec^2), a unit commonly used to measure astronomical sky brightness that represents light intensity on an inverse logarithmic scale. This means that lower Vmag/arcsec^2 values represent higher and more intense brightness, and higher Vmag/arcsec^2 values represent darker and less intense brightness, with a WOS value of 22.0 Vmag/arcsec^2 typically representing a naturally dark sky. For a qualitative description of WOS Vmag/arcsec^2 values relevant to Sky42 imagery, see Error! Reference source not found. and **Figure 3.**

Table 2: Night Sky quality range, Bortle scale, and Vmag/arcsec2 (Source: Bortle 2001).

Sky quality	Approx. Vmag/arcsec^2	Bortle class
Excellent dark sky site	21.99 – 22.00	1
Typical dark site	21.89 – 21.99	2
Rural sky	21.69 – 21.89	3
Rural/suburban transition	20.49 – 21.69	4
Suburban	19.50 – 20.49	5
Bright suburban	18.94 – 19.50	6
Suburban/urban transition	18.38 – 18.94	7
City	<18.38	8
Inner city sky	<18.38	9

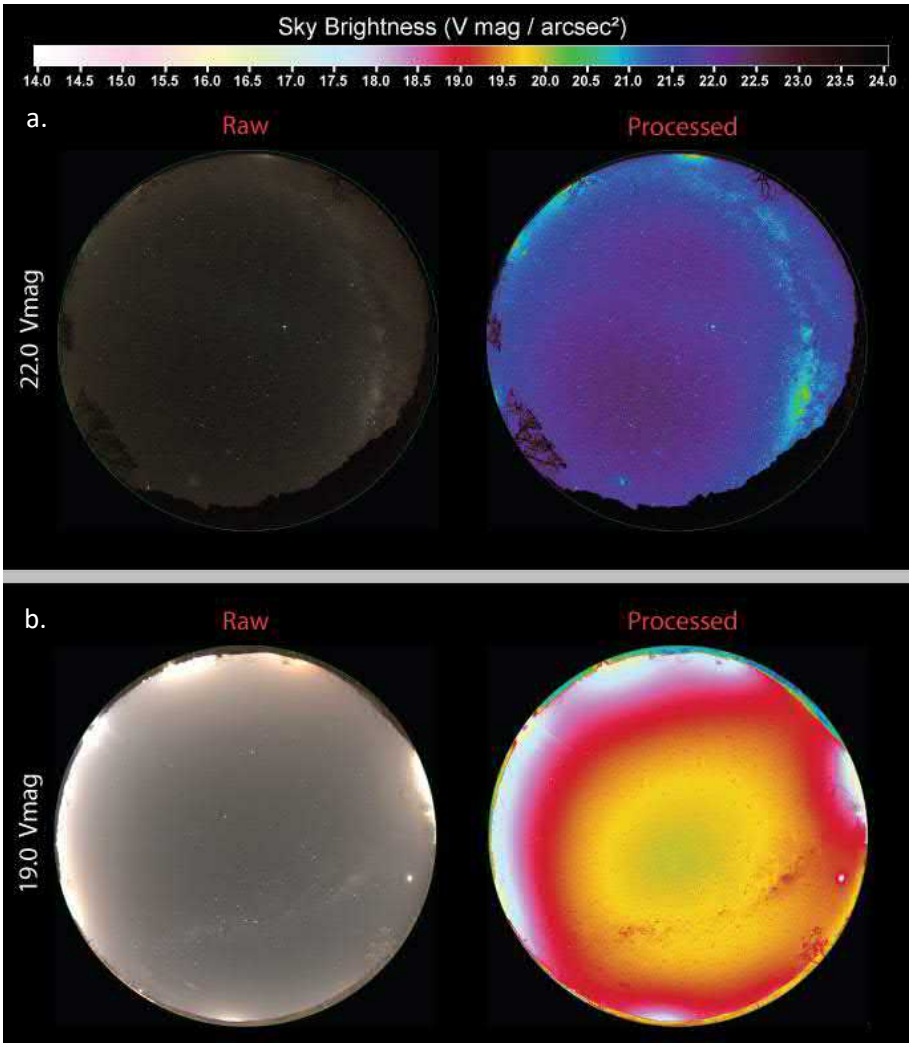


Figure 3: Examples of a dark and bright night sky. a. An 'ideal' natural dark sky with a WOS brightness value of 22.0 Vmag. B. A bright sky with a WOS brightness value of 19.0 Vmag, representative of a suburban night sky.

2.2 Light Modelling

Currently, there are no standard commercial models for landscape scale modelling of artificial light emissions (Commonwealth of Australia 2020). Recognising the 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 the International Dark Sky Association Dark Sky Park certification requirements, PENV has developed a landscape-scale model of artificial light.

The ILLUMINA model is used as the base model for the work, selected for its ability to represent light across large areas and distances, and across the entire visible spectrum, including biologically meaningful light from 350 – 700 nm (Aube et al. 2005). ILLUMINA accounts for both line-of-sight light visibility and sky glow derived from atmospheric scattering of light. The model also addresses the attenuation of light over landscape scale distances and, consequently, the areal extent of glow across the sky can be modelled.

2.2.1 Scenarios

Two scenarios were modelled for the BCI Stage 1 lighting inventory: worst case and base case scenarios. The worst case scenario included all lighting active concurrently, whereas the base case scenario was adjusted to reflect lighting that would likely be active during stage 1 of the Project. Specifically in the base case scenario the following lighting was changed:

- Barge lighting was removed as it is highly unlikely to be operational at night.
- Traveller lighting was reduced to an operational lighting standard.
- Onshore facilities lighting reduced to be focused on task specific areas.

A full description of inventories for both scenarios can be found in **Appendix A**.

2.2.2 Inputs

The following parameters were used as inputs into the model:

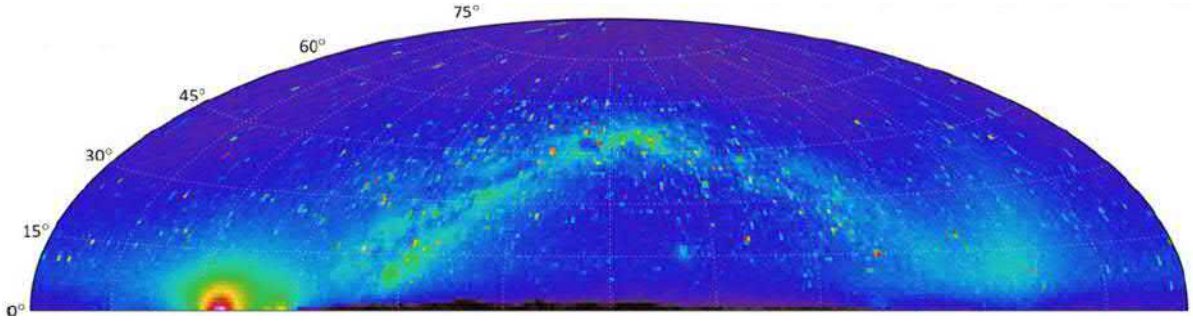
- Topography and reflectance: NASA Shuttle Radar Topography Mission (SRTM) digital elevation data (1 arc-second resolution).
- Latitude and longitude coordinates for the observer viewpoints.
- Weather conditions: all scenarios are considered free of any influencing atmospheric or weather conditions (sun, moon, rain, or cloud).
- A detailed lighting inventory (light types, positions, heights, intensity) for the Project's infrastructure based on information provided by BCI. For stage one modelling, the inventory contained 797 lights with a total power output of 9.58 million lumens. A detailed summary of the lighting inventory is provided in **Appendix A.**

2.2.3 Outputs

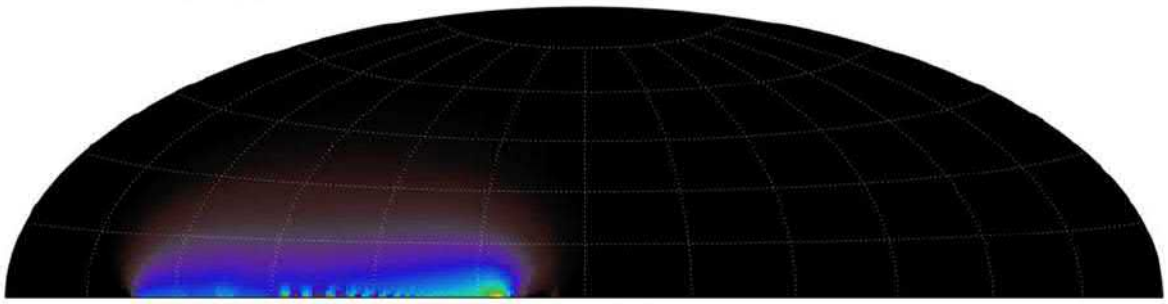
A projected all-sky modelled image 'as viewed' from each monitoring location was produced and combined additively with camera imagery to illustrate the predicted visible increase in brightness across the horizon and sky due to direct light and sky glow from the Project **(Figure 4)**.

Direct light is defined as lighting that has line of sight visibility from the monitoring location, and sky glow is defined as light that is scattered or reflected into the area surrounding a direct light source.

a. Benchmark image



b. Modelled brightness of proposed development



c. Benchmark image + modelled brightness (i.e. a + b = c)

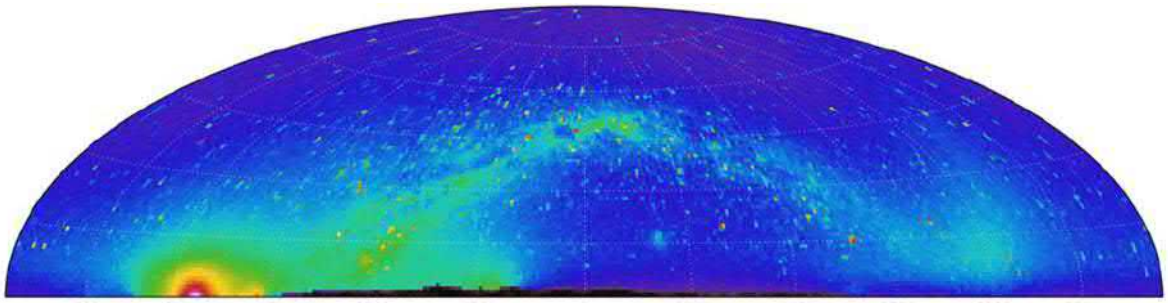


Figure 4: Example all-sky benchmark and modelled imagery from an observer location: a. Benchmark image; b. Modelled image based on lighting inventory; c. Cumulative result (benchmark + modelled image.

2.2.4 Assumptions

The lighting inventory was generated under the following assumptions:

- Lighting inventories provided by BCI are accurate.
- Only external lighting has been considered in the model (i.e. omits internal lighting that may be reflected externally).
- Jetty traveller (mobile construction equipment) was positioned at the end of the jetty as a worst-case scenario.
- Where colour temperatures are uncertain a worst-case is assumed.
- Rock Haul lighting is assumed to be amber LEDs.

2.2.5 Limitations

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

- Model results have not yet been definitively ground-truthed for large-scale projects (Linares et al. 2018, 2020), however, the technical approach outlined within this report is considered current with the most recent literature, subject matter expert input, and best practice.
- The precision of the model outputs is directly related to the level of input detail. Much of the lighting design is still conceptual and may be changed prior to construction.
- 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.
- Monitoring locations selected for benchmark data collection and subsequent modelling represent only a single viewpoint at each location. These locations have been selected based on the distribution of nesting activity and are considered to be most appropriate for determining potential impacts on hatchlings. However, the potential for impact is likely to change based on the specific location of a nest emergence (e.g. differences in dune topography, vegetation, beach slope). In this regard, the results should be interpreted with caution.

3 RESULTS

3.1 Light Monitoring

Artificial light data was successfully captured from all survey locations during the 2021/22 and 2022/23 field campaign (see **Figure 1** for light monitoring locations). A single clear image was selected from each monitoring location for analysis and processed results are show in **Figures 5a - 12a & Table 3**.

Table 3: Sky brightness results of benchmark artificial light monitoring for zenith, whole-of-sky and horizon in Vmags/arcsec^2.

Location	Sky Brightness (Vmag/arcsec^2)		
	Zenith	Whole-of-sky	Horizon
Long Island	21.47	21.27	21.10
MPI	21.94	21.64	21.45
Sholl Island	21.47	21.25	21.06
MCE	21.45	21.34	21.20

Several sources of horizon light were visible within the captured imagery at varying levels of brightness and located at different bearings from each monitoring location. Notable existing light sources included:

- Barrow Island
- Cape Preston
- Citic Pacific Sino Iron facility (Sino Iron)
- Mardie Village
- Mesa A Mine
- Varanus Island

The brightest source of light on the horizon was the Sino Iron Project Facility which was visible from all monitoring locations. Cape Preston was also visible from all monitoring locations except Middle Passage Island although it is substantially darker than the Sino Iron facility.

The visibility of other sources of light from the monitoring locations was dependent on the bearing and distance of the light source as well as shielding from nearby dunes or other localised topographic features. For example, artificial light from the Mesa A Mine was only visible from Long Island and Sholl Island (**Figures 5a** and **7a**) and shielded elsewhere, while light from both Barrow and Varanus Islands was only visible from Sholl Island (**Figure 7a**).

Benchmark sky brightness values captured during the surveys (**Table 3**) show that the darkest benchmark was Middle Passage Island with a zenith sky brightness value of 21.94 Vmag/arcsec^2, classified as a typical dark night sky (**Table 2**). Zenith sky brightness values captured at Mardie Creek East (21.45 Vmag/arcsec^2), Long Island (21.47 Vmag/arcsec^2), and Sholl Island (21.47 Vmag/arcsec^2) were classified as rural/suburban transition night sky (**Table 2**).

3.2 Light Modelling

Artificial light modelling was completed at four observer locations for both scenarios detailed in **Section 2.2.1**, the results have been processed and analysis has been completed as described below.

3.2.1 Worst Case Scenario

Artificial light modelling for stage one, worst case scenario was completed for each monitoring location and the processed results are shown in **Table 4** and **Figures 5b – 8b**. The modelled output for each scenario (Figures 4b – 7b) was then combined with the respective benchmark light monitoring data for each location to create a cumulative result (see **Figures 5c – 8c).**

At Long Island, the modelling indicates that there will be an increase in sky brightness (WOS: 106%; horizon: 278%), primarily due to its direct line of sight to the jetty traveller, barge, and onshore facilities. The size and magnitude of these sources on the horizon is comparable to existing Sino Iron source (**Figure 5**).

Similarly at Middle Passage Island, the modelling indicates that there will be an increase in sky brightness (WOS: 109%; horizon: 255%), with the jetty traveller, barge, and onshore facilities being the primary sources visible, which overlap with the existing Sino Iron facility. Smaller sources can be seen on the horizon from Mardie village, primary seawater intake, rock haul, and the pond transfer facilities (**Figure 6**).

Modelling completed for Sholl Island indicates that there will be an increase in sky brightness (WOS: 73%; horizon: 166%), with the largest source of artificial light being due to the jetty traveller, barge, and onshore facilities (**Figure 7**).

The modelling of the mainland location Mardie Creek East predicted a substantial increase of sky brightness (WOS: 594%; horizon: 2158%), which is due to its proximity and direct line of sight to jetty barge, traveller, and onshore facilities which appear as large domes of artificial light on the horizon. Other sources of artificial light are only visible as sky glow, due to the presence of dunes blocking the direct line of site to light sources over the 25 – 225° bearing range (**Figure 8**).

The cumulative changes in zenith sky brightness predicted by the modelling indicate Sholl Island (21.36 Vmag/arcsec^2), Long Island (21.35 Vmag/arcsec^2), and Mardie Creek East (21.20 Vmag/arcsec^2) to have maintained the classification of rural/suburban transition night skies. Middle Passage Island (21.76 Vmag/arcsec^2) is reclassified from a typical dark sky to a rural night sky (**Table 4**).

3.2.2 Base Case Scenario

Artificial light modelling for stage one, base case scenario was completed for each light monitoring location and the processed results are shown in **Table 5** and **Figures 9b – 12b**. The modelled output for each scenario was then combined with the respective benchmark light monitoring data (Figures 8a – 11a) for each location to create a cumulative result (see **Figures 9c – 12c**).

At Long Island, the modelling indicates that there will be an increase in sky brightness (WOS: 58%; horizon: 126%), primarily due to its direct line of sight to the jetty traveller and onshore facilities. The size and magnitude of these sources on the horizon are comparable to existing Sino Iron source (**Figure 9**).

Similarly at Middle Passage Island, the modelling indicates that there will be an increase in sky brightness (WOS: 45%; horizon: 70%), with the jetty traveller and onshore facilities being the primary sources visible, which overlap with the existing Sino Iron facility. Smaller sources can be seen on the horizon from Mardie village, primary seawater intake, rock haul, and the pond transfer facilities (**Figure 10**).

Modelling completed for Sholl Island indicates that there will be an increase in sky brightness (WOS: 57%; horizon: 121%), with the largest source of artificial light being due to the jetty traveller and onshore facilities (**Figure 11**).

The modelling of the mainland location Mardie Creek East predicted a substantial increase of sky brightness (WOS: 265%; horizon: 813%), which is due to its proximity and direct line of sight to jetty traveller, and onshore facilities which appear as large domes of artificial light on the horizon. Other sources of artificial light are only visible as sky glow, due to the presence of dunes blocking the direct line of site to light sources over the 25 – 225° bearing range (**Figure 12**).

The cumulative changes in zenith sky brightness predicted by the modelling maintain the classification of Sholl Island (21.36 Vmag/arcsec^2), Long Island (21.36 Vmag/arcsec^2) and Mardie Creek East (21.25 Vmag/arcsec^2) as rural/suburban transition night skies and reclassify Middle Passage Island (21.77 Vmag/arcsec^2) from a typical dark sky to a rural night sky (**Table 5**).

3.2.1 Comparison

Comparison of sky brightness results found in the worst and base case scenario are shown in **Table 6** for WOS, horizon, and zenith sky brightness values. A decrease in brightness is seen at all locations, with the greatest change occurring at Mardie Creek East (WOS: -48%; horizon: -60%; zenith: -9%) due to direct line of sight to the barge and traveller, which have reduced lighting inventories in the base case scenario. Substantial decreases are also seen at Middle Passage Island (WOS: -31%; horizon: -52%; zenith: -2%) and Long Island (WOS: -23%; horizon: -40%; zenith: -1%), with the smallest change occurring at Sholl Island (WOS: -9%; horizon: -17%; zenith: 0%).

Table 4: Worst case scenario comparison of benchmark and benchmark + modelled (cumulative) sky brightness values (Vmag/arcsec^2). Note that the scale is inverse logarithmic, brightness increases with decreasing Vmag/arcsec^2 values.

Location	WOS (0 – 90°) (Vmag/arcsec^2)			Horizon (60 – 90°) (Vmag/arcsec^2)			Zenith (0 – 30°) (Vmag/arcsec^2)		
	Benchmark	Benchmark + Modelled	Change	Benchmark	Benchmark + Modelled	Change	Benchmark	Benchmark + Modelled	Change
Long Island	21.27	20.88	106%	21.10	20.38	278%	21.47	21.35	24%
MPI	21.64	21.24	109%	21.45	20.76	255%	21.94	21.76	38%
Sholl Island	21.25	20.96	73%	21.06	20.53	166%	21.47	21.36	23%
MCE	21.35	20.29	594%	21.20	19.50	2158%	21.45	21.20	59%

Table 5: Base case scenario comparison of benchmark and benchmark + modelled (cumulative) sky brightness values (Vmag/arcsec^2).

Location	WOS (0 – 90°) (Vmag/arcsec^2)			Horizon (60 – 90°) (Vmag/arcsec^2)			Zenith (0 – 30°) (Vmag/arcsec^2)		
	Benchmark	Benchmark + Modelled	Change	Benchmark	Benchmark + Modelled	Change	Benchmark	Benchmark + Modelled	Change
Long Island	21.27	21.02	58%	21.10	20.66	126%	21.47	21.36	22%
MPI	21.64	21.44	45%	21.45	21.16	70%	21.94	21.77	35%
Sholl Island	21.25	21.01	57%	21.06	20.63	121%	21.47	21.36	22%
MCE	21.34	20.64	265%	21.20	20.00	813%	21.45	21.25	43%

Table 6: Comparison of benchmark + modelled (cumulative) sky brightness values (Vmag/arcsec^2) for worst and base case scenarios.

Location	WOS (0 – 90°) (Vmag/arcsec^2)			Horizon (60 – 90°) (Vmag/arcsec^2)			Zenith (0 – 30°) (Vmag/arcsec^2)		
	Worst Case	Base Case	Change	Worst Case	Base Case	Change	Worst Case	Base Case	Change
Long Island	20.88	21.02	-23%	20.38	20.66	-40%	21.35	21.36	-1%
MPI	21.24	21.44	-31%	20.76	21.16	-52%	21.76	21.77	-2%
Sholl Island	20.96	21.01	-9%	20.53	20.63	-17%	21.36	21.36	0%
MCE	20.29	20.64	-48%	19.50	20.00	-60%	21.20	21.25	-9%

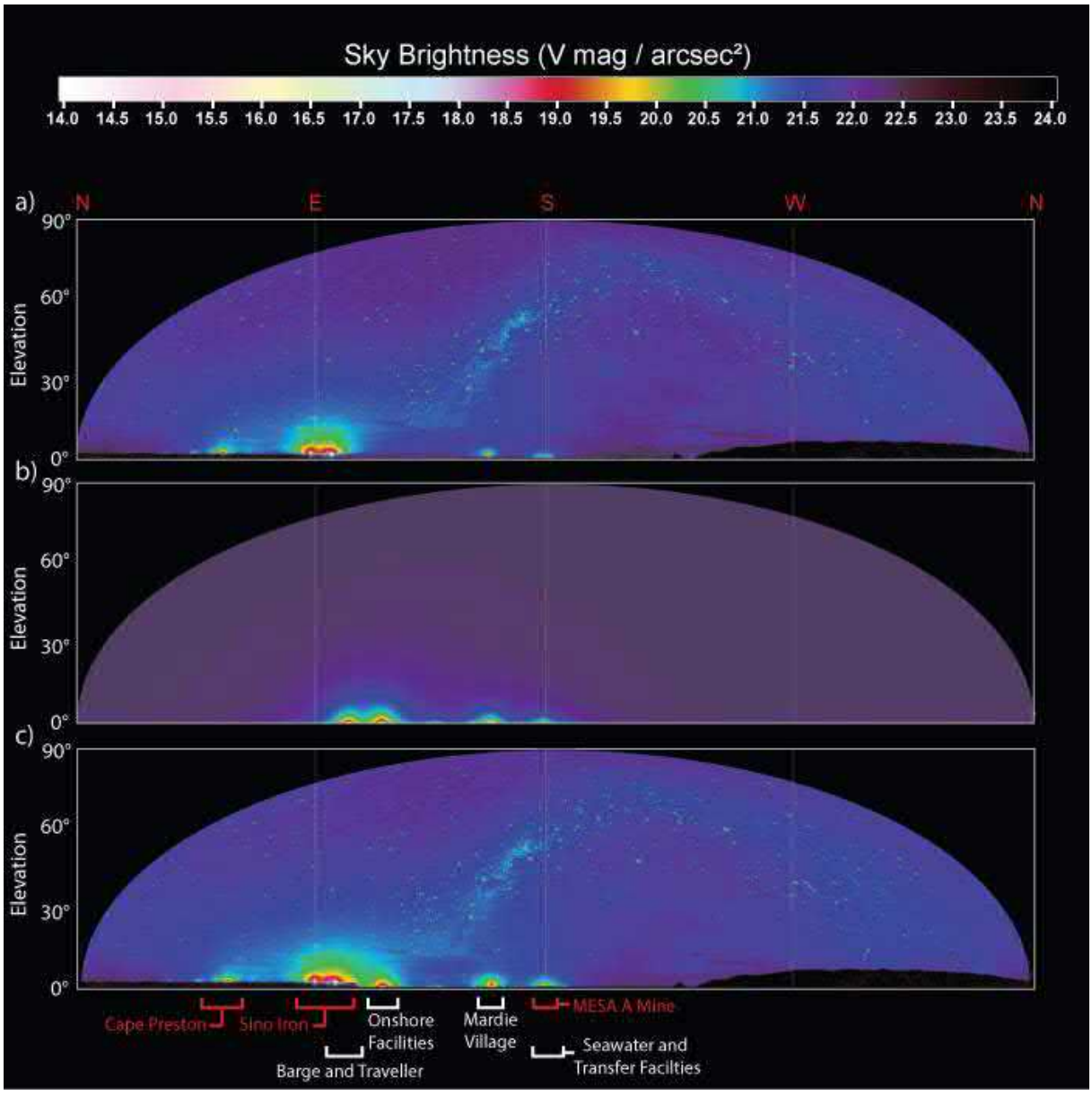


Figure 5: Artificial light modelling results for the worst case scenario at Long Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

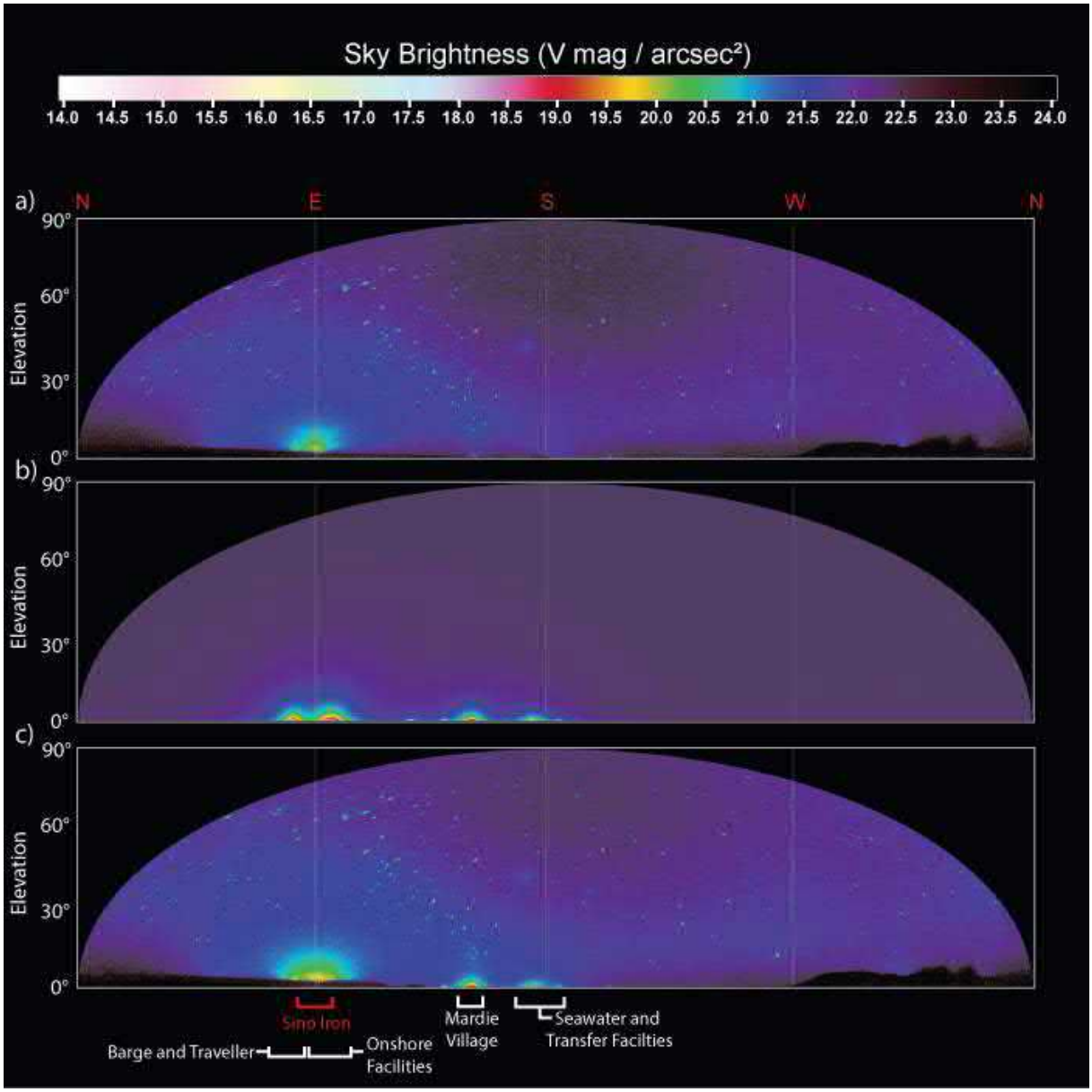


Figure 6: Artificial light modelling results for the worst case scenario at Middle Passage Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

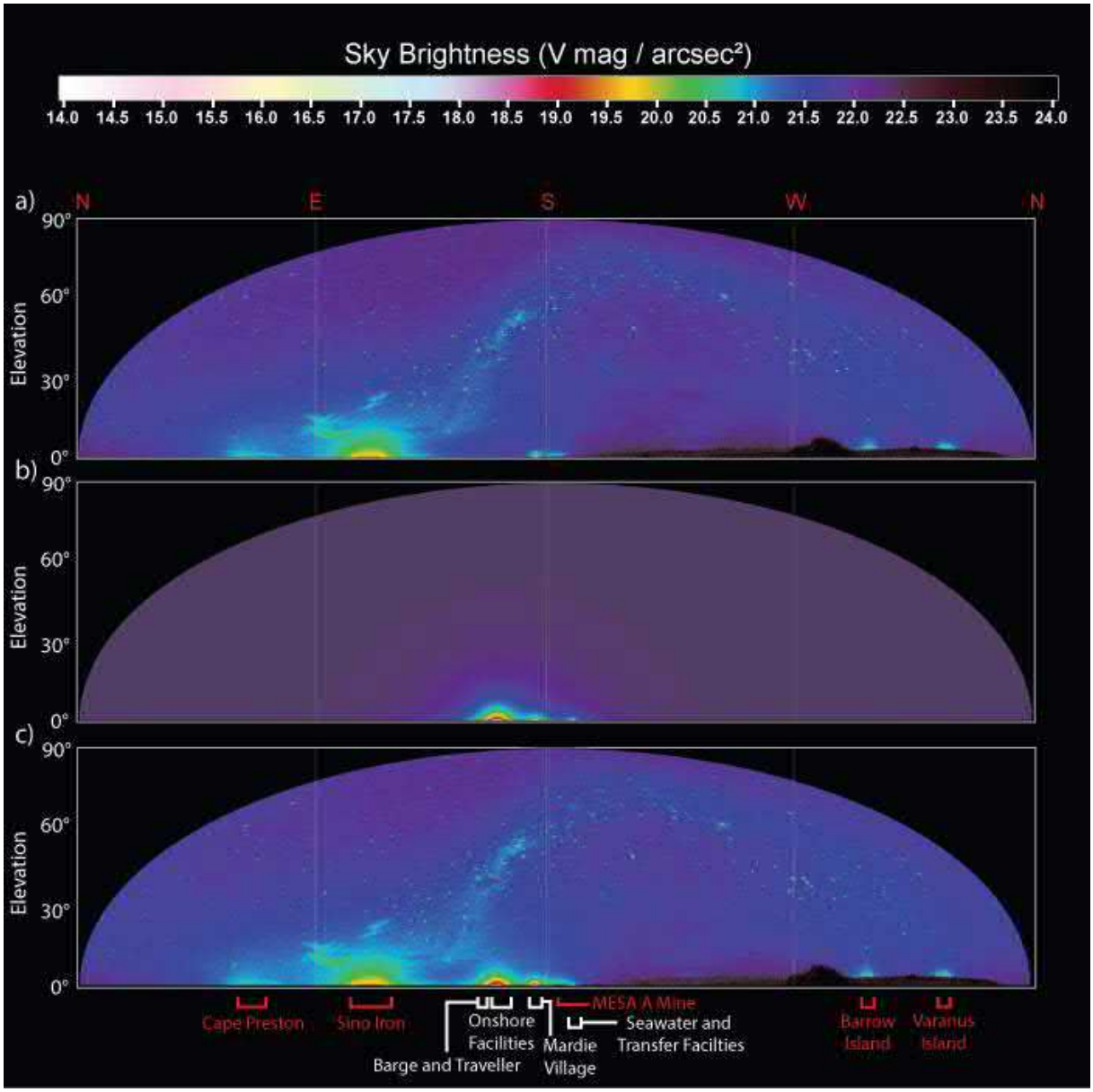


Figure 7: Artificial light modelling results for the worst case scenario at Sholl Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

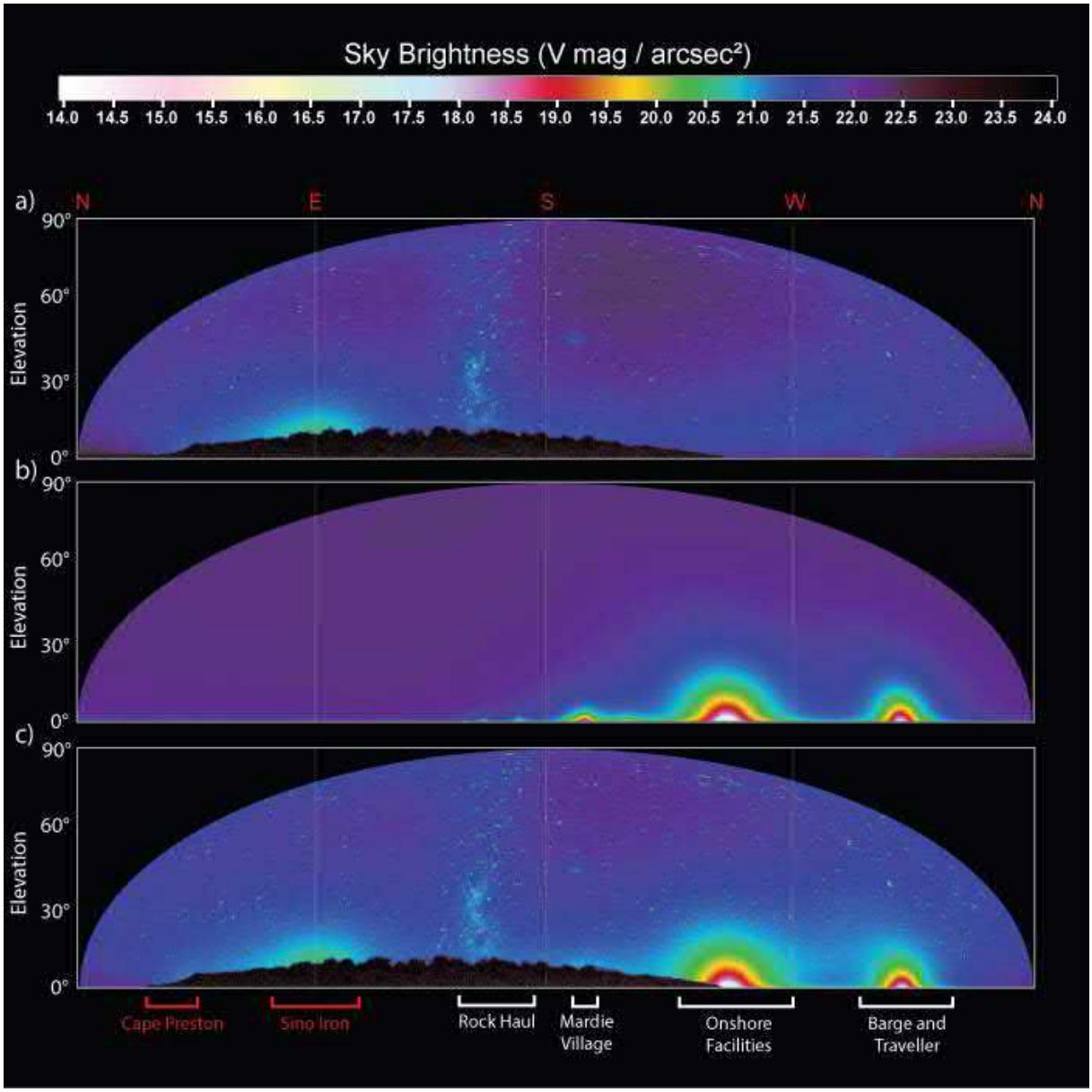


Figure 8: Artificial light modelling results for the worst case scenario at Mardie Creek East: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

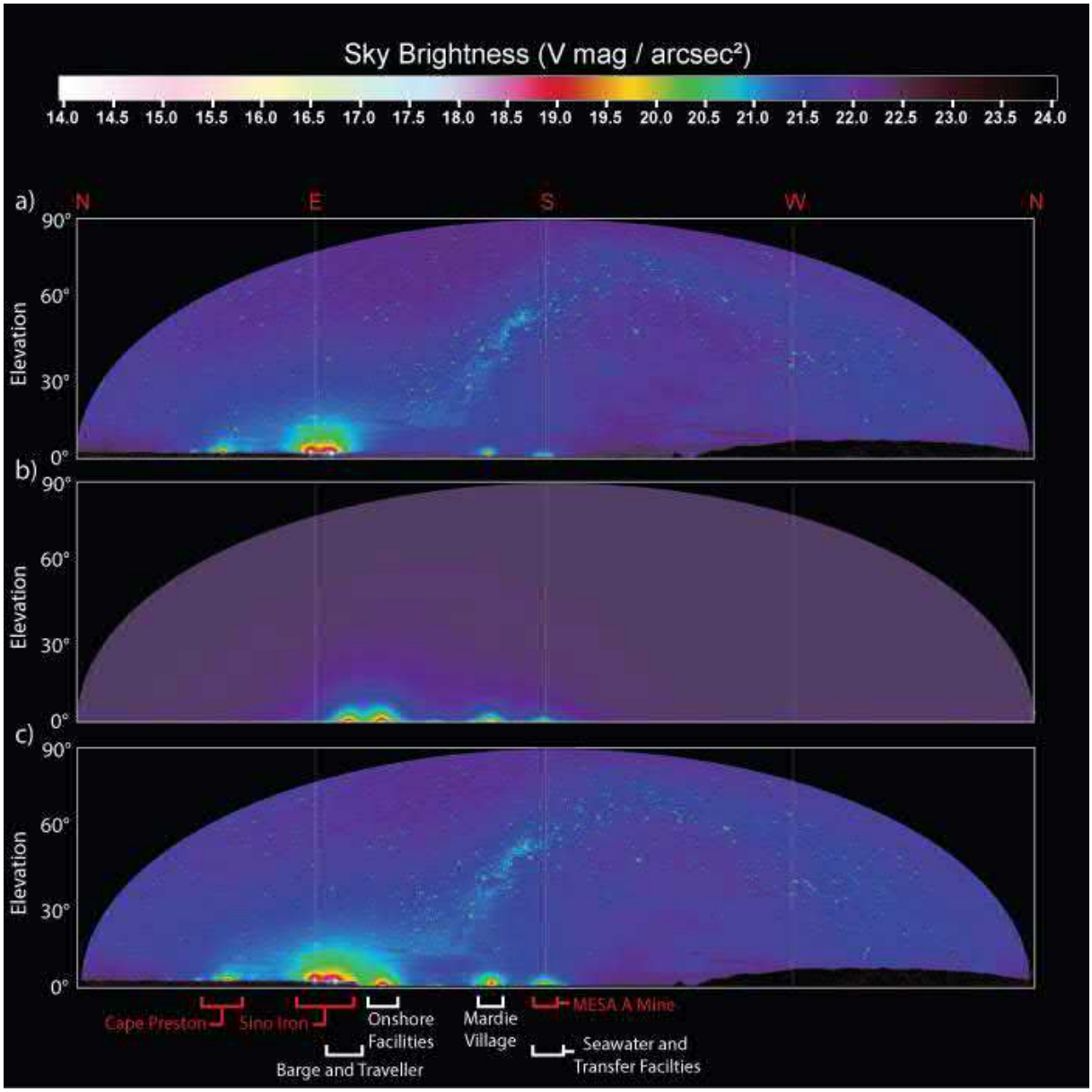


Figure 9: Artificial light modelling results for the base case scenario at Long Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

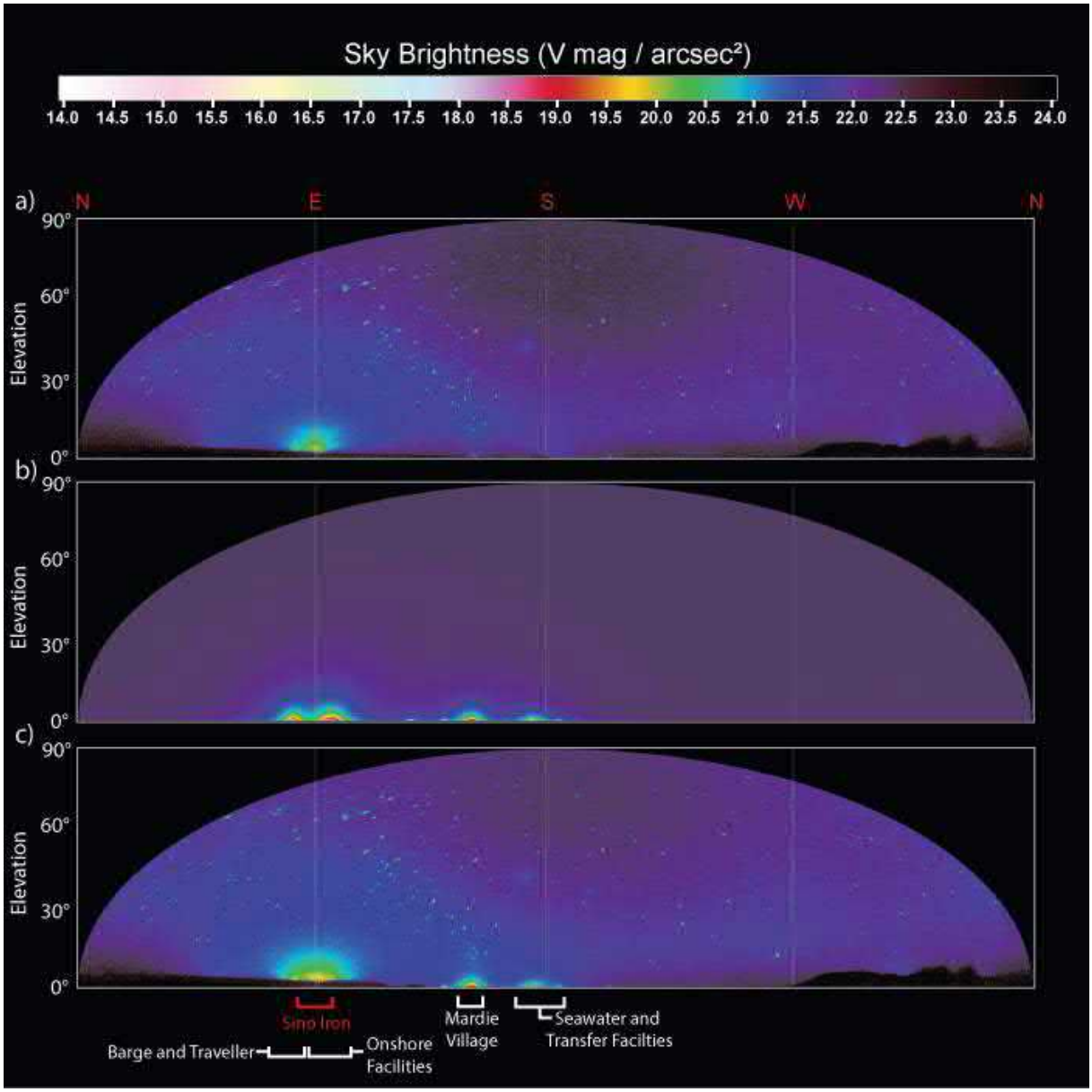


Figure 10: Artificial light modelling results for the base case scenario at Middle Passage Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

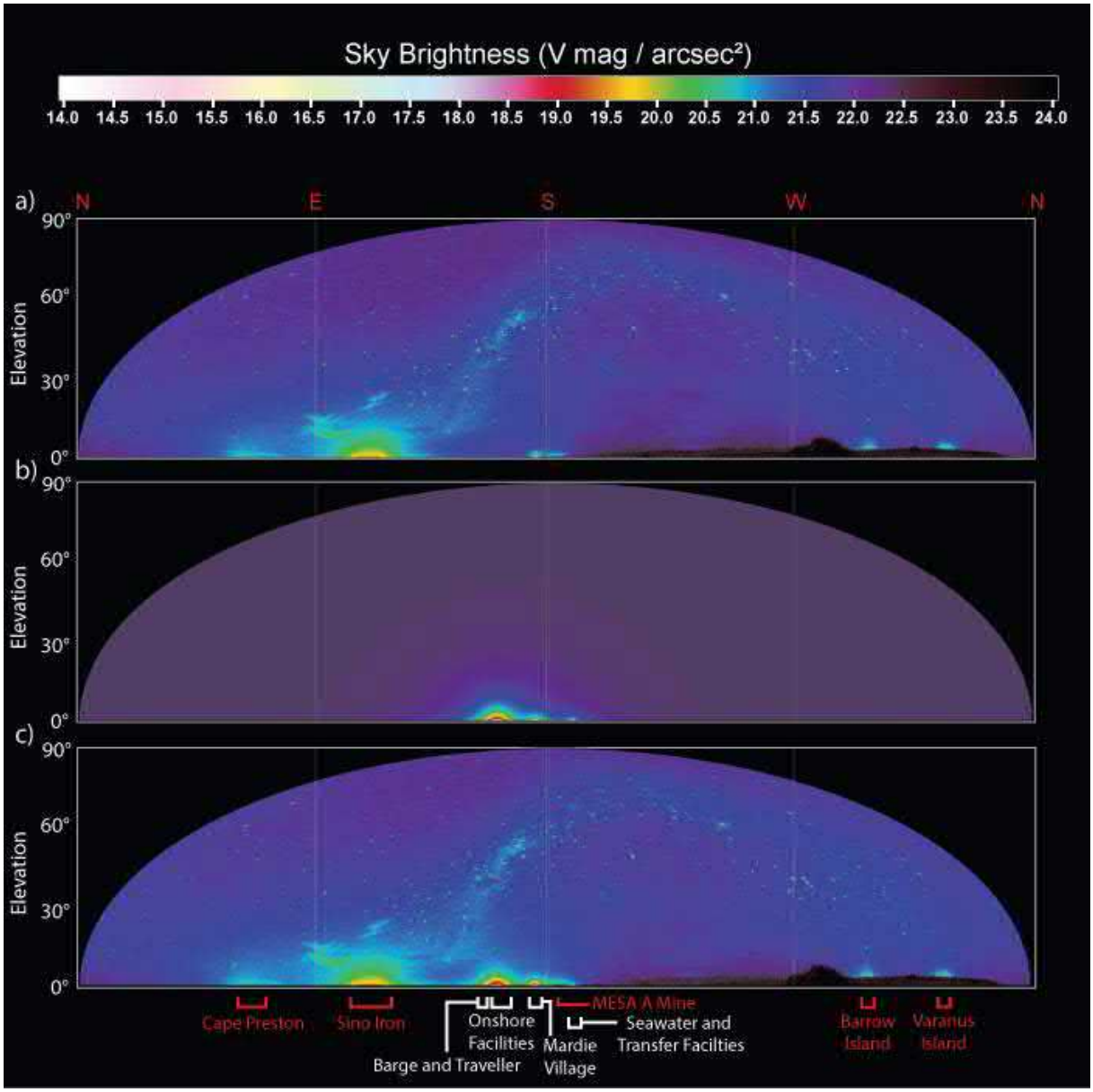


Figure 11: Artificial light modelling results for the base case scenario at Sholl Island: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

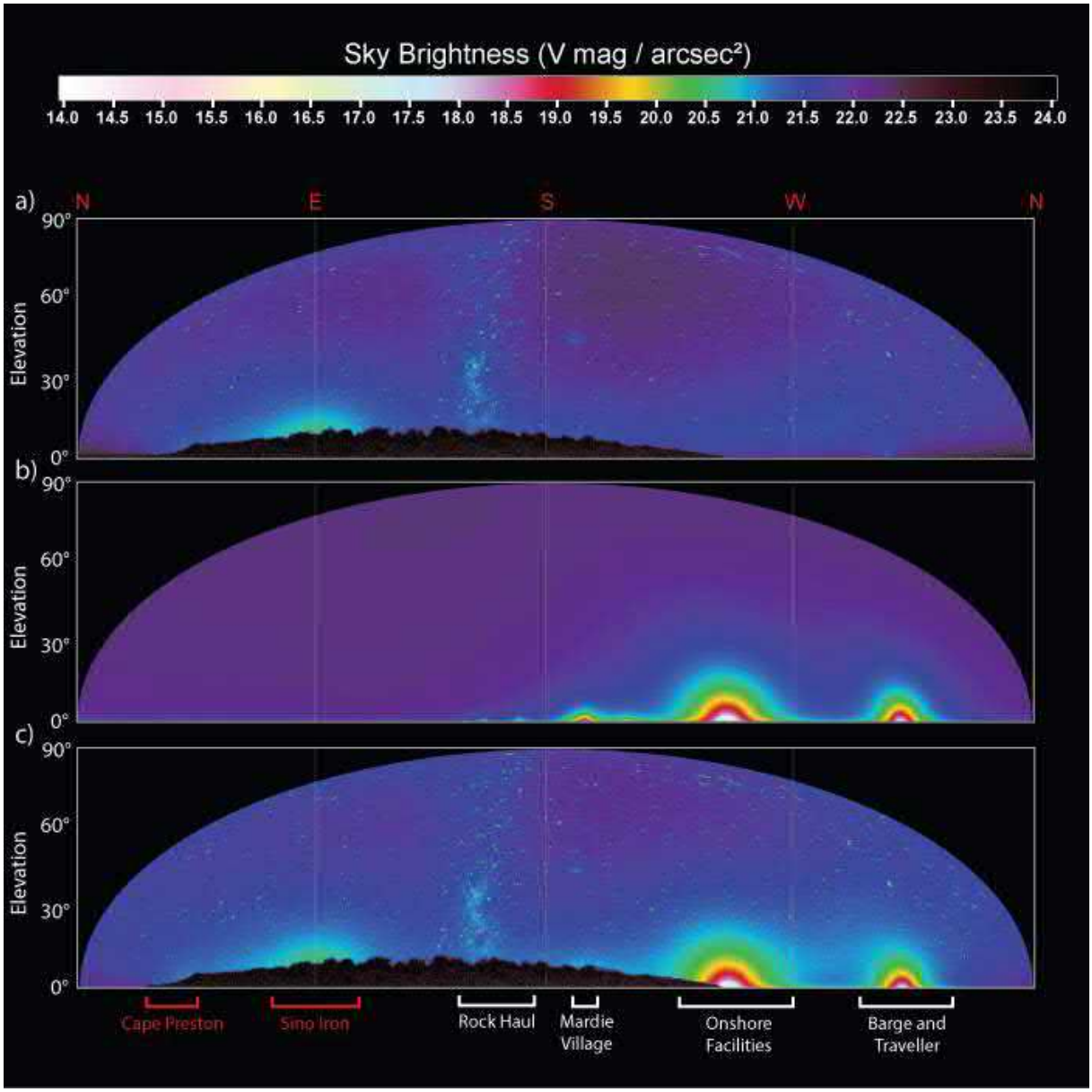


Figure 12: Artificial light modelling results for the base case scenario at Mardie Creek East: a. Benchmark all-sky processed image recorded during the light survey; b. Modelled brightness based on light design provided by BCI; c. Benchmark monitoring image + modelled brightness. Red labels = existing light sources, white labels = new light sources associated with the Project.

4 CONCLUSION

Artificial light monitoring successfully completed over the 2021/22 and 2022/23 field campaigns identified several key existing light sources that are visible from the monitored beaches, including the Citic Pacific Sino Iron facility, Barrow Island, Cape Preston, Mardie Village, Mesa A Mine, and Varanus Island. These sources were included in the light modelling undertaken by PENV to provide cumulative understanding of light emissions following the addition of the stage one project lighting associated with the BCI development.

Light modelling of the development predicted the greatest change in brightness occurring at the beach closest to the jetty (Mardie Creek East). This monitoring location has a direct line of sight to the jetty developments and is shielded from other major light sources (e.g., Sino Iron) by local topographic features. Predictive modelling for Long, Middle Passage, and Sholl islands shows a smaller increase in brightness across all three monitoring locations when compared to Mardie Creek East. The brightest new artificial light sources at each location are the jetty traveller, barge, and onshore facilities, other artificial light sources such as the new BCI worker accommodation at Mardie village, primary seawater intake, transfer pump stations, and rock haul lighting are visible but as much smaller sources of artificial light on the horizon. Existing sources of light are also visible from the island locations with the most dominant being the Sino Iron facility. Sholl island has the most visibility of existing sources with Cape Preston, Sino Iron, MESA A Mine, Barrow Island, and Varanus Island all appearing on the horizon.

In comparing the two modelled scenarios (worst and base case), under the base case there is a decrease in cumulative modelled sky brightness for WOS, horizon, and zenith values, with the greatest decrease occurring at Mardie Creek East and the smallest change at the Sholl Island observer location. In the worst case scenario, the cumulative changes in zenith brightness show that Sholl Island, Long Island and Mardie Creek East are classified as rural/suburban transition night skies, with Middle Passage Island being reclassified from a typical natural dark sky to a rural sky. In the base case scenario, the cumulative light changes also reclassify Middle Passage Island from a typical natural dark sky to a rural night sky. Mardie Creek East, Sholl Island and Long Island maintain their classification between benchmark and cumulative light modelling as rural/suburban transition night skies.

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Appendix A: Lighting Inventory.

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Appendix 2: Suitability of commercial lights for marine turtles, shorebirds and bats adapted from DCCEEW (2023)

Light Type	Suitability for use near marine turtle habitat	Suitability for use near shorebird habitat	Suitability for use near bat habitat
Low-pressure Sodium Vapour	Suitable	Suitable	Suitable
High-pressure Sodium Vapour	Suitable	Suitable	Not suitable
Filtered* LED	Suitable	Suitable	Suitable
Filtered* metal halide	Suitable	Suitable	Suitable
Filtered* white LED	Suitable	Suitable	Suitable
Amber LED	Suitable	-	Suitable
PC amber	Suitable	-	Suitable
LED with appropriate spectral properties for species present	-	Suitable	-
White LED	Not suitable	Not suitable	Not suitable
Metal halide	Not suitable	Not suitable	Not suitable
White fluorescent	Not suitable	Not suitable	Not suitable
Halogen	Not suitable	Not suitable	Not suitable
Mercury vapour	Not suitable	Not suitable	-

*'Filtered' means this type of luminaire can be used only if a filter approved by the manufacturer is applied to remove the problematic wavelength light (specified as 400 nm to 500 nm for marine turtles and bats)

- not stated by DCCEEW (2023)