PERDAMAN INDUSTRIES

CHEMICALS & FERTILISERS

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Perdaman Chemicals and Fertilisers Pty Ltd

ABN: 31 121 263 741

Date: 04 September 2023

EPA Ministerial Statement No:1180

Assessment No:

2184 (WA)

2018/8383 (Commonwealth)

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Project Name:

Perdaman Urea Project

File Reference:

PCF-PD-EN-LMP

Job Reference:

PCF-PD

Date:

4 September 2023

Version Number: PCF3

Review conducted by:

Name: Saipem-Clough Joint Venture

Effective Date: 24 July 2023

Approved By:

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Chairman – Perdaman Chemicals and Fertilisers

Effective Date: 4 September 2023

Document History

Version	Effective Date	Description of Revision	Prepared by	Reviewed by
Rev A	07/02/2022	DRAFT Plan to EPA	SCJV/Pendoley	Perdaman
Rev B	29/03/2022	Submission for Peer Review	SCJV/Pendoley	Perdaman
PCF 1	13/04/2022	FINAL Submission to EPA	SCJV/Pendoley	Perdaman
PCF 2	04/05/2022	Addressed EPA comments	SCJV/Pendoley	Perdaman
PCF 3	24/07/2023	Update formatting, spelling and grammar. Updating of information, to reflect MS 1180 condition 10. Removed reference to fauna impacts - addressed in separate Management Plans.	SCJV	Perdaman

Executive Summary

Proposal Title	Perdaman Urea Project
Proponent name	Perdaman Chemicals and Fertilisers Pty Ltd.
Ministerial Statement No.	1180
Proposed Construction& Operation Commencement Dates	Bulk earthworks is scheduled to commence September 2023. Construction is scheduled to commence June 2024. Operation of the facility is proposed to commence 2027.
Purpose of this Plan	Ministerial Statement 1180 (MS 1180) requires the Project is implemented to avoid or minimize the impacts of nightglow and light overspill to protect the social surroundings environmental values, at locations including Hearson Cove and Deep Gorge. This Lighting Management Plan (LMP) has been prepared to comply with the Conditions for Project implementation set out in Condition 10 of MS 1180. The LMP provides a framework which describes how the Project will address, manage, monitor and mitigate impacts on social surroundings caused by lighting, to achieve the environmental objectives as stipulated by MS 1180. This plan supplements the PCF-PD-EN-PEMP Project Environmental Management Plan (PEMP). This version of the LMP has been prepared in accordance with the annual review requirements. No substantive changes have been made to this plan.
Key environmental factors and objectives	The environmental outcomes for lighting are associated with the EPA Social Surroundings Factor objective: To protect social surroundings from significant harm. The Environmental Objective for managing impacts to surrounding sensitive receptors for the Project (as provided by MS 1180) is: • avoid, where possible, and otherwise use best practice technology and risk-based management actions to minimise nightglow and light overspill from the Project so that the environmental values of amenity at sensitive locations, including, but not limited to Hearson Cove and Deep Gorge, are protected.
Condition Clauses	Condition requirements related to Ministerial Statement 1180 for the management of Lighting have been detailed in Appendix 1 of this Plan and Section 1.3.
Key provisions in the plan	The LMP's key provisions are included in Section 2 and Appendix 3. Section 2 details the management-based actions and best practice technology that will be implemented and applied for the life of the Project.

Foreword

This Light Management Plan (LMP) is a sub-plan of the overarching Project Environmental Management Plan (PEMP) for the Perdaman Urea Project. An overview of the structure of the PEMP and associated management is illustrated in Figure 0-1-1.

This plan shall be reviewed and updated as necessary throughout the construction, operation and decommissioning phases of the Project. The review process is detailed in *Section 15 Review and Continual Improvement* of the PEMP.

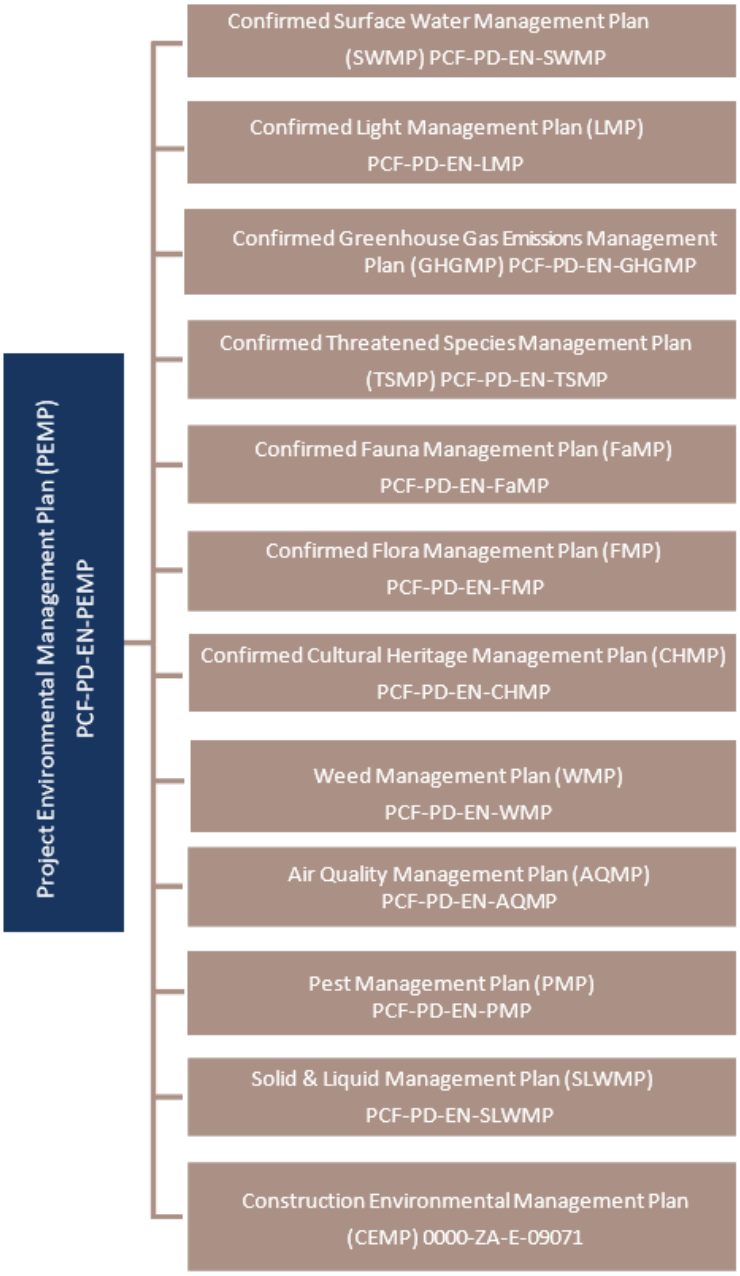

Figure 0-1-1 Structure of the Project Environmental Management Plan and supporting management plans

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1 Context, Scope & Rationale

1.1 Project Description

Perdaman proposes to establish a state-of-the-art urea production plant with a production capacity of approximately 2 million tonnes per annum (Mtpa) on the Burrup Peninsula in the Northwest of Australia (Figure 1-2) (the Project).

The Project infrastructure including the main production facility (urea plant), administration, maintenance and storage infrastructure, conveyor and port storage and shiploading facilities are situated within the Burrup Strategic Industrial Area (Burrup SIA). The estate's close proximity to gas, port and other key infrastructure makes it an ideal location for the Project.

The Burrup SIA is located in close proximity to the Murujuga National Park which covers an area of 4,913 ha on the Burrup Peninsula. The area is considered to host the largest concentration of ancient rock art in the world. As such, the Project will apply effective management strategies that minimise or abate, actual or potential impacts on the environment, heritage and cultural values of the region.

The Project involves piping natural gas from the nearby Woodside operated LNG facility to the Project site under a long term commercial off-take agreement. Natural gas is converted to urea and the final granulated product is transported by conveyor to the Dampier Port by closed conveyor along the East West Service Corridor route, where new facilities will include an enclosed stockpile shed and ship loading facilities.

Proven Urea production technology underpins each of the key stages of this Project. The technologies being applied to the plant are equivalent to the industry best for the specific applications and successfully operate elsewhere in the world. The processing plant can be broadly considered in four sections, or Blocks, namely:

- Gas Block
- Product Block
- Utility Block
- Infrastructure and Logistics

Each of the Process Blocks is made up of a number of process units or physical sections of the plant. The major process sections are described in Figure 1-1.

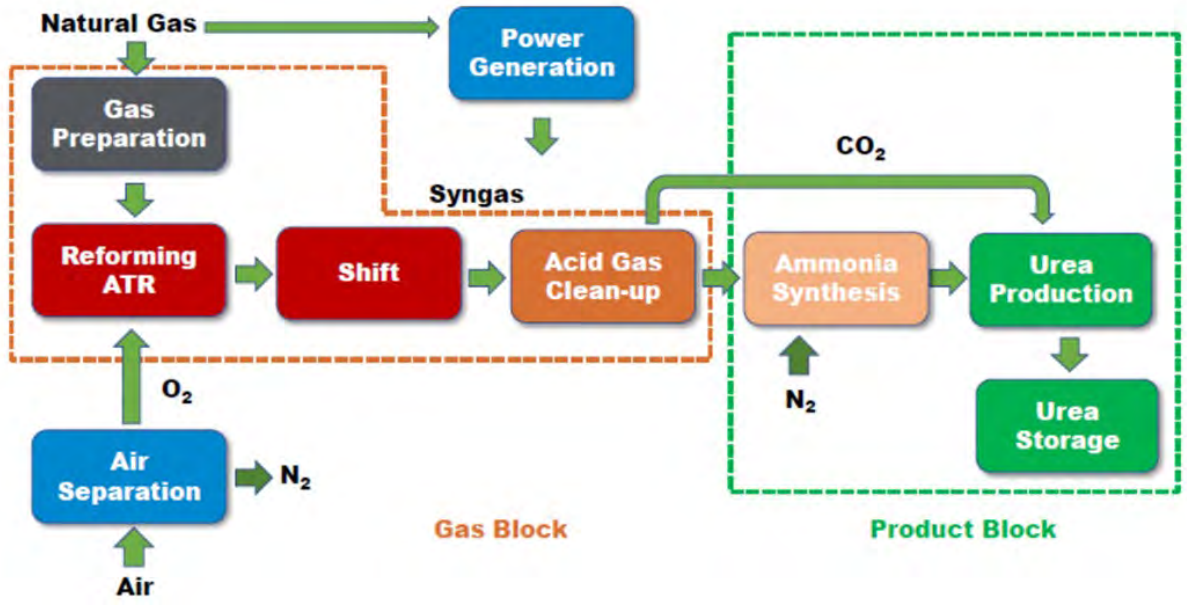


Figure 1-1 Urea Production Process Flow

The Project area, including Sites C and F, the causeway, conveyor and Port storage and loading facilities, extends east-west approximately 3.4 km covering approximately 106.7 hectares in area. As illustrated in Figure 1-2 the Project area can be separated into five key areas, as follows:

Site C

Site C is relatively undeveloped with the only visible disturbance being a few access tracks. The site is situated adjacent to the Yara Pilbara Fertilisers ammonia plant to its east, to the north are steep rocky outcrops (P1 Priority Environmental Community (PEC)) and to the south the saline coastal flat area. Drainage from the site flows in a southerly direction towards the saline coastal flat between Hearson Cove and King Bay.

Once developed Site C will include the main process plant and a 75,000-tonne urea storage shed.

Site F

Site F is situated to the south of Site C, on the opposite side of the saline coastal flat. It includes Hearson Cove Road and a significant proportion of previously disturbed area (now rehabilitated). Drainage from this area flows primarily north into the saline coastal flat.

This area will be used as laydown for equipment and modules, and for shutdown / maintenance activities. The eastern portion of Site F will be developed to include the Project's administration, maintenance, storage and warehousing facilities.

Causeway

The causeway, which links Sites C and F, extends across the saline coastal flat. The causeway will be built up above the flat and will include several hydrological and fauna friendly culverts to ensure the structure does not impede natural drainage, tidal action or the movement of wildlife.

Conveyor

The 3.5 km conveyor will transport urea from the storage shed at Site C to the Port loading shed. From Site C the conveyor will be constructed on relatively undisturbed land, to the west of the existing Water Corp pipeline corridor. It will extend north, connecting to the existing Burrup East West Services Corridor (EWSC).

The EWSC is a bitumen sealed corridor which already includes the Yara Pilbara Fertilisers ammonia pipeline which extends to the bulk liquids jetty adjacent to the Project's Port facilities. The Project's conveyor will be positioned within this corridor and where possible use existing culverts to avoid roads and other infrastructure. Where the conveyor crosses Woodside's Haul Road the road will be built up to allow the conveyor to pass underneath it.

Port Area

The Port Area includes a storage shed, covered conveyor and ship loader. The storage shed will be located within an existing highly disturbed quarry and the shiploader on a wharf which will be constructed by Pilbara Ports Authority (PPA). The Conveyor will be situated on cleared area associated with the new wharf and existing quarry, and a small section of rocky ground between these two areas.

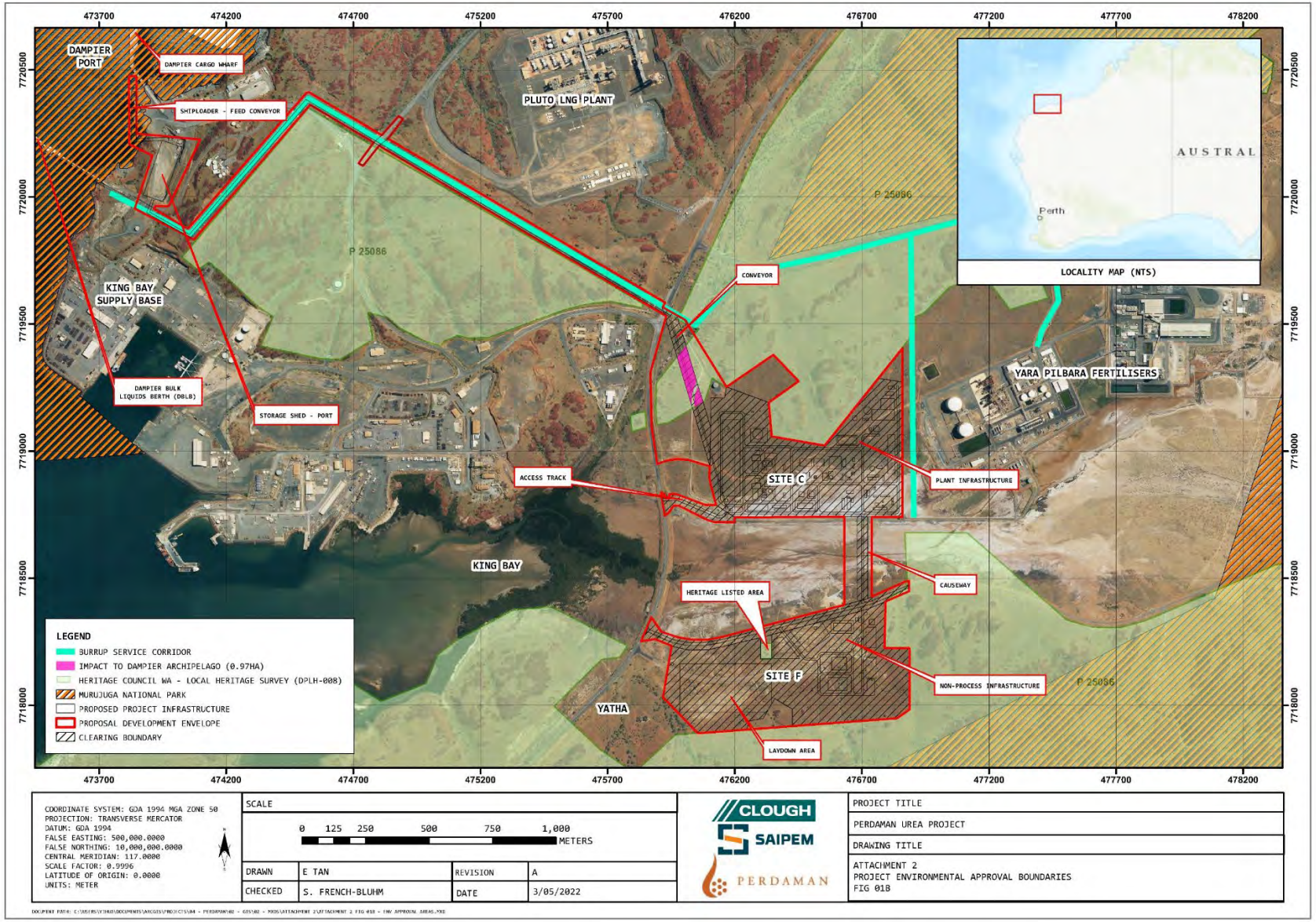


Figure 1-2 Project site layout and adjoining facilities.

1.1.1 Scope & Requirement for the Plan

This Light Management Plan has been prepared and will be implemented for the life of the Perdaman Urea Project in accordance with the Ministerial Statement 1180 (MS 1180). In accordance with the requirements of Condition 10-2 (MS 1180), this plan was provided to the CEO on 9 May 2022 and was prepared in consultation with the Murujuga Aboriginal Corporation (MAC). The CEO confirmed in writing on 8 July 2022 that the Light Management Plan (PCF-PD-EN-LMP-PCF2) submitted satisfies the requirements of Condition 10.

In accordance with Section, this plan has undergone an annual review.

The plan details management provisions that demonstrate the fulfilment of Condition 10-1 of MS 1180, which requires that the 'proposed lighting design adopts best practice technology and risk-based management to minimise the impacts of nightglow and light spill so that environmental values of amenity are protected'.

This Light Management Plan (LMP) meets the requirements of the EPA's "Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plan" (2021), and includes the requirements for management and monitoring of environmental performance against cultural heritage outcomes and objectives during the construction and operational activities at Site C, Site F, the causeway, the conveyor corridor, Port side storage, transfer and ship loading areas.

Light emissions from the Project have the potential to impact on social surroundings (cultural heritage and amenity). The EPA advised (EPA, 2021) that the likely residual lighting impacts of the Project on cultural heritage comprise:

- Additional lighting to the existing (baseline) night glow that may impact on Hearson Cove and Deep Gorge (Ngajarli).

Best practice lighting design, management and mitigation strategy measures will be implemented throughout the construction and operational phases of the Project to minimise or abate these impacts. These strategies are the provisions which form this LMP's legal requirements which will be adhered to across all Project sites.

The purpose of this LMP plan is to provide a framework which describes how the Project will design, address, manage, monitor and mitigate environmental impacts from artificial light.

The LMP has the following objectives:

- Specify best practice technology to minimise the impact of night glow on surrounding receptors;
- Prescribe mitigation measures to minimise night glow during construction and operations of the Project and;
- Establish responsibility, reporting and compliance guidelines.

The scope of the LMP addresses both construction and operational activities for the life of the Project that could impact cultural heritage and environmental values of amenity at sensitive locations. It applies to all sites during the construction and operational phases of the Project and includes all Project areas including:

- Site C process plant and storage sheds;
- Site F administration, maintenance and storage buildings;
- Access roads within the Development Envelope;
- The causeway crossing the supratidal flat between sites C and F;
- The conveyor route to the west of Site C and its route through the existing East-West Service Corridor (EWSC); and
- Landside areas of the Port including storage, transfer and ship loading areas.

The Project approach for lighting will also be consistent with the principles of dark sky protection promoted by locally based Australasian Dark Sky Alliance (ADSA) and by the International Dark Sky Association (IDA), the global authority on dark sky conservation and the certifying body for International Dark Sky Places.

The scope of this LMP does not include the construction of port facilities such as the jetty or infill of the coastal area for the provision of a wharf. These Works are to be managed by the Pilbara Ports Authority (PPA) under separate approval and management systems.

This plan is to be read in conjunction with the Project Environmental Management Plan (PEMP) (PCF-PD-EN-PEMP), Construction Environmental Management Plan (CEMP) (0000-ZA-E-09071) including the Cultural Heritage Management Sub-plan, and Cultural Heritage Management Plan (PCF-PD-EN-CHMP)).

The Project will implement the most recent version of the Confirmed Light Management Plan in accordance with Condition 10-4 (MS 1180).

Should there be any contradiction in light management requirements between the afore-mentioned plans and LMP, then the LMP shall take precedence.

1.1.2 Responsibility

The responsibility for lighting management and compliance with this plan sits primarily with Perdaman.

It is the responsibility of the EPC Contractor and personnel to understand their scope of works and how light management applies to their activities during the construction program.

For specific roles and responsibilities related to Light management during the relevant phase of the Project, refer to Section 5 of the Perdaman Project Environmental Management Plan (PEMP) and Section 9 of the Construction Environmental Management Plan (0000-ZA-E-09071) and the Cultural Heritage management Sub-plan (for responsibilities during the construction phase).

1.1.3 Legislative Framework

Perdaman Chemicals and Fertilisers Pty Ltd sought approvals both under State and Commonwealth legislative frameworks. The two main pieces of legislation that relate to this Project and provide the overall framework for environmental management for the Project are as follows:

- *Environment Protection and Biodiversity Conservation Act 1999* - Commonwealth
- *Environmental Protection Act 1986* - State

The Perdaman Urea Project was referred to the Environmental Protection Authority (EPA) under the *Environmental Protection Act 1986* in accordance with Section 38 Part IV. Pursuant to section 45 of the EP Act, it has been agreed that this proposal may be implemented under the Conditions of Ministerial Statement 1180, as of the 24th of January 2022.

The EP Act provides for "the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing".

The EPA advised (EPA, 2021) that the Project will intensify the industrial development in the central location of the BSIA on the Burrup Peninsula and will be seen in the context of the surrounding industry by receptors travelling through the industrial estate and accessing Hearson Cove and Deep Gorge (Ngajarli). However, the EPA concluded that the "*proposal's impact on viewsheds at Hearson Cove and Deep Gorge (Ngajarli) is not expected to be significant due to the landscape obscuring the majority of the proposal infrastructure with views limited to rooftops and a partially visible stack structure*". With regards to lighting, it was further noted that the Project "*has the potential to impact on the experience of night visits at Deep Gorge (Ngajarli) and Hearson Cove from an increase of night glow*".

The EPA determined that the proposal's lighting will add to the existing night glow and may impact on Hearson Cove and Deep Gorge (Ngajarli). The EPA was unable to assess the specific potential impact of night glow on the surrounding environment due to the absence of detailed information and noted that the proponent proposed to adopt *AS/NZS 4282-2019: Control of Obtrusive Effects from Outdoor Lighting Guidelines* with the relevant management and mitigation measures. In conclusion, the EPA assessed impacts from lighting not to be significant.

The Australian Government's key environmental legislation is the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The *EPBC Act* protects and manages matters of national environmental significance (MNES) which include nationally and internationally important flora, fauna, ecological communities, and heritage places.

The Project was referred to the then Commonwealth Department of the Environment and Energy (DoEE) under the EPBC Act on the 21st of December 2018 (Reference: 2018/8383) through the s.87 accreditation provisions.

The DoEE determined on 28th March 2019 that the Proposed Action was a "Controlled Action" under s.75 of the EPBC Act. The proposal was referred and assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) for its impacts on Listed threatened species and communities (sections 18 & 18A), National Heritage places (sections 15B & 15C), Listed migratory species (sections 20 & 20A) and Commonwealth Marine Areas (sections 23 & 24A).

With lighting potentially affecting sensitive receptors regarding social surroundings, additional legislation relevant to lighting management on the Project includes, but is not limited to the *Aboriginal Cultural Heritage Act 2021*This Plan will be developed and regularly reviewed to comply with the commitments and legal obligations arising from the project approvals process.

1.1.4 Policy and Guidance

To ensure compliance with the EPA guidelines for Project approval, the following policies and guidance have been considered when developing this LMP:

- EPA (2018) Statement of Environmental Principles, Factors and Objectives
- EPA (2018) Environmental Impact Assessment (Part IV Divisions 1 and 2) Procedures Manual
- EPA (2016) Environmental Impact Assessment (Part IV Divisions 1 and 2) Administrative Procedures 2016
- EPA (2016) Environmental Factor Guideline: Social Surroundings
- Australian Standard (AS/NZS) 4282-2019: Control of Obtrusive Effects from Outdoor Lighting Guidelines
- Department of Planning, Lands and Heritage and Western Australian Planning Commission (2020) Position Statement: Dark Sky and Astrotourism

1.2 Key Environmental Factors

The EPA identified the key environmental factors for the Project as including Flora and Vegetation, Terrestrial Fauna, Inland Waters, Air Quality, Greenhouse Gas Emissions, Coastal Processes, Social Surroundings and Marine Environmental Quality.

This plan addresses the EPA's Social Surroundings key environmental factor. Social Surroundings have been included in this plan as a requirement of MS 1180 Condition 10 and is detailed in **Appendix 1** of this Plan. Although there is overlap of values between Cultural Heritage and other key environmental factors due to association by environmental process, this Plan has been developed to meet the EPA's Social Surroundings factor objective and potential impacts as outlined in Table 1-1. The relevance of this environmental factors to the Project impacts is presented in Section 1.1 of this LMP.

How light from the Project impacts on native fauna and resulting mitigation strategies, is included in the Confirmed Fauna Management Plan (PCF-PD-EN-FaMP) and Threatened Species Management Plan (PCF-PD-EN-TSMP), the Construction Environmental Management Plan (0000-ZA-E-09071) and the Native Fauna Management Sub-plan (for responsibilities during the construction phase).

Table 1-1 Key Environmental Factors

Key Environmental Factor	Objective
Social Surroundings	*"To protect social surroundings from significant harm".*

1.2.1 Cultural Heritage Values

Indigenous Australians are recognised as the oldest Astronomers on earth using the Moon and stars to inform navigation, calendars, predict weather, law and social structure. Their astronomy also serves as the foundation for narratives that are passed down the generations through song, dance, and oral tradition over tens of thousands of years.

With over one million recorded rock engravings or petroglyphs, Murujuga National Park contains the densest concentration of rock art of any area in the world. The petroglyphs of Murujuga date back approximately forty

thousand years. Access to some rock engraving sites within the park is restricted under Aboriginal lore and custom. The rock art sites are also protected under the *WA Aboriginal Heritage Act 1972*, which sets penalties for disturbing or interfering with the sites.

The most accessible site for visitors to view these engravings is at Ngajarli (Deep Gorge) and the ability to view and engage with the engravings in the absence of light is an important aspect of this experience. The same applies to Hearson Cove.-

As highlighted above, this LMP interacts directly with the CHMP, and therefore these documents should be read together to ensure the EPA Environmental Factor – Social Surroundings, is protected.

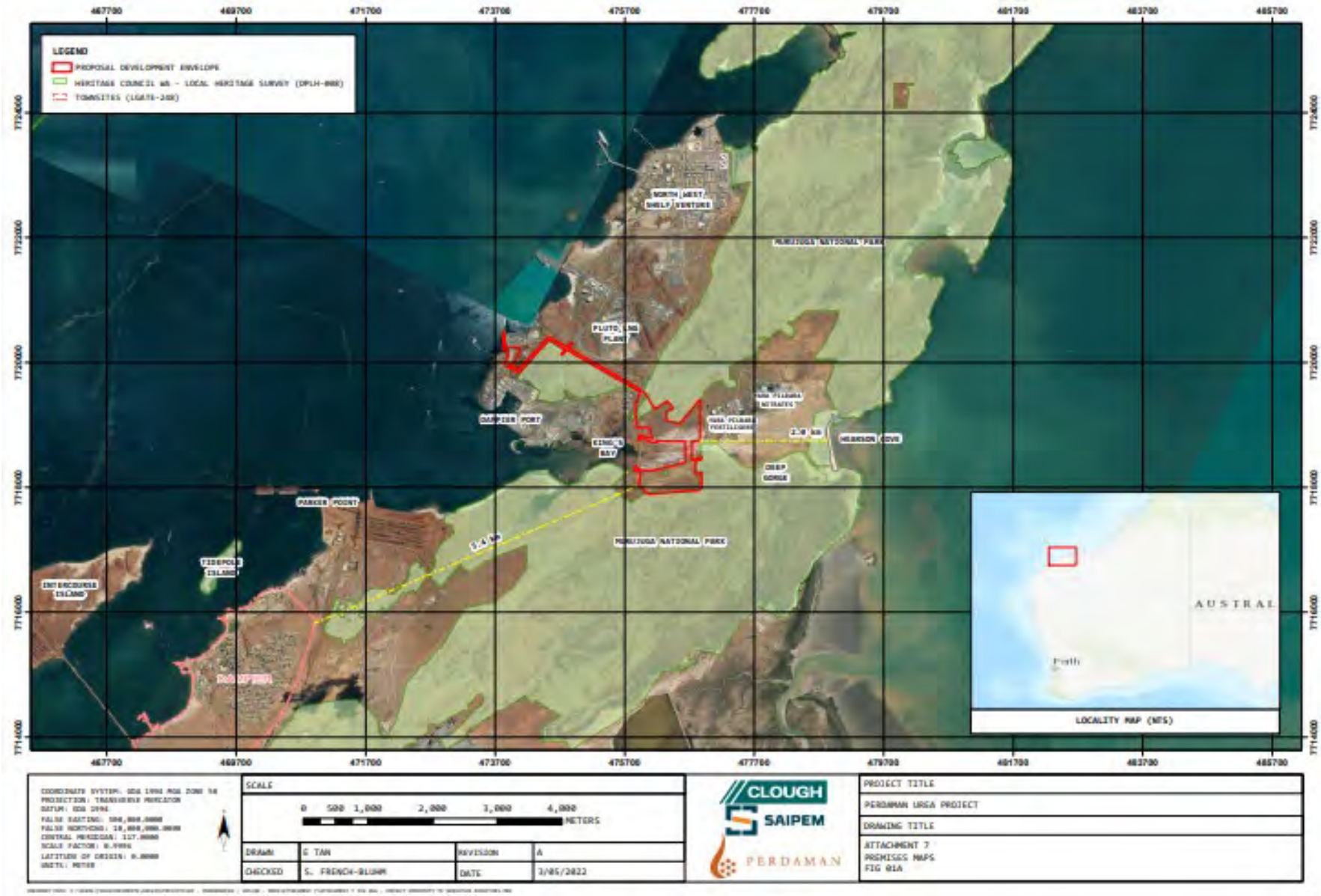


Figure 1-3 Proximity of Sensitive Receptors to Project

1.2.2 Potential Impacts

The potential impacts from construction and operational lighting emissions included degradation of amenity and cultural experience at the following sites:

- Yatha Site
- Hearson Cove and Deep Gorge.
- Fish Thalu site and Site ID 9439
- Murujuga Rock Art (petroglyphs)
- Heritage sites (see Section 1.3.5 of CHMP)
- National Heritage Place Listings
- Potential World Heritage Listing.

1.3 EP Act Ministerial Statement MS 1180 Condition Requirements

Pursuant to section 45 of the *Environmental Protection Act 1986* (EP Act), it has been agreed that the Project, as described in Section 1.1 of this Plan and subject to changes approved under section 43A of the *EP Act* on March 20th 2020, February 10th 2021, and May 13th 2021 may be implemented subject to the implementation Conditions and procedures detailed in Ministerial Statement 1180 (MS 1180).

Appendix 1 details the Ministerial Statement Conditions relating to Light Management and in which Section of the LMP each Condition is addressed.

As the Project has the potential to impact aspects with both State and Federal significance, the respective regulatory bodies (EPA and DCCEEW) have imposed Conditions associated with environmental approval (MS 1180 and EPBC 2018/8383) for the Project. Only MS 1180 includes conditions in relation to light management, however, EPBC 2018/8383 requires the implementation of the Confirmed Fauna Management Plan and Confirmed Threatened Species Management Plan, both of which contain provisions for the protection of native fauna from impacts of lighting from the Project.

The proponent must ensure all details and procedures included in this management plan are in alignment with the MS 1180 Conditions provided, and commencement of construction activities are not to proceed until permission has been granted in writing, by the **CEO**.

Permission will only be granted if the most recent version of the LMP plan addresses the following:

- Specify best practice technology and risk-based management actions that will be implemented to demonstrate compliance with the objective specified in Condition 10-1;
- Specify measurable management target(s) to determine the effectiveness of the best practice technology and risk-based management actions;
- Specify monitoring to measure the effectiveness of best practice technology and management actions against management targets;
- Specify a process for revision of best practice technology and management actions and changes to Project activities, in the event that the management targets are not achieved, and this process must include an investigation to determine the cause of the management target(s) not being met;
- Provide the format and timing to demonstrate that Condition 10-1 has been met for the reporting period in the Compliance Assessment Report required by Condition 15-6 including, but not limited to:
    - verification of the implementation of best practice technology and management actions; and
    - reporting on the effectiveness of best practice technology and management actions against management target(s).

This Revised Light Management Plan has been prepared in consultation with the Murujuga Aboriginal Corporation, and is submitted in accordance with MS 1180, Condition 10-6 (1). As required under Condition 16-1, this Plan will be made publicly available for the life of the project. The requirements of these Conditions and where they are addressed in this Plan are presented in Appendix 1.

In accordance with Condition 10-7, Perdaman shall implement the most recent version of the Confirmed Light Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated that the environmental objective in condition 10-1 has been met.

1.4 Rationale & Approach

1.4.1 Survey & Study Findings

Pendoley Environmental (PENV) were engaged to undertake benchmark artificial light monitoring to establish current light pollution levels, create a baseline for light modelling and future light monitoring surveys. The survey goal was to capture all-sky imagery from three primary locations (as specifically identified by the DWER conditions) and any additional locations identified after consultation with Murujuga Aboriginal Corporation (MAC), as per the EPA Recommended Conditions (EPA Report 1705, Assessment number 2184) Condition 10, Light Management . Specifically, the objectives of this survey was to establish the current light pollution levels at specific locations including (but not limited to) the project site, Hearson Cove, and Ngajarli (Deep Gorge), locations to be refined in consultation with Murujuga Aboriginal Corporation.

The benchmark survey report also included recommendations for additional surveys to be carried out to allow for modelling and benchmarking for future monitoring.

The full *Perdaman Urea Project: Benchmark Artificial Light Monitoring. Perdaman Light Survey Report* (Pendoley, 2022). is provided as **Attachment A**.

The benchmark survey was carried over five days and four nights during new moon conditions between the 28 February and 4 March 2022 using Sky42 light monitoring equipment.

The survey goal was to capture all-sky imagery from Hearson Cove and Deep Gorge (as per Condition 10-1 of MS 1180) and an additional three locations identified after consultation with MAC. On the second day of the survey, a MAC ranger guided the team to additional culturally important survey locations and assisted to select a better site to place the Deep Gorge 2 camera. Night sky conditions were varied over the survey period with intermittent cloud throughout Nights 1-3, with clearest conditions occurring on Night 4. In general, the imagery was mostly clear with only the Yatha and Shell Midden images affected by thin cloud on the 1st and 2nd of March. The camera survey locations are listed in and shown in Figure 1-4.

Table 1-2 Light Survey Locations - Feb 2022

Benchmark Monitoring Location	Latitude	Longitude	Nights	Height (cm)
Hearson Cove	-20.631220	116.796927	1-4	92
Deep Gorge 1	-20.636803	116.788455	1-4	130
Deep Gorge 2 (L1)	-20.637774	116.788269	1	107
Deep Gorge 2 (L2)	-20.638179	116.788369	2-4	107
Project Site C*	-20.629227	116.771407	1	130
Shell Midden Pool*	-20.641315	116.773911	2	130
Yatha*	-20.637298	116.768176	3	130
Cultural Heritage Site	-20.637340	116.772969	4	130

* Additional locations identified after consultations with MAC

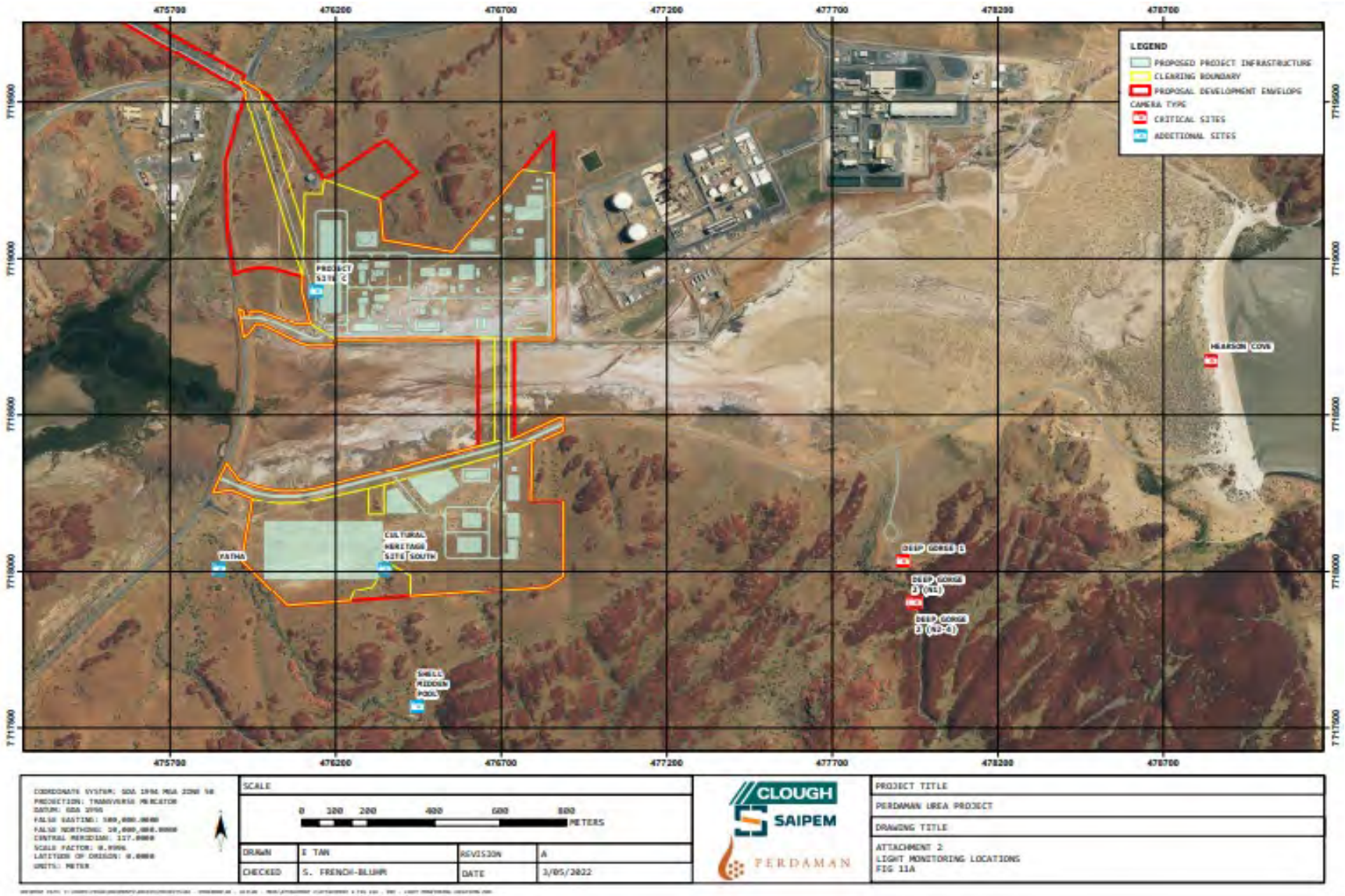


Figure 1-4 - Light Monitoring Locations Agreed with MAC

Data was successfully collected from the three primary survey locations during each night of monitoring, with the clearest imagery captured on the 3 March 2022. Four additional survey locations were captured during the survey period, with clear imagery captured at Project Site C and Cultural Heritage Site South. Monitoring nights at Yatha and Shell Midden Pool were partially affected by thin cloud, and this may have inflated the brightness levels measured at these locations due to increased reflection of light from the clouds. Each camera was mounted on a tripod to better capture horizon sources of artificial light and remove the influence of vegetation on the images (see). Cloud cover varied over the course of the survey, and to allow for better comparison between imagery the clearest image from the whole survey was selected from each location for analysis and processed results are shown in through and detailed in .

Table 1-3 Brightness for Whole-of-Sky, Zenith and Horizon Captured at Each Survey Location During the Field Survey.

	Sky Brightness (Vmag / arcsec^2)		
Monitoring Location	**Zenith**	**Whole-of-Sky**	**Horizon**
Hearson Cove	20.33	19.29	18.85
Deep Gorge 1	20.25	19.36	18.97
Deep Gorge 2 (L2)	20.20	20.13	20.33
Project Site C*	19.84	18.97	18.58
Shell Midden Pool*	20.16	19.49	19.21
Yatha*	19.95	19.15	18.79
Cultural Heritage Site	20.01	19.07	18.66

A unique, innovative monitoring tool (Sky42™ camera) was used for recording ambient night-time light emissions**.** The camera measures light on a landscape scale including the light at the horizon which is most pertinent to humans observing the sky from viewing locations within the Murujuga National Park and Hearson Cove. The Sky42 cameras are stand-alone and rugged, encased within all-weather proof housing, and can be transported by hand in the field. The cameras were deployed at the three primary survey locations plus at one additional location on each survey day and were programmed to automatically begin taking photos in 10-minute intervals between sunset and sunrise. Cameras were retrieved, charged, and had their data downloaded every second day.

The cameras feature custom-written software to automatically capture multiple low light night sky images of night-time light emissions visible from the beach, on a full 360° horizon, every 15 minutes throughout the night (commencing after sunset and ending prior to sunrise). The images allow for:

- All visible, individual light sources to be identified and monitored across a full night;
- Suitable comparison against future monitoring campaigns; and
- The effectiveness of any implemented light management controls to be quantified.

Figure 1-5: Examples of deployed Sky42 light monitoring camera

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

All suitable images were processed to determine 'whole-of-sky', 'zenith', and 'horizon' sky brightness levels. Zenith is the mean value of sky glow in magnitudes within 0 – 30° field of view directly overhead, whole-of-sky (WOS) is the mean value of sky glow in the entire image, and horizon is the mean value of sky glow within the 60 – 90° outer band (see).

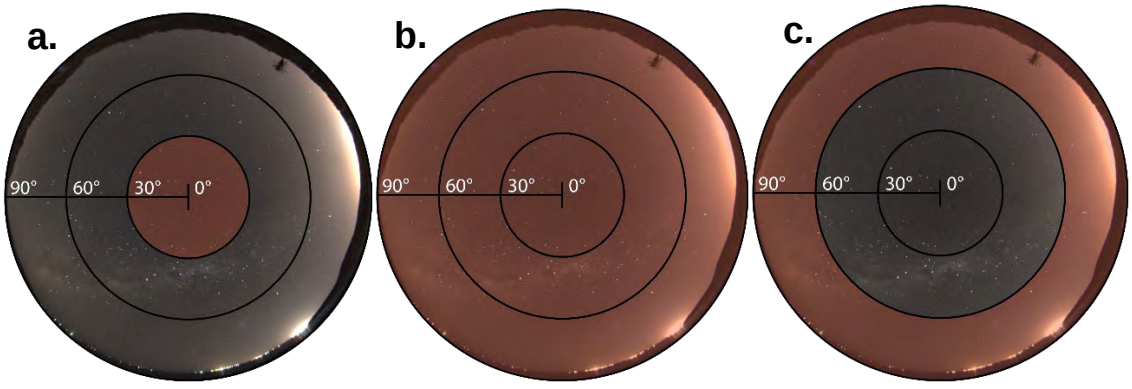


Figure 1-6: Measurement of mean pixel values from processed images captured by a Sky42 camera;

a. Zenith brightness (0 – 30°); b. WOS brightness (full image); c. Horizon brightness (60 – 90°). White shaded areas denote the region of the sky being measured.

Sky brightness is quantified in units of visual magnitudes/arcsec^2 (Vmag / arcsec^2)(a standard unit used in astronomical measurements and emerging as a standard for sky glow monitoring globally). The visual magnitudes/arcsec^2 unit quantifies light intensity on an inverted logarithmic scale i.e., higher values represent lower intensity light, while lower values represent higher intensity light.

Additionally, for each relevant monitoring location, a set of processed images were generated detailing the raw fisheye image, processed fisheye image, and an "unwrapped" version as a projected all-sky benchmark image allowing horizon light sources to be easily identified (see through). The re-projected all-sky image for each

site was used as input into the artificial light modelling.

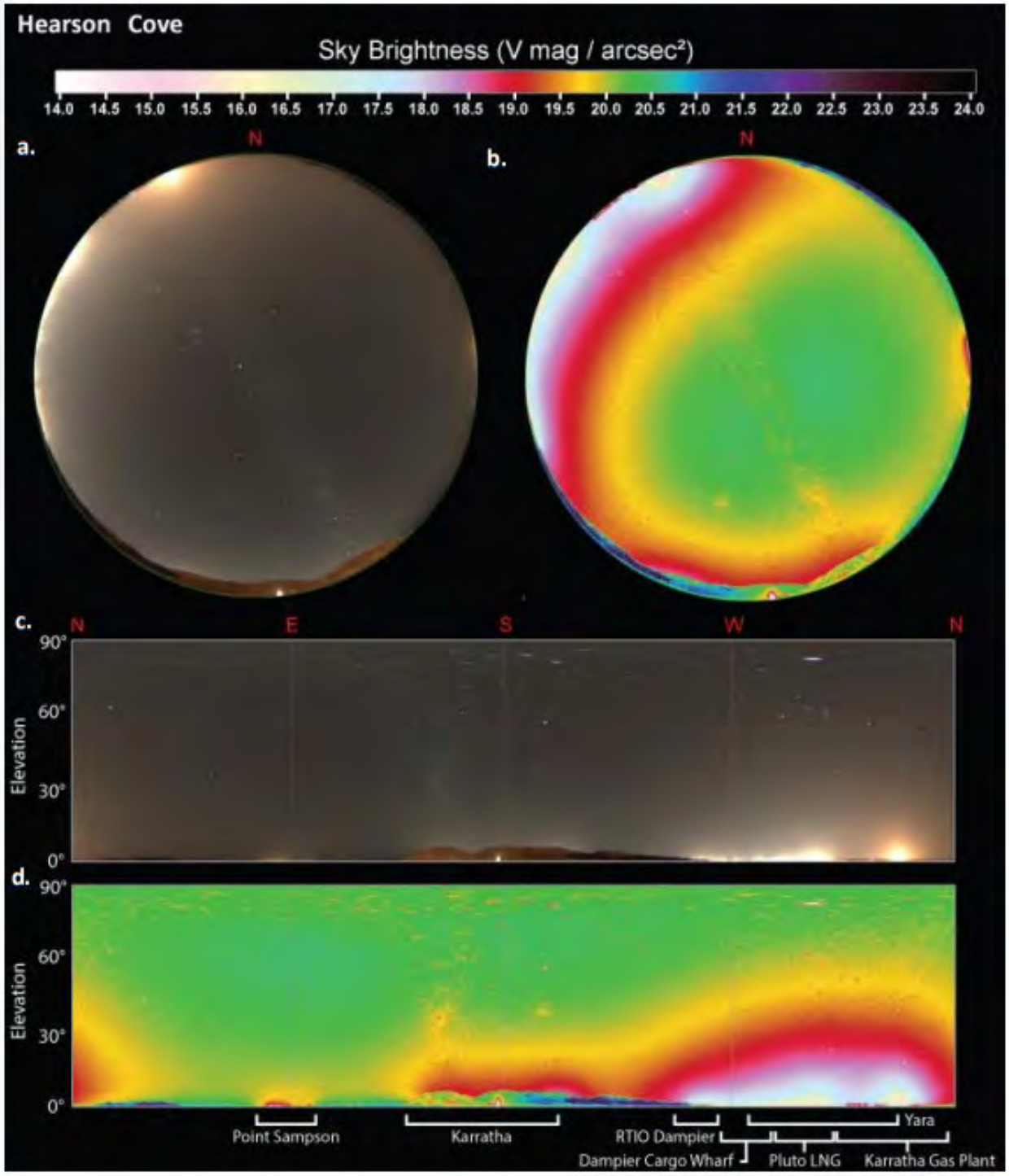


Figure 1-7 Artificial light monitoring at Hearson Cove from the 3rd of March 2022.

a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

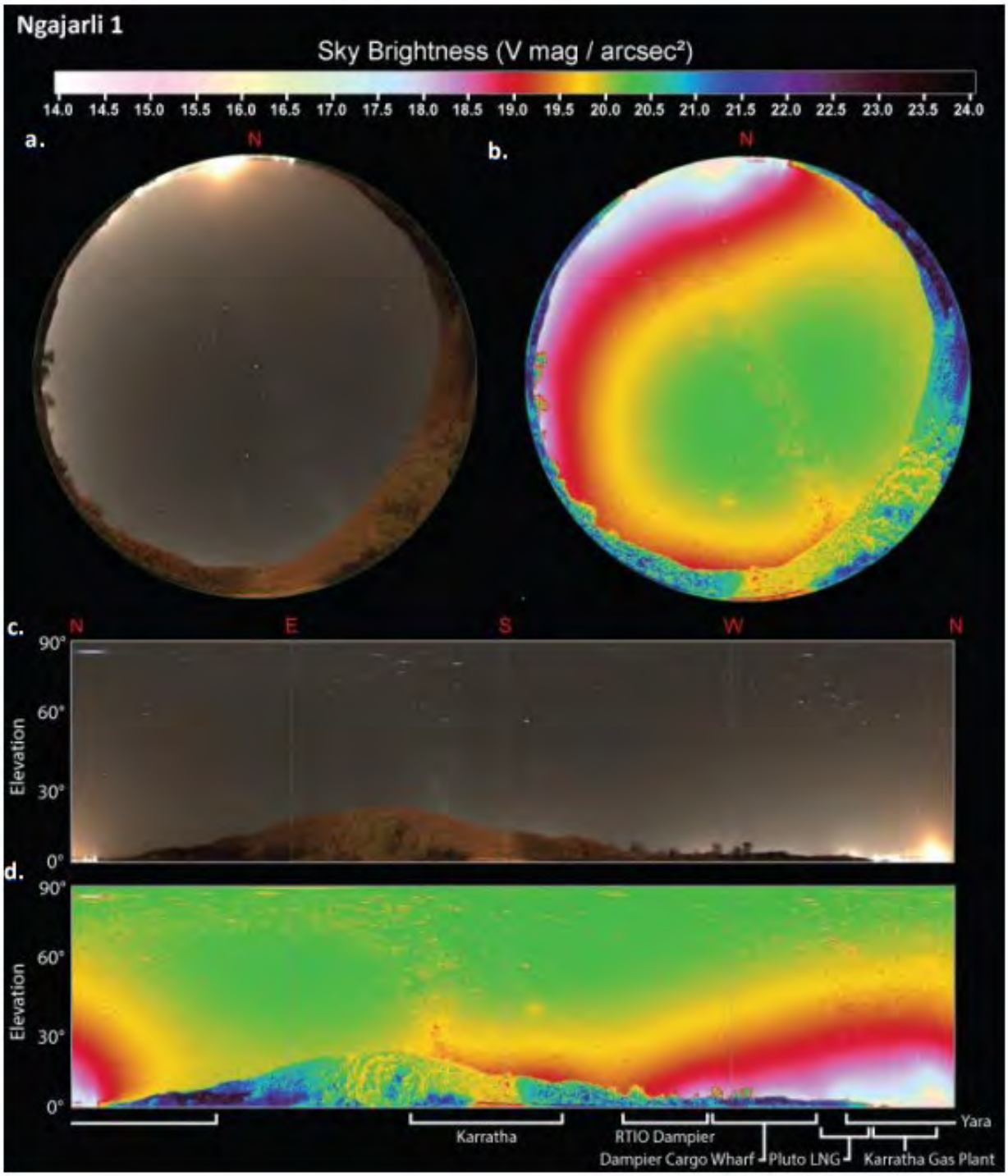


Figure 1-8 Artificial light monitoring at Ngajarli Site 1 from the 3rd of March 2022.

a. Raw fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

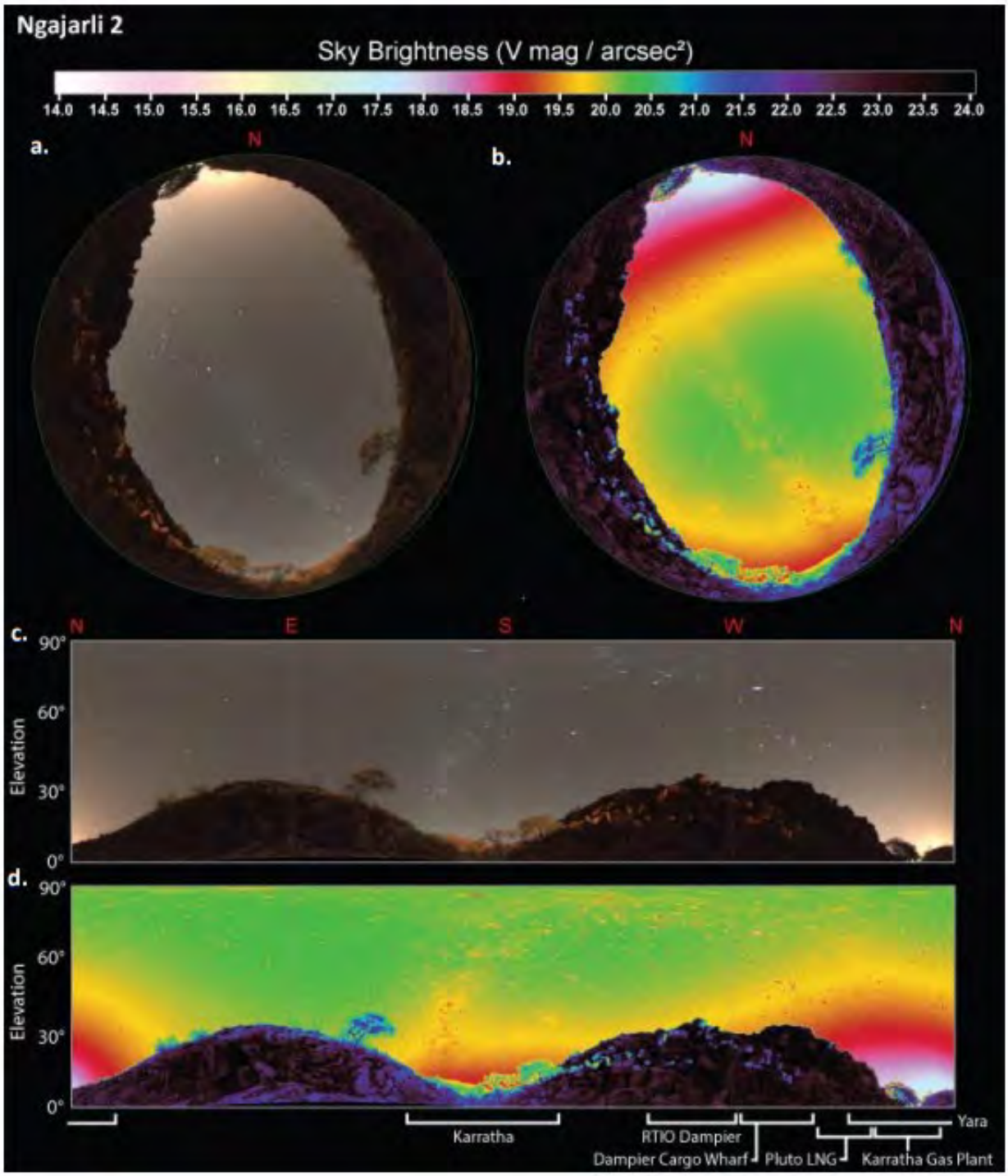


Figure 1-9 Artificial light monitoring at Ngajarli Site 2 from the 3rd of March 2022.

a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

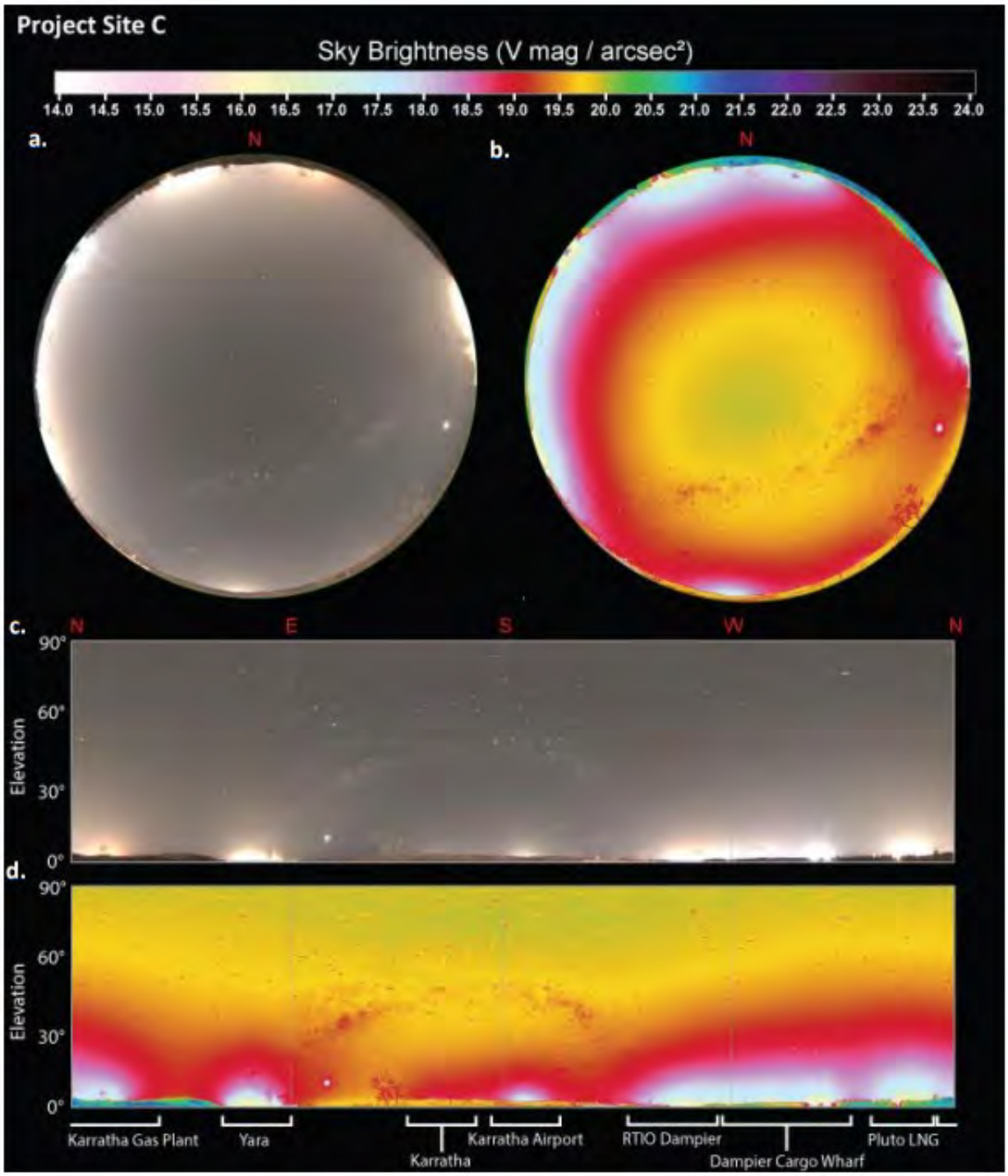


Figure 1-10 Artificial light monitoring at Project Site C from the 28th of February 2022.

a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

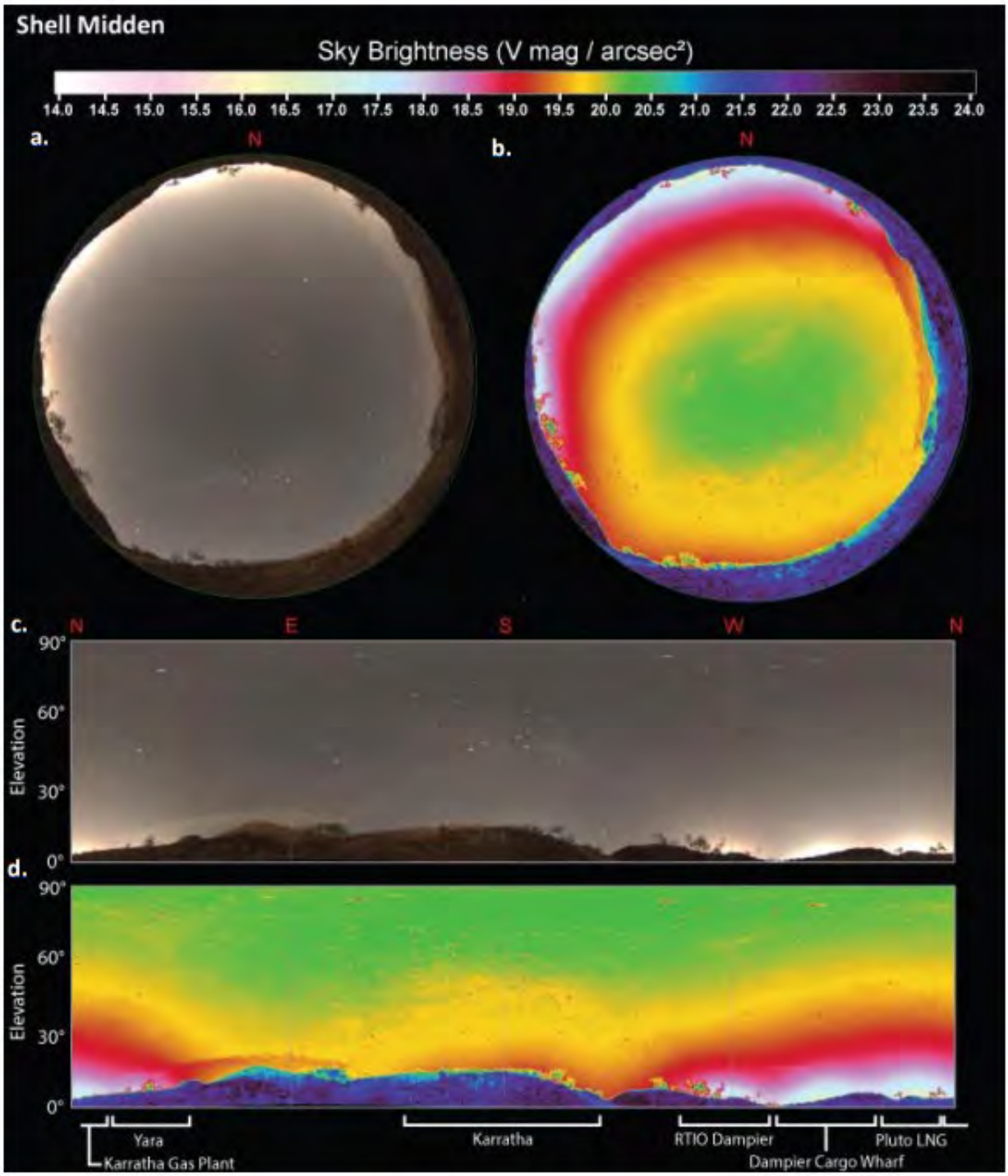


Figure 1-11 Artificial light monitoring at Shell Midden from the 1st of March 2022.

a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

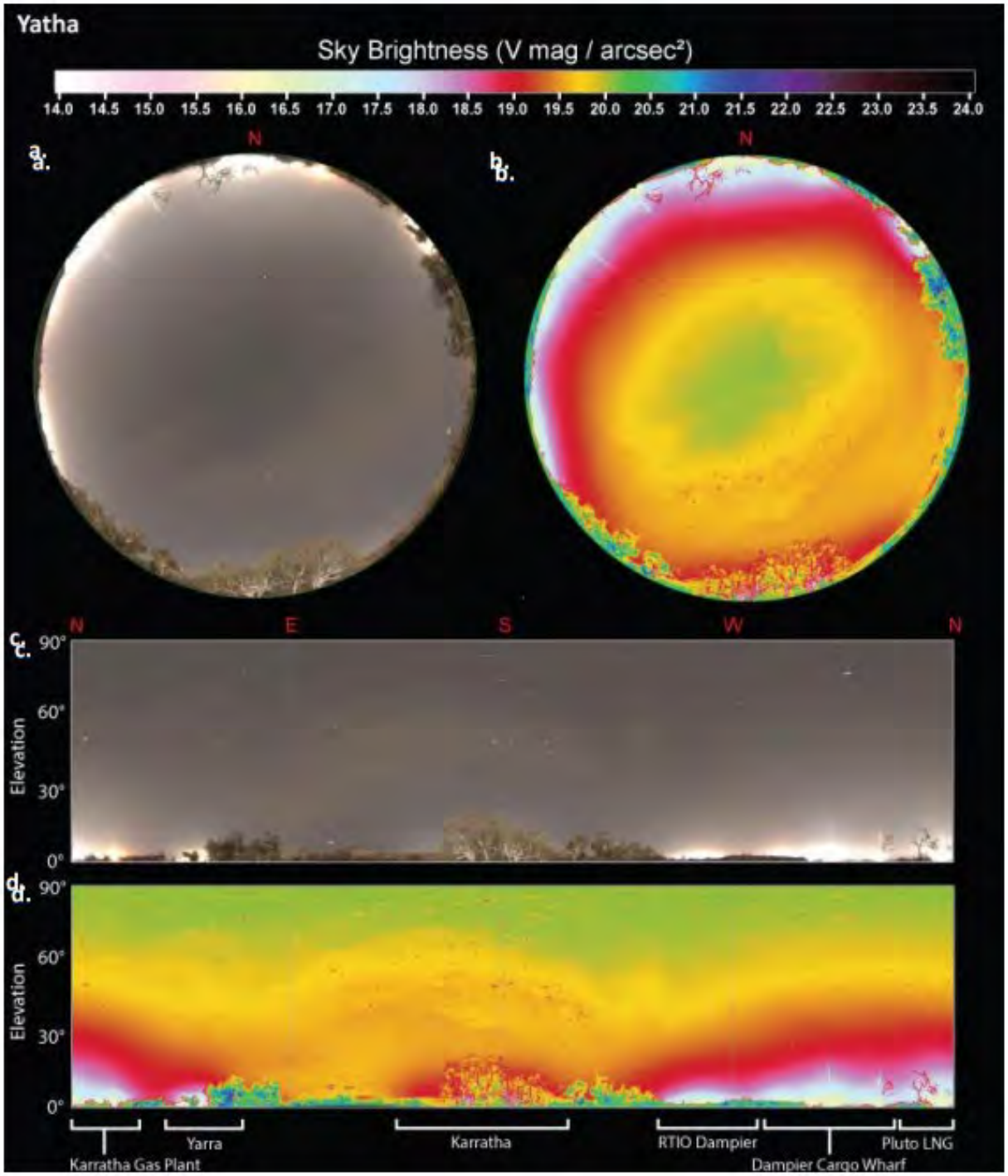


Figure 1-12 Artificial light monitoring at Yatha from the 2nd of March 2022.

a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

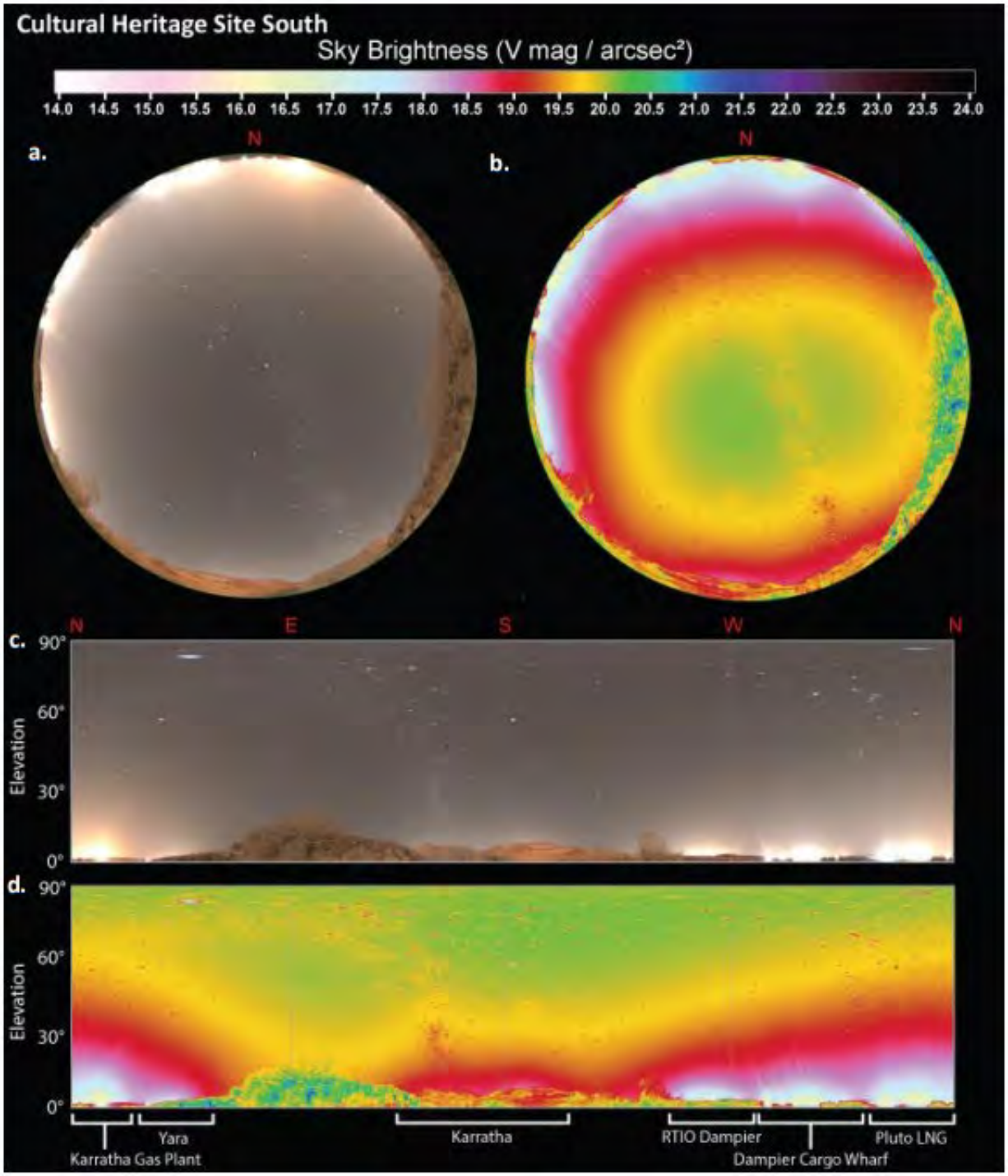


Figure 1-13 Artificial light monitoring at Cultural Heritage Site South from the 3rd of March 2022.

a. Raw circular fisheye image; b. Processed circular image; c. Raw "unwrapped" projected all-sky benchmark image; d. Processed "unwrapped" projected all-sky benchmark image.

Of the primary monitoring locations in, zenith brightness was similar between all three locations, with the brightest measurement recorded at Ngajarli 2 (20.20 Vmag / arcsec^2 ; Figure 7), followed by Ngajarli 1 (20.25 Vmag / arcsec^2; Figure 8) and Hearson Cove (20.33 Vmag / arcsec^2; Figure 9). However, WOS (20.13 Vmag / arcsec^2) and horizon brightness (20.33 Vmag / arcsec^2) were darkest at Ngajarli 2 due to the gorge walls/cliffs providing natural shielding from light sources on the horizon. WOS (19.29 Vmag / arcsec^2) and horizon brightness (18.85 Vmag / arcsec^2) was greatest at Hearson Cove where there is little natural shielding present on the horizon.

Of the additional locations (to), Project Site C was the brightest in all categories due to its proximity to artificial light sources. Zenith, WOS and horizon brightness were measured at 19.84, 18.97 and 18.58 Vmag / arcsec^2 respectively. Shell Midden Pool was the overall darkest of the additional locations with a zenith, WOS and horizon brightness of 20.16, 19.49, 19.21 Vmag / arcsec^2 respectively.

Based on the zenith brightness, all locations fall in the magnitude range of 19.50-20.49 (Bortle Class 5) with reduced visibility of stars and the Milky Way, which is equivalent to a suburban night sky (().

Data captured during this pre-development light monitoring survey will be utilised for the proposed artificial light modelling of the Perdaman development and can be used to compare with any post-development surveys to determine changes in light over time.

The existing lighting environment is very bright, and all the monitoring locations were heavily influenced by surrounding artificial light sources from Burrup industrial sites, the King Bay Port facilities, LNG plant gas flares, town of Dampier and the Karratha airport and townsite. Existing light pollution has degraded the natural night sky to that of a suburban equivalent, where many stars are no longer visible to the naked eye and the milky way is only partially visible.

Further works are required, in accordance with Pendoley (2022), which includes:

- Artificial light modelling, discussed in Section 1.4.3
- Light assessment, discussed in Section 1.4.4, and
- Light Management Plan amendment discussed in Section 1.4.4.

1.4.2 Management Approach

With consideration of the EPA Conditions (see **Section 2**), this Light Management Plan for the Project has been prepared to detail:

- Overall management approach to lighting.
- best practice technology for lighting on the Project;
- measurable management targets;
- monitoring to measure effectiveness of lighting management controls; and
- corrective actions should management targets not be achieved.

The management approach of this LMP has been informed by best practice and the expectations within the environmental Conditions stated in MS 1180. The primary approach taken focusses on avoiding potential impacts through design and planning mechanisms. Where the impacts are unavoidable, management actions will be applied to minimise the duration, intensity or extent of the potential impact to sensitive locations.

In addition, implementation of an Environmental Management System (EMS) Framework provides a structure for achieving the key environmental objectives during the construction and operational phases of the Project. Implementation of the EMS Framework ensures environmental performance is achieved through environmental management practices that are consistent with the Perdaman Environmental Policy and Objectives. Management measures and actions are specifically detailed within this Plan (Section 2) and reiterated within the Light Management Protocol as Appendix O of the CEMP. The *Environmental Management Protocols* have been developed to address the environmental risks posed by construction and operational based activities of the Project.

A summary of the management approach for this LMP includes:

- Avoid impacts to identified sensitive locations, including, but not limited to Hearson Cove and Deep Gorge;

- Risk Assessment and the internal use of early response indicators and criteria with performance indicators to track impacts;
- The establishment of spatially defined Project areas, as per the Areas discussed in Section 1.1 of this Plan and shown in Figure 1-2 (i.e., Site F, Site C, Causeway etc);
- Consideration and investigation of use of new technologies and techniques that will inform updates to monitoring parameters, monitoring sites, and management measures;
- Regular review and update of the monitoring program based on changes to Project, timings of construction and operations, and light monitoring data etc.;
- Review of management measures to be implemented in the event of trigger criteria being exceeded;
- Measurement and review of effectiveness of implemented management measures; and,
- Assessment of background contributing sources not associated with this Project.

1.4.3 Artificial Light Modelling

Currently, there are no standard commercial models for landscape scale modelling of artificial light emissions (Commonwealth of Australia 2020). Recognising this gap and the growing need to respond to both local and national regulatory concerns over artificial light impacts on wildlife (Commonwealth 2020) and on dark sky conservation values required to meet IDA Dark Sky Place (DSP) certification requirements. A base model called the ILLUMINA model has been developed by Sherbrooke University, Canada (Aube et al. 2005). This well-documented, open-source model is the most appropriate for this Project due to its ability to represent light across large areas and distances and across the entire visible spectrum, including biologically meaningful light from 350 nm – 700 nm.

Unlike commercially available engineering light models that are commonly used to design human centric lighting for the relatively small footprint of single or multiple buildings, parking lots, streetlighting etc., ILLUMINA is a three-dimensional model that accounts for both line-of-sight light visibility in addition to the glow derived from atmospheric scattering of light. The model also addresses the attenuation/loss of light over landscape scale distances and, consequently, the areal extent of light glow across the sky can be modelled. Additional details of the equations and model parameterisation can be found in Aube et al. (2005) and Aube & Simoneau (2018).

The inputs, outputs, and limitations of the model are as follows:

Inputs

Inputs to be extracted and/or extrapolated from information provided by the EPC Contractor:

- Topography:
    - High-resolution elevation data provided by Clough is preferred. If unavailable, publicly available Shuttle Radar Topography Mission (SRTM) data will be used.
- Detailed lighting design/inventory, including the location, height, and type of all luminaires to be installed for the operations phase. If unavailable, PENV will generate a generalised lighting inventory using the following information:
    - Approximate number of buildings and locations within the proposed development;
    - The location of lit roadways and access ways;
    - Building heights (where available);
    - Estimated lumen output of structures or zones within the development area;
    - Estimated shielding on all lights (e.g., 0 %, 50 %, 60 % etc.); and
    - An estimated ratio of lighting types/CCT present – e.g., 35 % 2200K LED vs 65 % Cool White Fluorescent.
- Benchmark all-sky imagery (collected in Phase 1).

Outputs

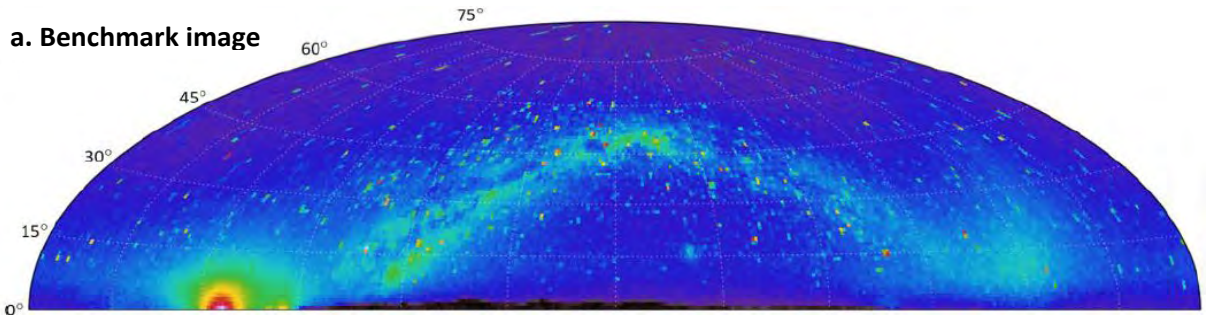
Local-scale - All-sky Modelled False-colour Map.

A projected all-sky modelled images ‘as viewed’ from selected monitoring locations will be produced that can be added directly to the benchmark camera imagery to show the predicted increase in brightness across the whole sky, including the horizon, from the monitoring locations (see for an example). Other useful metrics, such as all-sky and zenith brightness, can also be extracted from this modelled data.

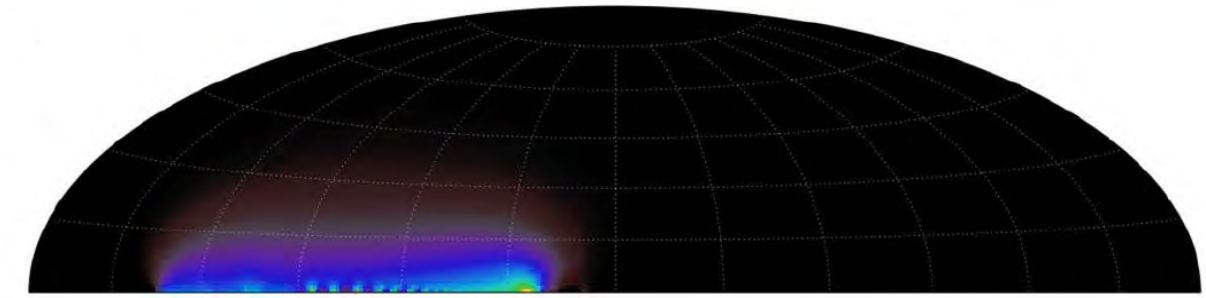
Figure 1-14: All-sky benchmark imagery and modelled all-sky image from an observer location

a. benchmark image recorded by a Sky42 camera; b. modelled brightness based on lighting design; c. benchmark + predicted brightness.

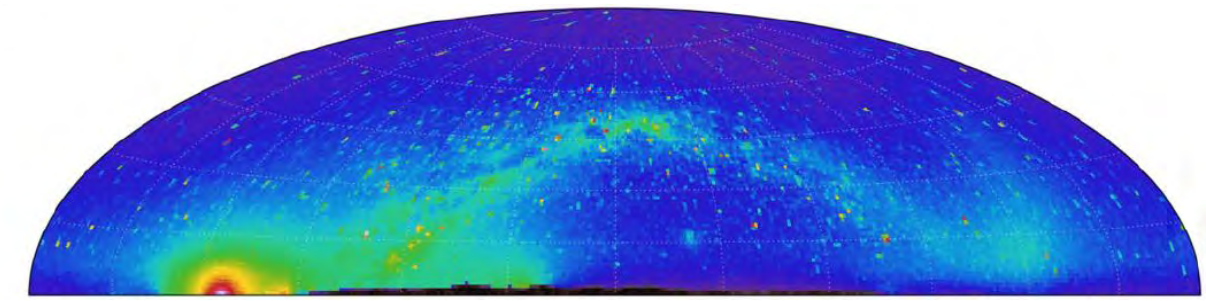
a. Benchmark image



b. Modelled brightness of proposed development



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



While the local-scale modelling shows brightness across the whole sky from just a few locations, broad-scale modelling uses hundreds of observer points, but models only a small region of the sky overhead (0 – 30°). This results in a false-colour map of zenith brightness (i.e., what an observer sees when they look directly upwards at the sky) that can be directly compared with Sky Quality Meter and Bortle Scale measurements that is commonly used for classifying Dark Sky regions (). One broad-scale map will be produced, and raw outputs can also be provided as a shapefile for input into GIS software.

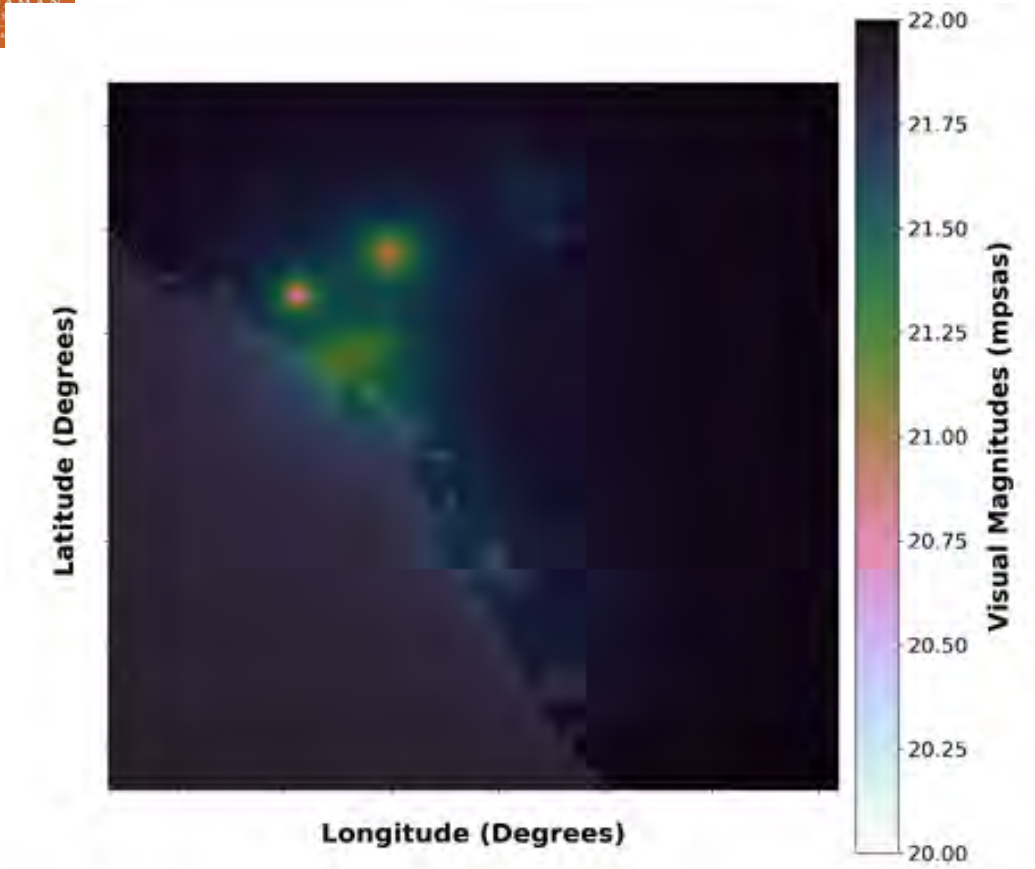


Figure 1-15: Broad-scale model output showing zenith brightness on a regional scale.

Model Assumptions

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

- If manufacturer specifications for luminaires are not available, the spectral power distribution for the light types used in the model is generated based on a typical curve for the light type specified e.g., HPS, Fluorescent, 3000K LED etc.
- The modelled all-sky imagery assumes the observer is located at 1 m height above ground to match that of the benchmark imagery.
- There is no impact from weather conditions (for example, cloud and rain may increase reflection and scattering of light).
- There is no influence of the sun or moon on light intensity.
- Where there are gaps in the details of the lighting design, we will make assumptions on the lighting needs and apply these to the model. These assumptions and the basis for making them will be discussed and agreed upon with Clough in advance.

1.4.4 Light Impact Assessment and LMP Amendment

The light impact assessment is made up of the following components which are consistent with the general approach outlined in the *Commonwealth Light Pollution Guidelines for Wildlife* (the guidelines) and *the NSW Department of Planning and Environment* (2016) Dark Sky Planning Guideline.

Information from the proposed lighting design, benchmark light monitoring program and the modelling will be used to carry out a light impact assessment.

The light impact assessment will review the Project against the Commonwealth guideline best practice light principles, qualitative assessment of the horizon visibility of sky glow/ direct light sources and the Bortle Class sky quality guide ().

Table 1-4 Interpretation of magnitude band values (Source: Bortle Scale). Use as guide only.

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

Upon completion of the light assessment, this Light Management Plan shall be revised to include:

- Description of the sensitive receptors.
- Description of the existing and proposed light environment.
- Lighting design and mitigation measures.
- Impact assessment based on the proposed light management.
- Details regarding the minimum suitable mitigation measures and best practice lighting design
- A proposed ongoing ALAN monitoring program to inform an adaptive management framework to support continuous improvement in light management.
- Auditing and reporting schedule.

1.4.5 Monitoring Approach

The purpose of light monitoring is to inform, through the environmental criteria, if the environmental outcomes as defined in the amended Light Management Plan (Section 1.4.4) are being achieved and if required to determine when the defined trigger level or threshold levels are exceeded. The exceedance of trigger or threshold criteria then informs which contingency management measures need to be implemented.

Due to the outcomes required in Condition 10-1 of MS 1180, monitoring construction and operations will be undertaken as per the timing and methodology detailed in the amended Light Management Plan.

Details of the monitoring proposed is shall be provided in the amended Light Management Plan.

1.4.6 Rationale for Choice of Provisions

The management provisions in this Plan are based on both the management approach detailed in section 1.4.2 and the requirements of the MS 1180 Condition 10. As the nature of potential impacts from Project lighting on social surroundings do not directly relate to environmental aspects that can be quantitatively measured, a management-based (objective-based) approach has been taken to manage light impacts, such as nightglow and overspill during the life of the Perdaman Project (see Section 2.1).

The rationale for the choice of management provisions including the management actions, targets, monitoring and reporting has been made partly on the basis of the MS 1180 Condition 10 requirements and additionally, from consultation with MAC. Correspondences from recent MAC consultations are provided in **Attachment B – Letter to EPA for MAC Consultation on Project** and **Attachment C – MAC Consultation – 24th Jan 2022.** Additional records of consultations are provided in Table 4-1 Stakeholder Consultation Register

Some potential impacts managed under this LMP are subject to further scientific monitoring and results, therefore the understanding of how these impacts are best managed during the Project implementation may change. To address the uncertainty associated with these potential impacts, an adaptive management approach (Section 3) will be implemented for the Project.

2 Light Management Plan Provisions

This Section of the LMP sets out the provisions that will be implemented for the Project. This Plan outlines the risk-based management (Section 2.1) provisions. All requirements will be carried out during construction and operations and until the Perdaman Urea Plant is decommissioned and closed.

This LMP will be implemented in conjunction with the Cultural Heritage Management Plan (PCF-PD-EN-CHMP-), Fauna Management Plan (PCF-PD-EN-FMP-) and the Threatened Species Management Plan (PCF-PD-EN-TSMP-), as well as the Construction Environmental Management Plan (0000-ZA-E-09071), Heritage Management Sub-plan, and Native Fauna Management Sub-plan.

As the number and intensity of artificial lights in the Burrup Industrial Area increases there will be a visible, cumulative increase in sky glow. Sky glow is the brightness of the night sky caused by the reflected light scattered from particles in the atmosphere and can comprise both natural and artificial sources.

The proponent has committed to design the plant lighting in accordance with AS/NZS 4282-2019: Control of Obtrusive Effects of Outdoor Lighting Guidelines, placing light shields on large equipment to minimise light overspill, and using minimum wattage lighting in the plant where possible

The following Section of the LMP provides guidance for how best to achieve these objectives. This LMP applies to lighting associated with the Project and does not allow for seasonal light management.

2.1 Objective (Management) - Based Provisions

An objective is the Project-specific desired state for an environmental factor to be achieved from the implementation of management actions and must relate to the EPA's environmental objective for a particular factor.

This section of the LMP provides details of the objective based provisions to implement on the Project. Management-based provisions relate to management actions and are used where it is not practical, efficient or necessary to implement outcome-based provisions because the priority for protection is lower.

Management actions are the actions implemented to achieve the environmental objective (Condition 10-1 of MS 1180) which generally relate to the 'minimise' and 'rehabilitate' steps of the mitigation hierarchy, while management targets are a type of indicator defined to demonstrate that the objective is being met.

The management actions presented in Table 2-1 below have been prioritised using a risk-based approach (see Risk Assessment & Mitigation Appendix 3), so that the greatest effort will be placed on the Project activities that have the highest likelihood of causing environmental impacts where the consequence of the impact is likely to be severe and irreversible. In addition, the management actions will be implemented to demonstrate compliance with the objective (Condition 10-1) and will include best practice technology.

The measurable targets, which are specified against each management action (Table 2-1), will be subject to a monitoring program, which will aid the Project in determining the effectiveness of the best practice technology being applied and the risked based management actions being implemented for achieving the objective stated within Condition 10-1 of MS 1180.

Table 2-1 Objective Based Management Actions & Targets

EPA Factors and Objectives	Social Surrounds - "To protect social surroundings from significant harm"
Conditional Objectives	Condition 10-1 - avoid, where possible, and otherwise use best practice technology and risk-based management actions to minimise nightglow and light overspill from the Project so that the environmental values of amenity at sensitive locations, including, but not limited to Hearson Cove and Deep Gorge, are protected.
Key Environmental Values	Maintain environmental values of amenity Protect sensitive human and environmental receptors.
Key Impacts and Risks	Impacts to Hearson Cove and Deep Gorge. Impacts to social surroundings by impacting heritage sites, obstructing traditional use of sites due to overspill of lighting. This may deteriorate tourism through obstruction of amenity values of the surrounding environment, further impacting social surrounds.

MANAGEMENT ACTIONS	MANAGEMENT TARGETS	MONITORING	REPORTING
MANAGEMENT ACTION 1 To achieve Condition 10-2(1) Specify best practice technology to minimise nightglow and light overspill at sensitive locations, including, but not limited to Hearson Cove and Deep Gorge, are protected.	**LMP TARGET 1** Apply principles of AS/NZS 4282-2019: Control of Obtrusive Effects from Outdoor Lighting Guidelines to Project light design.	**Indicator:** This LMP and Lighting Design compliance to best practise technology (AS/NZS 4282-2019). **Method:** Implementation of this LMP and lighting design that meets target (LMP Target 1 and Condition 10-2(1). Preparation and reviewing of Lighting Design Reports. **Location:** Entire Project (PDE) site that could impact Hearson Cove and Deep Gorge and other sites identified by the MAC. **Timing and Frequency:** Lighting Design to be finalised and assessed against design principles of AS/NZS 4282-2019. Environment and Heritage Management responsible for monitoring, updating and review of this LMP. **Responsibility**	Reporting to Project Director in design reports. Reporting in the annual Compliance Assessment Report (CAR) to the EPA.

MANAGEMENT ACTIONS	MANAGEMENT TARGETS	MONITORING	REPORTING
		Design Manager Construction Manager. Project Director accountable.	
MANAGEMENT ACTION 2 Benchmark light monitoring. Develop a light monitoring program to measure the effectiveness of best practice technology and management actions against management targets (pending results of the benchmark monitoring).	**LMP TARGET 2** Establish benchmark against which light visibility at Hearson Cove, Deep Gorge and any other sites identified by MAC that can be measured.	**Indicator:** Establishment of monitoring for benchmarking light visibility at sensitive sites. Benchmark results from monitoring program. **Method:** Establishing benchmark monitoring- Sky42 camera monitoring Develop Monitoring Program from Benchmarking. **Location:** Hearson Cove and Deep Gorge and other sites identified by MAC. **Timing and Frequency:** Commencing prior to construction. date to be determined 2023 , consecutive nights at new moon. **Responsibility** Pendoley Environment Environmental Manager accountable	Compliance to this Target reported in the CAR.
MANAGEMENT ACTION 3 Modelling of plant lighting design.	**LMP TARGET 3** Development of optimum plant light design, model to be used to predict visibility of proposed lighting design and to test light management and mitigation refinements.	**Indicator:** Final plant lighting design Report. Plant Model **Method:** Using the results from benchmark monitoring. Development of light provisions in plant design. Modelling the predicted plant lighting design and potential emissions. If required, prepare additional management and mitigation measures in design to assess and predict proposed light	Results to be reported in amended **Confirmed** Light Management Plan. Compliance to this Target reported in the CAR.

MANAGEMENT ACTIONS	MANAGEMENT TARGETS	MONITORING	REPORTING
		design emissions of plant. Review similar modelling of plants and light emissions in the Burrup Peninsula to prepare & compare modelling. Review and apply best practise technology. **Location:** Hearson Cove and Deep Gorge and other sites identified by MAC. **Timing and Frequency:** Following submission of 85% light design by EPC Contractor. Update the Light Model as required through adaptive management approach. **Responsibility** Pendoley Environment - Modelling Design Manager - Implementation Construction Manager. Project Director accountable.	
MANAGEMENT ACTION 4 Commissioning light monitoring	**LMP TARGET 4** Confirm compliance with light management plan commitments. Ground truth light modelling results.	**Indicator:** Light monitoring results during commissioning. **Method:** Conduct light monitoring during plant commissioning and compare against benchmark. Review commitments against results. **Location:** Hearson Cove and Deep Gorge and other sites identified by MAC. **Timing and Frequency:**	Post commissioning light monitoring report. Compliance to this Target reported in the CAR.

MANAGEMENT ACTIONS	MANAGEMENT TARGETS	MONITORING	REPORTING
		During Plant commissioning. **Responsibility** Pendoley Environment - Modelling Design Manager - Implementation Construction Manager. Project Director accountable.	
MANAGEMENT ACTION 5 EPC Contractor to prepare a Light Management Protocol as part of its Construction Environmental Management Plan Framework.	**LMP TARGET 5** EPC Light Management Protocol to be developed in accordance with this LMP and principles of AS/NZS 4282-2019: Control of Obtrusive Effects from Outdoor Lighting Guidelines.	**Indicator:** Light Management Protocol – Construction Based. **Method:** Conduct compliance review and gap analysis between this LMP and the Light Management Protocol. Review principles of AS/NZS 4282-2019: Control of Obtrusive Effects from Outdoor Lighting Guidelines. Ensure changes to this LMP are reflected in the construction Light Management Protocol . **Location:** Hearson Cove and Deep Gorge and other sites identified by MAC. **Timing and Frequency:** During Plant commissioning. Conduct light monitoring during construction **Responsibility** EPC Contractor Environmental Manager accountable	Light Management as item in monthly construction reports to Perdaman.

MANAGEMENT ACTIONS	MANAGEMENT TARGETS	MONITORING	REPORTING
MANAGEMENT ACTION 6 ***Training and Awareness*** All Project Personnel working on the Project site will be made aware of this LMP and their responsibilities for broader environmental management via a site induction. All Contractors undertaking construction works willbe provided with a copy of the LMP. Following the induction, all persons working on site will be required to sign the induction form and a log will be kept of all staff that have completed the environmental site induction. All construction personnel will hold appropriate competencies and qualifications for their intended role. Toolbox meetings will be conducted regularly to maintain and improve awareness of environmental and safety issues, as required. A review of the key elements of this LMP should be included as toolbox topics to reinforceits requirements and maintain compliance throughout the Project.	**LMP TARGET 6** Environmental induction will effectively communicate best practise lighting control measures during construction works to prevent the impacts to sensitive receivers.	**Indicator:** Environmental Induction Slides and Toolbox presentations. Induction competency assessment for personnel **Method:** Review induction records Review and update induction slides and toolbox talks. Conduct regular toolbox talks and ensure lighting management is a theme for at least one annually or where known activities or works may impact heritage sites. Consult MAC regarding light impacts to cultural heritage sites for inclusion in induction. **Location:** Entire Site. **Timing and Frequency:** Throughout construction and operations (NB: Induction will be updated to reflect each phases' potential impacts and proposed controls). **Responsibility** EPC Contractor Environmental Manager accountable	Monthly Project Reporting (EPC) to Perdaman. Compliance to this Target reported in the CAR.
MANAGEMENT ACTION 7 Revision of best practice technology , management actions and changes to Project activities. In the event that the management targets are not achieved, an investigation to determine the cause of the management target(s) not being met will be carried out;	**LMP TARGET 7** Conduct revisions on an annual basis at least unless otherwise triggered by a consideration stated in Section 3 of this Plan (as part of the adaptive management approach).	**Indicator:** This LMP has been updated to reflect latest technology and Project changes. (revision table - Table 5-1 Changes to Light Management Plan Table) **Method:** Conduct compliance review and gap analysis. Review principles of AS/NZS 4282-2019: Control of Obtrusive Effects from Outdoor Lighting Guidelines and review updates to relevant legislation, policies and AS.	Compliance with this Target reported in the CAR.

MANAGEMENT ACTIONS	MANAGEMENT TARGETS	MONITORING	REPORTING
		Review monitoring results. Ensure changes to this LMP are reflected in the construction Light Management Protocol. **Location:** Entire Project Site - Hearson Cove and Deep Gorge and other sites identified by MAC. **Timing and Frequency:** Throughout Construction and Operations **Responsibility** EPC Contractor Environmental Manager accountable	

2.2 Environmental Monitoring – Light

The purpose of light monitoring is to inform, through the environmental criteria, if the environmental outcomes as defined in the amended Light Management Plan (Section 1.4.4) are being achieved and if required to determine when the defined trigger level or threshold levels are exceeded. The exceedance of trigger or threshold criteria then informs which contingency management measures need to be implemented.

Due to the outcomes required in Condition 10-1 of MS 1180, monitoring construction and operations will be undertaken as per the timing and methodology detailed in the amended Light Management Plan.

Details of the monitoring proposed shall be provided in the amended Light Management Plan.

2.2.1 Light Monitoring Management Actions & Targets

2.2.1.1 Management Actions

In the event that a management action for lighting aspects is not implemented and/or met, the Perdaman Environment & Heritage Manager will be notified immediately with all relevant information. All reasonable actions to implement the management action will be undertaken to rectify the non-compliance.

If a management action requires adjustment following evaluation of monitoring data, review of assumptions and uncertainties, re-evaluation of risk assessment, increased understanding of the environmental setting, or changes to the Project scope or technology, Perdaman must seek formal approval from the CEO and may require consultation with MAC as per Condition 10-6 of MS 1180 if the plan is reviewed and updated on account of these changes.

Mitigation and management measures for potential impacts have been summarised in *Appendix 3 – Risks & Mitigation* and management actions specified in Table 2-1.

2.2.1.2 Management Targets

The magnitude of change required for management-based provisions is assessed via management targets. Management targets are focused on best practice lighting technology, and mitigating impacts to cultural heritage and other sensitive social environments and the key elements within those.

Where a management target is not achieved, an investigation will be undertaken to determine the cause of the target(s) not being met. This will include the Environment & Heritage Manager reviewing monitoring data, surveys, investigations, incident reports, inspection checklists and other documentation that might indicate the area of risk and where a change or additional management action may be required. Where relevant revisions are required in the form or amendments or additional management targets and or actions details of these must be provided in a report as per Condition 10-5 (1) of MS 1180. Analysis of causes for non-achievement of targets can arise in changes to relevant Project activities. In which case, these changes must be reviewed by the CEO in consultation with MAC.

2.3 Best Practice Lighting Technology and Risk Management Actions

2.3.1 Light Hierarchy of Controls

Overall lighting management seeks to minimise light that may have an adverse impact on sensitive receptors, subject to operational and safety requirements. This Section describes the lighting design principles common to most terrestrial facilities.

Lighting management is based on the following hierarchy of controls, starting with the most efficient through to the least efficient and is presented in Figure 2-1.

Figure 2-1 is a summary of Appendix A (Commonwealth of Australia, 2020) best practice light design principles for external light sources and will be considered in the Project design. The application of best practice lighting design for all outdoor lighting is intended to reduce sky glow and minimise the impacts of artificial lights on the surrounding environment.

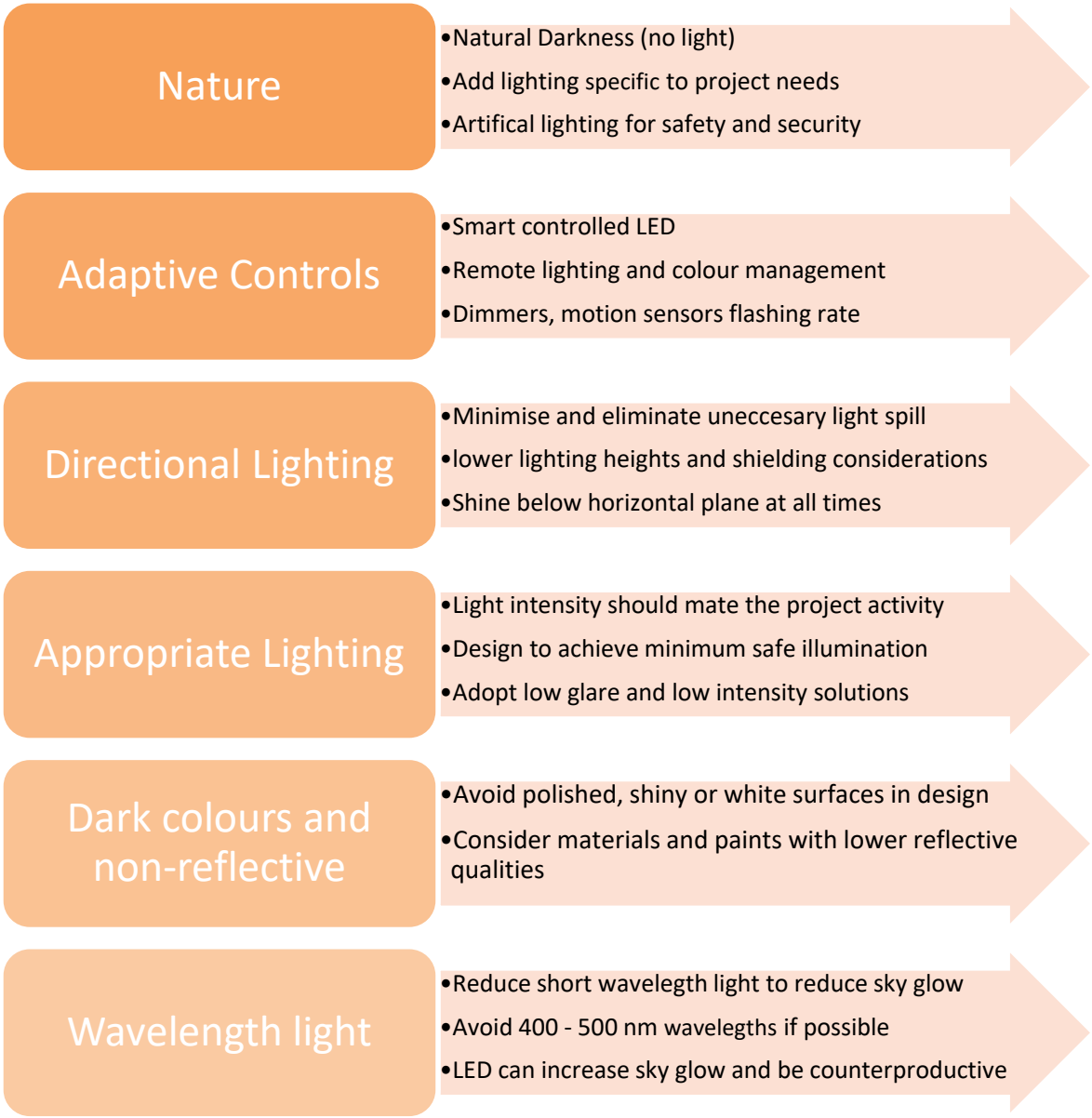


Figure 2-1 Light Hierarchy of Controls

2.3.2 Best Practice Lighting Design Principles

The following light design principles for external light sources are summarised below and will be applied specific to the Project.

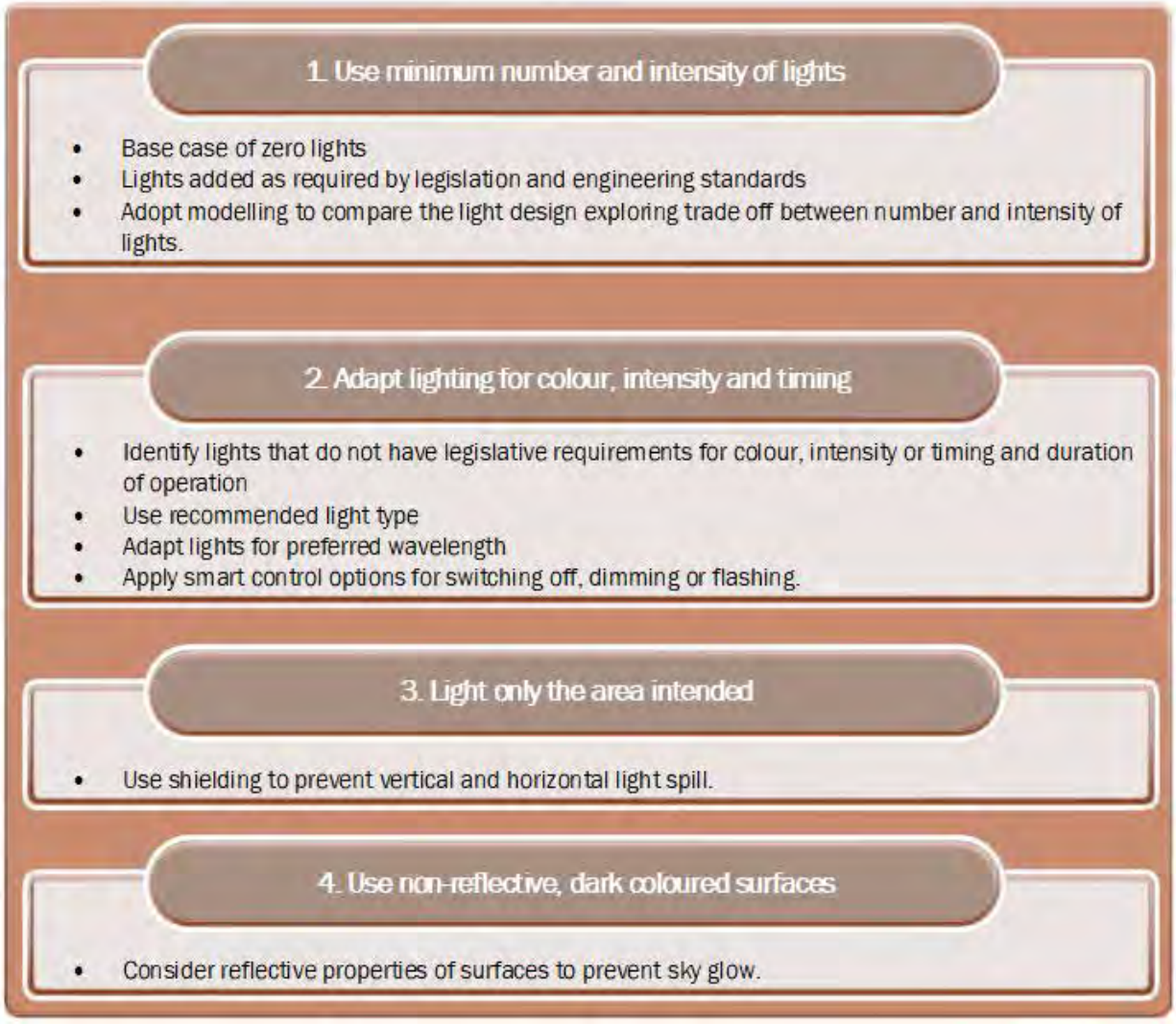


Figure 2-2 Summary of Design Control Measures applicable to the Project

2.3.3 Number of light fixtures and light intensity

Starting from a base case of no lights, use only the minimum number and intensity of lights needed to provide safe and secure illumination required to meet the lighting objectives, including health and safety requirements. Avoiding light fixtures surplus to needs will decrease overall light emissions.

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

Control measure:

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

2.3.4 Adapt Lighting for Colour, Intensity and Timing

Where compliant with health and safety requirements, white lights should be avoided, and amber/orange lights used instead. Because long wavelength light scatters much less than white light and produces less sky glow, the impacts on both marine turtles and sensitive receptors in Condition 10-1 (MS 1180) will be reduced. If white lights are required, filters to block green, blue, violet, and ultra-violet wavelengths should be applied.

For information: potential for impacts from white light is universal across fauna groups (Commonwealth of Australia 2020). However, the optimum wavelength for reducing potential impacts differs between the species and the behaviours being undertaken. Marine turtles are most sensitive to short wavelength (UV

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to blue/green).

For lights that are not required to be continuously lit, smart light-emitting diode (LED) technology should be implemented to allow for switching off when not in use, or the use of intermittent flashing lights. The suitability of different commercial lights is summarised in Table 2-2.

Independently assessed and certified light types suitable for use in various applications, including those most suitable for use around wildlife, can be found at the ADSA website under the ADSA Approved luminaire program (https://www.australasiandarkskyalliance.org/certified-luminaires). The ADSA Approved luminaires listed on the site, conform with dark sky principles specific to Australasian standards and guidelines including AS/NZS 4282-2019 and the Australian Commonwealth National Light Pollution Guidelines (Commonwealth of Australia 2020).

Table 2-2 Suitability of Commercial lights (Source: Commonwealth of Australia 2020)

LIGHT TYPE	SUITABILITY
Low Pressure Sodium Vapour	Recommended *"*" means this type of luminaire can be used only if a filter is applied to remove the short wavelength light*
High Pressure Sodium Vapour	
Amber / Orange LED	
Filtered* LED, metal halide and white LED	
White LED	Not Recommended
Metal Halide	
White Fluorescent	
Halogen	
Mercury Vapour	

Control measures:

- Outdoor public areas, high mast floodlighting to be minimised and use reduced blue light LEDs (<= 2700K Correlated Colour Temperature (CCT) light).
- Walkway/pathway utilise amber LED emitters (~585 nm 'true amber' emitters, 'phosphor-coated amber').
- Streetlights to utilise LEDs with a CCT equal to or lower than 2300 K.
- If specific, intermittent tasks require a brighter white light for better colour rendition (i.e., higher CCT), head torches should be used.
- Lighting design to identify lights that are not required to be continuously lit.
- Lights that are not required to be continuously lit to be motion activated, put on a timer, or wired to allow manual ON/OFF operation.
- All non-essential lighting to be automatically switched off.

2.3.5 Light only the Area Intended

Light spill is light that falls outside the area that is intended to be lit. Vertical light spill is light that spills above the horizontal plane, which contributes directly to artificial sky glow. Light spill that spills into adjacent areas is known as light trespass and can potentially impact sensitive receptors. To avoid any form of light spill, light fittings should be designed, located, and directed to avoid lighting anything but the target area.

Control measures:

- All lights to be directed downwards using targeted asymmetrical distribution to illuminate only the specific areas of need, while minimising the reflectance.
- All lights to be mounted at a height as low as possible while meeting lighting objectives e.g., low bollard lighting for pathways and walkways, low wall mounted lights around buildings and on decks, banister mounted lights on stairs or embedded in risers and focussed downwards.
- Streetlights to only be used where necessary, pole heights should be as low as possible, and consideration given to using bollard lighting in place of light poles/masts.

- The existing vegetation between the Project site and adjacent bushland to be maintained where feasible.
- No unshielded wall mounted bulkhead lighting to be used on buildings.
- Project lights to be directed away from sensitive receptors. For lights required to be directed in the direction of sensitive receptors, lights should be placed so that buildings provide inherent shielding.
- Shielding of all lights to achieve an upward waste light output ratio (UWLOR) 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.
- All glass (windows/doors) of buildings to have a glass light transmissivity rating of 0.5 or less.
- All glass (windows/doors) of buildings to have opaque (block-out) blinds/curtains/shutters fitted.
- Position doors and windows facing on the north and south ends of the building to avoid light escaping in the direction of the sensitive receptors located to the east and west.
- No upward facing lighting to illuminate buildings facades.
- All service and laydown areas to be illuminated only where and when it is needed and shielded to prevent light spill.

2.3.6 Use Non-reflective, Dark Coloured Surfaces

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

Control measures:

- Exterior finishes on all buildings to be matte and have a maximum reflective value of 30%.
- All other surfaces, including roads, to be matte and have a maximum reflective value of 30%, unless not technically feasible or presents a health and safety risk.
- Avoid shiny bright white painted surfaces on buildings, on wastewater treatment tanks and facilities and in-service areas.

2.3.7 Light Management During Construction

Construction of the Project has the potential to temporarily impact the night-time sky quality at Hearson Cove and Deep Gorge. The EPC Contractor is required to implement the Light Management Protocol within the CEMP to minimise impacts. and the following control measures.

Control measures:

- Lighting will be kept low, shielded and directional, and away from water where possible to minimise horizon glow. Construction lighting will not be aimed upwards.
- The use of white lights will be avoided.
- Light intensity in nearshore areas will be minimised as far as practicable.
- Temporary Plant and Equipment lighting will be designed in accordance with AS 4282-1997: Control of Obtrusive Effects of Outdoor Lighting Guidelines and that light shield will be placed on large equipment to minimise light overspill and using minimum wattage lighting in the plant where possible.
- Perimeter and internal lighting shall be facing inwards towards the centre of the work area.
- If lighting is required to be facing to the site exterior, it must focus on the specific work area and controlled using louvres or shields.
- Where practical and safe to do so, dimming or complete switch off of specific lighting shall occur where the traffic flows or tasks decrease or cease.
- Photo-electric cell sensors to be installed on all outdoor lighting.
- Ensure lamps maintain light output to Australian Standard and Building Code of Australia maintenance levels.
- Energy consumption of Project luminaires to be recorded.
- Position luminaires to directly focus on intended target.
- Select lighting with beam characteristics applicable to the task.
- Decrease luminance to minimum safe operating levels.

- Luminary observations to be recorded at sensitive receptors
- All Project personnel will be informed of the requirements of the Confirmed Light Management Plan and the Light Management Protocol.
- Luminary observations to be recorded at sensitive receptors.
- Appropriate, site-specific trigger values will be established in the amended Light Management Plan following impact assessment.

2.4 Environmental Reporting & Compliance Requirements

2.4.1 Environmental Reporting

Perdaman is responsible for the preparation of overall project related environmental reports including compiling data from monitoring programs.

Reporting to external stakeholders and regulators will be in strict accordance with the project's approval conditions.

The reporting and relevant compliance to be conducted for this LMP is identified in Table 2-3.

Table 2-3 Reporting Requirements

Aspect	Compliance Requirement	Responsibility	Authority	Timing	Actions to be taken
Failure to implement any best practice technology or management actions specified in the Confirmed Light Management Plan	MS 1180 Condition 10-5	Environment and Heritage Manager	CEO	Report the exceedance within seven days of the exceedance being identified	Comply with condition 15-5 of MS 1180
Failure to comply with the requirements of the Confirmed Light Management Plan	MS 1180 Condition 10-5	Environment and Heritage Manager	CEO	Report the exceedance within seven days of the exceedance being identified	Comply with condition 15-5 of MS 1180
Review and revise the Confirmed Light Management Plan	MS 1180 Condition 10-6	Environment and Heritage Manager	MAC CEO	Submit upon finalisation	Consult with MAC Comply with condition 10-6 (1) and (2) of MS 1180
Submit an Environmental Performance Report to the Minister and the Murujuga Aboriginal Corporation	MS 1180 Condition 12-1	Environment and Heritage Manager	MAC Minister for Environment (WA)	Every 5 years. The first report to be submitted within three months of the expiry of the five year period commencing from the first date of Ground Disturbing Activities, or such other time as may be approved by the CEO	Comply with conditions 12-3, 12-4 and 12-5 of MS 1180
Assess compliance with conditions in accordance with the Confirmed Compliance Assessment Plan and prepare Compliance Assessment Report	MS 1180 Condition 15-3	Environment and Heritage Manager	CEO EPA	The first Compliance Assessment Report due fifteen months from the date of issue of MS 1180 addressing the twelve month period from the date of issue of MS 1180	Comply with condition 15-7 (1) to (5) of MS 1180

Aspect	Compliance Requirement	Responsibility	Authority	Timing	Actions to be taken
				and then annually from the date of submission of the first Compliance Assessment Report, or at another time agreed in writing by the CEO.	

A series of registers relevant to light management practices will be maintained throughout the life of the Project. These are listed below:

- Training records
- Environmental incident register - record and monitor all environmental incidents within the Project

2.4.2 Environmental Performance Report

As noted in Table 2-3, an Environmental Performance Report shall be submitted to the Western Australian Minister for Environment and MAC every five (5) years in accordance with MS 1180.

The first report is to be submitted within three (3) months of the expiry of the five-year period commencing from the first date of Ground Disturbing Activities or another time approved by the CEO. Ground Disturbing Activities commenced on 11 July 2023 by Main Roads WA for the development of Hearson's Cove Road. Therefore, the first report is due no later than 11 October 2028.

Relative to lighting, the Performance Report shall report on the following:

- State of social surroundings including cultural heritage and visual amenity, and
- State of the holistic environment.

The report shall include a comparison of those values mentioned above at the end of the five-year period against the state of each value at the beginning of the five-year period. Also, a comparison of the environmental values identified above at the end of the five-year period; against the state of the environmental values identified in the first Environmental Performance Report submitted in accordance with Condition 12-2. In addition, the report will include the proposed Adaptive Management and continuous improvement strategies.

2.4.3 Compliance Assessment Report (CAR)

As noted in Table 2-3, Perdaman is to submit to the CEO of the EPA a Compliance Assessment Report (CAR) annually in accordance with MS 1180. The CAR's are to be prepared in accordance with the Confirmed Compliance Assessment Plan (PCF-PD-EN-CAP).

The first CAR is to be submitted fifteen (15) months from the date of issue of MS 1180. The Statement was issued on 24 January 2022. Therefore, the first CAR was due 24 June 2023. CAR's are required annually from the date of submission of the first CAR, therefore, by 24 June, each year.

The CAR demonstrates Perdaman's compliance with MS 1180 through reporting the monitoring results in comparison to the established trigger and threshold criteria. This will help to identify non-compliances and describe the corrective and preventative actions to be taken to maintain compliance.

The Compliance Assessment Report shall be provided as per direction given in the Compliance Assessment Plan, which is to be submitted to the CEO at least 6 months prior to the first CAR or prior to ground disturbing activities; whichever is sooner.

In accordance with Condition 15-7 of the MS 1180, each CAR shall:

- (1) be endorsed by the proponent's Chief Executive Officer or a person delegated to sign on the Chief Executive Officer's behalf;
- (2) include a statement as to whether the proponent has complied with the Conditions;
- (3) identify all potential non-compliances and describe corrective and preventative actions taken;
- (4) be made publicly available in accordance with the approved Compliance Assessment Plan; and
- (5) indicate any proposed changes to the Compliance Assessment Plan required by Condition 15-2.

Where the outcome of the objective is not met and the trigger / threshold criteria are exceeded during the reporting period, the CAR shall include a description of revised management actions / contingency actions to be implemented to achieve the outcome and objectives during the next reporting period. All changes to management actions will require review and approval by the CEO.

Specific to **Lighting management** objectives the CAR will report on the following status (verification & effectiveness) of management actions against the management targets presented in Table 2-1, and recorded in Table 2-4 below.

Table 2-4 Ministerial Compliance – Light Management

Ministerial Condition	Target ID	Light Management Objective
10-1	LMP 1 LMP 2 LMP 3 LMP 4 LMP 5 LMP 6 LMP 7	Avoid, where possible, and otherwise use best practice technology and risk-based management actions to minimise nightglow and light overspill from the proposal so that the environmental values of amenity at sensitive locations, including, but not limited to Hearson Cove and Deep Gorge, are protected.
10-3	-	The proponent must not commence Ground Disturbing Activities until the CEO has confirmed in writing that the Light Management Plan satisfies the requirements of condition 10-2
10-4		The proponent shall implement the most recent versions of the Confirmed Light Management Plan.
10-5		Without limiting condition 4-5 (implementation of the plans) and notwithstanding compliance with condition 4-8 (response to exceedance), the proponent must not cause or allow: (1) a failure to implement any best practice technology or management actions specified in the Confirmed Light Management Plan; and/or (2) non-compliance with the requirements of the Confirmed Light Management Plan.

2.4.4 Compliance with MS 1180

As stipulated in Table 2-3, reporting to the CEO of the EPA is required under the following circumstances:

- MS 1180 condition 10-5: Failure to implement any best practice technology management actions specified in the Confirmed Light Management Plan.
- MS 1180 condition 10-5: Failure to comply with the requirements of the Confirmed Light Management Plan

In accordance with Condition 15-5 of MS 1180, where the above reporting is triggered, the following is required:

- Report the failure or non-compliance in writing to the CEO within seven days of the exceedance being identified.

2.4.5 Submission and Publication of Plans

In accordance with Condition 16 of MS 1180, and subject to condition 16-2, for the remainder of the life of the proposal, Perdaman shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g. maps), management plans and reports relevant to the assessment of this proposal and implementation of this Statement.

If any data referred to in condition 16-1 contains particulars of:

(1) a secret formula or process; or

(2) confidential commercially sensitive information;

the proponent may submit a request for approval from the CEO to not make these data publicly available. In

making such a request the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.

2.4.6 Weekly Environmental Inspections

Perdaman shall undertake weekly environmental inspections of all Project work areas and activities of their Project personnel, including impacts to receptors potentially caused by lighting. This includes relevant aspects such as:

- Attraction of feral species;
- Incidents and interactions with threatened and / or native species
- MAC consultation or concerns in relation to heritage places;
- Environmental incidents and corrective action close out;

2.4.7 Environmental Audits

Perdaman shall conduct environmental audits of individual construction work packages and operational areas via an integrated audit schedule. This will be undertaken to ensure all Project activities and environmental management processes conform with the planned arrangements and whether the PEMP has been properly implemented. The key requirements to be reviewed may include:

- Performance against licensing and approval Conditions, Project targets, objectives and policy statements;
- Adequacy of resources and training;
- Complaints and non-conformance management.

The audit schedule will be developed in consultation with relevant Project Personnel. Results of all audits will be communicated and discussed at management review meetings.

3 Light Management Plan Review

Perdaman will employ adaptive management throughout the monitoring program pertaining to lighting to incorporate knowledge from the implementation of mitigation measures, monitoring and evaluation of data against management actions and targets to meet the Condition environmental objectives and ensure best practice technology is implemented more effectively.

The adaptive management approach of reviewing the management targets for lighting on the Project and evaluating the best practice technology regularly as well as monitoring the applied management and mitigation measures against the objective (Condition 10-1) has been detailed in Section 2 of this LMP.

In line with the concept of adaptive management, the management actions and targets within this LMP shall be monitored, reviewed, evaluated and updated as required considering the following:

- Results of the scientific light monitoring, and benchmarking being carried out for the Project, by Pendoley in February 2022.
- Results of the Plant Design Modelling.
- New scientific information is published or comes available on best-practice lighting available.
- New and relevant data as a result of implementing this LMP.
- Changes to state, federal legislation and policy.
- Concerns and issues from MAC regarding light emissions to sensitive locations and values.

The following approach will be implemented to ensure the above is considered thoroughly:

- Monitoring data will be systematically evaluated and compared to baseline data.
- Best Practise technology will be regularly evaluated for potential implementation on the Project.
- Re-evaluate risk assessments annually.
- Incorporate additional knowledge as it comes to hand to address assumptions and uncertainties to gain a greater understanding of impacts by lighting to sensitive receptors.

- Complete review of risk-based priorities after annual monitoring is completed.
- Undertake revision when management measures are not as effective as predicted.
- Incorporate alternative techniques, technologies and methodologies to enhance and improve the program.
- Expand monitoring as required to respond to additional operational activities that may pose a threat to sensitive receptors such as Hearson Cove or Deep Gorge.
- Incorporate and modify the program to include any external changes during the life of the Project (e.g., changes to the sensitivity of the vegetation, climate change, implementation of other activities in the area, etc.).

This LMP will be reviewed and updated at least annually throughout the life of the project, where changes are required following the evaluation of monitoring data, review of assumptions and uncertainties, re-evaluation of risk assessment, increased understanding of the environmental setting, or changes to the project scope or technology.

Any revisions or amendments of this LMP must be in consultation with MAC and must be submitted to the CEO as per Conditions 10-6 and 10-7 of MS 1180.

4 Stakeholder Consultation

This Confirmed Light Management Plan was prepared in consultation with Murujuga Aboriginal Corporation (MAC) in accordance with Condition 10-6 of MS 1180. Reviews and revision of the LMP will be done in consultation with MAC, with submissions to be sent to the CEO.

Perdaman shall provide for the relevant traditional owners to be invited to observe any Ground Disturbing Activities and during construction activities and take reasonable steps to facilitate the observation of those activities by those persons.

In addition, Perdaman has carried out stakeholder consultation with other key stakeholders. The consultation register in Table 4-1 summarises the consultation and Perdaman responses, and the most recent consultations with the Murujuga Aboriginal Corporation are included as **Attachment B** and **Attachment C** of this plan.

Table 4-1 Stakeholder Consultation Register

Date	Stakeholder	Consultation Type	Issues, Topic Raised	Proponent Response
31 Jan 2022	Murujuga Aboriginal Corporation (MAC) and Circle of Elders	Presentation / Meeting / Endorsement of CHMP	Presentation of the salvage and relocation proposal for the CHMP (Cultural Heritage Management Plan).	Endorsement of the amended and of the salvage and relocation methodology.
24 Jan 2022	Murujuga Aboriginal Corporation (MAC)	Site visit/ Presentation	MAC Board Presentation of key aspects of this Light Management Plan for discussion. Opportunities Potential challenges and solutions.	None Required.
2019 & 2020 (Various times during this period)	Hon. Alannah MacTiernan	Presentation / Meeting	Project update including: - Community stakeholder consultation & feedback - Environmental Impact Assessment - Common-user infrastructure - Social benefits - Employment opportunities - Training opportunities	Details discussed including potential social and economic benefits Commercial arrangements with PPA and Water Corporation
January 2020	MAC	In principle Endorsement of Heritage Charter	Overarching Perdaman Project Destiny Overarching Position for Heritage Interaction and management, including Rock Art and Murujuga.	In principle (subject to final Part IV approval of Project) endorsement of Proponent commitment to its overarching position which will underpin Aboriginal Heritage Management Plans, protocols and actions for life of the Project
November & December 2019	Hon. Mark McGowen, Premier	Presentation / Meeting	Project update including - Community stakeholder consultation & feedback - Social benefits - Employment opportunities - Training opportunities - Environmental Impact Assessment - Common-user	Details discussed including potential social and economic benefits Commercial arrangements with PPA and Water Corporation

Date	Stakeholder	Consultation Type	Issues, Topic Raised	Proponent Response
			Infrastructure	
November 2019	Hon. Ben Morton, Assistant Minister to the Prime Minister and Cabinet	Presentation / Meeting	Project update including - Community stakeholder consultation & feedback - Social benefits - Employment opportunities - Training opportunities - Environmental Impact Assessment - Common-user Infrastructure	Details discussed including potential social and economic benefits Commercial arrangements with State GTEs and common-user infrastructure requirements
27 November 2019	MAC	Agreement Signing	Signing of Commercial Agreement, transformative opportunities	Agreement on mutual support for future aspirations of both parties
14 October 2019	Kevin Michel MLA, Karratha	Briefing	Update on the Environmental Impact Assessment Update on liaison with other community stakeholders	Details discussed
14 October 2019	City of Karratha, PDC	Meeting	Update on the Environmental Impact Assessment Discussions about the housing strategy, City of Karratha is supportive of a strategy that will provide long-term benefits to the community	Details discussed Accommodations for the Project will be integrated to the local community rather than building isolated camps
14 October 2019	Circle of Elders	Presentation / Meeting	Access to the meeting site in the south-west corner to Site F Location of the proposed infrastructure on site Transformative opportunities	The fence that will be installed aims at preventing site workers to access the cultural site and will not block access for the Traditional Owners (TO) Refer to Figures in Appendix A of the ERD Commercial Agreement to be signed with MAC
14 October 2019	MAC	Workshop	Commercial Agreement, transformative opportunities	Further discussions to be held between MAC and the Proponent
September 2019	Hon. Ben Wyatt, Treasure	Presentation / Meeting	Update on Project including the Environmental Impact Assessment	Details discussed including potential social and economic benefits
20 September 2019	MAC & Advisors	Meeting	Commercial Agreement, transformative opportunities	Further discussions to be held between MAC and the Proponent
4 September 2019	MAC & Advisors	Meeting	Commercial Agreement, transformative opportunities	Further discussions to be held between MAC and the Proponent

Date	Stakeholder	Consultation Type	Issues, Topic Raised	Proponent Response
June-August 2019	Pilbara Ports Authority (PPS)	Online form, letter	Panamax size vessels Capacity of the shed at the Port	The Proponent will be using high tides to access the berth Storage capacity at the port changed to 65,000 tonnes
05 July 2019	MAC	Presentation / Meeting	Assessment timeline clarification Plant design	The Proponent provided clarification regarding the environmental approval processes The Proponent provided an update on the plant design MAC advised that they support the draft ESD and confirmed the Project aligns with their core objectives (ref. email to the EPA of the 8thJuly 2019)
June 2019	Karratha, Roebourne, Dampier and Wickham Community	Information booths, online form	Project timeline Employment opportunities	Refer to Section 2.3.7 of the ERD.
16 May 2019	Pilbara Development Corporation (PDC)	Meeting	PDC indicated a preference for flexible working hours for employees so they can pursue activities/sports Visual amenity	The Proponent is committing to give the opportunity to all employees to request flexibility to pursue nominated activities/hobbies/sports. Refer to Section 4.9.5 (ERD)
16 May 2019	NYFL	Presentation / workshop	Approach to monitoring and detriment to rock art NYFL Chairman requested information about continuous access for Aboriginal people to NHL area thought to be associated with “Fish Thalu” site within the boundary of site F Any changes to the access to Ngajarli as a result of Hearson Cove Road realignment Access to the meeting site in the south-west corner of site F Visual aspects and opportunities	The Proponent worked with Woodside to obtain a comprehensive regional airshed model (Section 4.8.5 and Appendix D (ERD)). An Air Quality Management Plan and Heritage Management Plan have been developed (Appendix K (ERD)) The Proponent will make access arrangements whereby those with connection to the NHL site would be met at the gate and escorted to the sacred site. The sacred “Fish Thalu” site is outside the operational site boundary (refer to plan layout, Figure 3, Appendix A (ERD)) Hearson Cove Road will be realigned to its official gazetted alignment. Access to Ngajarli will be

Date	Stakeholder	Consultation Type	Issues, Topic Raised	Proponent Response
				maintained The construction-phase boundary has been modified to ensure this cultural site is outside of the fenced area and its use is not impaired Discussed opportunities to use the wall surfaces of Project buildings and facilities as a medium for Aboriginal artworks and as a visual medium to communicate heritage stories
April 2019	Woodside	Meeting	Air Quality modelling	Data share agreement
February 2019	Senator Michaelia Cash, Federal Minister for Employment, Skills, Small and Family Business		Update on Project including –Potential social benefits –Potential employment & training opportunities –Potential economic opportunities	Details discussed
25 February 2019	Water Corporation	Letter	Discharge in the MUBRL and seawater intake	Appendix J of the ERD
12 February 2019	Murujuga Aboriginal Corporation (MAC) City of Karratha	Site visit / Presentation	MAC: Construction phase, Site preparation, Plant erection Potential Heritage issues Plant emissions / impacts on Burrup Rock Art General processing plant understanding Employment, training and business opportunities MAC could benefit from Work undertaken to evaluate a Project location at Maitland City of Karratha: The City of Karratha would prefer that the Dampier public wharf be used, and the shed located north of proposed options A & B.	Section 2.3.3 of the ERD Section 2.2.4 of the ERD Third option ‘C’ added to the Port infrastructure location options. Refer to Section 2.2.6 of the ERD

4.1 Internal and External Communication

Regular updates of environmental issues and related matters will be communicated to all Project personnel. This communication will include the induction process, through regular team meetings and toolbox talks, and via written communications including emails and newsletters disseminated electronically or in hard copy.

All external communications will be managed by the Project Director. No other Project personnel or Contractors

are to provide comment or information to external organisations or individuals without the consent of the Project Director.

4.2 External Incident Notification

Only the Environment and Heritage Manager, in consultation with the Project Director, is authorised to notify external regulatory agencies of any Project related environmental incidents.

This communication will be in accordance with individual agencies' reporting and notification requirements.

5 Changes to LMP

This plan has been amended from the previous version PCF-PD-EN-LMP_PCF1 to update formatting, spelling and grammar, and updating of information, including the clarification that this document meets the requirements of MS 1180, condition 10, relating only to the Environmental Factor – Surrounding Environment. This document has removed reference to fauna impacts, as these impacts are addressed specifically in the Confirmed Fauna Management Plan and Confirmed Threatened Species Management Plan.

All changes to this LMP post-assessment must be provided separate to compliance reports and submitted to registrar@dwer.wa.gov.au.

Table 5-1 Changes to Light Management Plan Table

Complexity of changes	Minor revisions ☐			Moderate revisions	☐	Major revisions	☒	
Number of Key Environmental Factors	One	☒	2-3	☐	> 3	☐		
Date revision submitted to DWER:								
Proponent's operational requirement timeframe for approval of revision Reason for Timeframe: **Approval of revised Management Plan not required**	< One Mth ☐	< Six Months ☐	> Six Months ☐	None ☒				

Item no.	EMP Section no.	EMP page no.	Summary of change	Reason for change
1	Executive Summary	iv	Proposed Construction& Operation Commencement Dates	Updated
2	Executive Summary	iv	Purpose of this Plan	Updated
3	Executive Summary	iv	Key environmental factors and objectives	Updated
4	Forward	v	Forward	Updated
5	Figure 0-1-1	v	Structure of the Project Environmental Management Plan and supporting management sub-plans	Updated
6	1.1.1	4	Scope & Requirement for the Plan	Updated
7	1.1.2	5	Responsibility	Updated
8	1.1.3	5	Legislative framework	Updated
9	1.1.4	7	Policy and Guidance	Updated
10	1.2	7	Key Environmental Factors	Updated
11	1.2.1	8	Cultural Heritage Values	Updated
12	1.2.2	10	Potential impacts	Added
13		10	Marine turtles	Deleted
14		10	Seabirds	Deleted
15		11	Shorebirds	Deleted

16	1.3	11	EP Act Ministerial Statement 1180	Updated
17	1.4	12	Part V Approvals	Deleted
18	1.4.1	13	Survey & Study Findings	Moved
19	1.4.2	25	Management Approach	Updated
20	1.4.3	26	Artificial Light Monitoring	Moved
21	1.4.4	28	Light Impact Assessment and LMP Amendment	Moved
22	1.4.5	39	Monitoring Approach	Added
23		29	Objectives	Deleted
24	2	33	Light Management Plan Provisions	Updated
25	Table 2-1	34	Objective based Management Actions and Targets	Updated
26	2.2	40	Environmental Monitoring - Light	Added
27	2.2.1	40	Light Monitoring Management Actions & Targets	Moved
28	2.3.7	44	Light Management During Construction	Updated
29		45	Environmental Monitoring - General	Deleted
30	2.4.1	64	Environmental Reporting	Updated
31	Table 2-3	65	Reporting Requirements	Added
32	2.4.2	67	Environmental Performance Report	Updated
33	2.4.3	67	Compliance Assessment Report	Updated
34	Table 2-4	68	Ministerial Compliance – Light Management	Updated
35	2.4.4	69	Compliance with MS 1180	Added
36	2.4.5	69	Submission and Publication of Plans	Added
37	2.4.6	69	Weekly Environmental Inspections	Moved
38	2.4.7	69	Environmental Audits	Moved
39		70	Non-compliance with Ministerial Statement (1180)	Deleted
40		70	MS No. 1180 Reporting Summary	Deleted
41	3	71	Light Management Plan Review	Updated
42	4	73	Stakeholder Consultation	Updated
43	4.1	76	Internal and External Communication	Added

44	4.2	77	External Incident Notification	Added
45	5	78	Changes to LMP	Updated

6 References

Cardno 2021a, Environmental Review Document – Response to Submissions – Perdaman Urea Project. Perdaman Chemicals and Fertilisers Pty Ltd, WA.

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

COMMONWEALTH OF AUSTRALIA (2020) National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds and Migratory Shorebirds. January 2020. Available at: https://www.environment.gov.au/biodiversity/publications/national-light-pollution-guidelines-wildlife.

DoD (2014) Australian Government Department of Defence, Space Surveillance Telescope Facilities, Statement to Evidence to the Parliamentary Standing Committee on Public Works

Environmental Protection Authority, 2001. Report and Recommendations of the Environmental Protection Authority: Ammonia Plant, Burrup Peninsula. Available online: http://www.epa.wa.gov.au/sites/default/files/EPA_Report/998_B1036.pdf

Environmental Protection Authority, 2021. How to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans – Instructions. EPA, Western Australia.

Environmental Protection Authority, 2021a. Perdaman Urea Project – Report 1705. EPA, Western Australia.

Environmental Protection Authority, 2021b. Statement That a Proposal May be Implemented (Environmental Protection Act 1986) - Perdaman Urea Project, Assessment No. 2184, Report No. 1705. Perth, Western Australia.

EPA (2010) Environmental Assessment Guidelines No 5 Environmental Assessment Guideline for Protecting Marine Turtles form Light Impacts, Nov 2010.

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

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

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

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

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

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

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

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

KAMROWSKI, R.L., LIMPUS, C., PENDOLEY, K. & HAMANN, M. (2014) Influence of industrial light pollution

on the sea-finding behaviour of flatback turtle hatchlings. Wildlife Research 41: 421-434.

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

LEVENSON, D.H., ECKERT, S.A., CROGNALE, M.A., DEEGAN, J.F. & JACOBS, G.H. (2004) Photopic spectral sensitivity of green and loggerhead sea turtles. Copeia, 2004(4), 908□914.

LIMPUS, C. AND KAMROWSKI, R.L., (2013) Ocean-finding in marine turtles: the importance of low horizon elevation as an orientation cue. Behaviour, 150(8), pp.863-893.

LIMPUS, C. & NICHOLLS, N. (2000) ENSO regulation of Indo-Pacific green turtle populations. In Applications of seasonal climate forecasting in agricultural and natural ecosystems (pp. 399-408). Springer, Dordrecht.

LOHMANN, K. & LOHMANN, C. (1996) Orientation and open-sea navigation in sea turtles. Journal of Experimental Biology, 199(1), pp.73-81.

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

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

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

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

NSW (2016) NSW DEPARTMENT OF PLANNING AND ENVIRONMENT Dark Sky Planning Guideline, Protecting the observing conditions at Siding Spring, June 2016, 25pp

PENDOLEY, K & CHARLTON, E. (2022). Perdaman Urea Project: Benchmark Artificial Light Monitoring. Perdaman Light Survey Report Draft Rev A, Pendoley Environmental Pty Ltd.

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

PENDOLEY, K. (2005) Sea turtles and the environmental management of industrial activities in north west Western Australia. (Doctor of Philosophy), Murdoch University, Perth, Australia, Perth, Australia.

PIKE, J. (2010) "Space Surveillance Telescope" (Basic overview). GlobalSecurity.org.

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

ROBERTSON, K., BOOTH, D.T. & LIMPUS, C.J. (2016) An assessment of 'turtle-friendly' lights on the sea-finding behaviour of loggerhead turtle hatchlings (Caretta caretta). Wildlife Research, 43(1), 27-37.

RUPRECHT, JESSICA D; USHOMIRSKY, GREG; WOODS, DEBORAH F; VIGGH, HERBERT E M; VAREY, JACOB; CORNELL, MARK E; STOKES, GRANT. Asteroid Detection Results Using the Space Surveillance Telescope Defense Technical Information Center. DTIC. 2018.

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

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

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

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

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

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

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

WHITING, A. (2016) Estimating abundance and detecting trends for greens, loggerhead and hawksbill turtles nesting within the Ningaloo region: 2013-14 to 2015-16 seasons. Unpublished report to the Department of Parks and Wildlife, Exmouth WA, August 2016

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

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

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

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

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

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

WITHERINGTON, B.E. & MARTIN, R.E. (2003) Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches.

WYNEKEN, J. & SALMON, M. (1992) Frenzy and postfrenzy swimming activity in loggerhead, green, and leatherback hatchling sea turtles. Copeia, 1992(2), 478-484.

7 Definitions

Contractor

The Contractor on the Project is any individual or party engaged directly or indirectly by Perdaman, that is not an employee of Perdaman, to carry out the Project.

Environmental Representative

The Environmental Representative includes Perdaman's Environment and Heritage Manager, the Environmental Coordinator or their delegated representative.

Environment and Heritage Manager

The Environment and Heritage Manager is Perdaman's site based Environmental Representative who has the authority and responsibility for managing the implementation, compliance and effectiveness of the Project's environmental and heritage requirements.

Ground Disturbance Permit

A Ground Disturbance Permit (GDP) is a permit issued to a Subcontractor, by the Contractor, enabling Works within defined battery limits to manage any impacts on native vegetation, heritage or other environmentally sensitive values. It includes the key approval commitments and obligations obtained by or issued to the Contractor or Owner by regulators, tenure holders and other third parties.

May

Indicates that the Subcontractor is permitted to do something, or the Contractor reserves the right to do something according to the text.

Perdaman

Perdaman Chemicals and Fertilisers Pty Ltd is the proponent of the Project.

Project Personnel

Project Personnel includes all persons working on the Project directly employed by Perdaman, or its Contractors.

Project Work Sites

The Project work sites include Area C, Area F, the causeway linking these two areas, the conveyor corridor tothe Port and the Port storage and loading infrastructure. It can also include any other Project relevant locationunder operational control of Perdaman.

No-Go Zones

No-Go Zones are defined areas within the Project's footprint which are not to be entered and or disturbed by Project activities. These areas are established to protect environmental, cultural heritage, infrastructure and other values from damage or other detrimental impacts.

Shall

Indicates that a statement is mandatory.

Should

Indicates a recommendation.

Works

Works includes all work which the SCJV and or its Subcontractors are required to perform to comply withits obligations under the Contract (during construction).

True Amber

Long-wavelength lighting emitted around 585 nm, providing an amber-coloured glow.

Phosphor-coated Amber

A method of producing amber-coloured light emissions from exposing a phosphor coated LED to radiation. The

orbital electrons in its molecules are excited to a higher energy level; when they return to their former level they emit the energy as light within the amber colour spectrum.

8 Abbreviations

Abbreviation	Description
AHA	*Aboriginal Heritage Act 1972*
ALAN	Artificial Light at Night
APM	Animal Plant Mineral Pty Ltd
Arcsec^2	Second of an Arc (unit of measurement)
CAR	Compliance Assessment Report
CCT	Correlated Colour Temperature
CEO	Chief Executive Officer
DBCA	Department of Biodiversity Conservation and Attractions
DAWE	Department of Agriculture, Water and Environment (Commonwealth)
DCCEEW	Department of Climate Change, the Environment, Energy and Water
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPC	Engineering, Procurement and Construction
EPBC	*Environmental Protection and Biodiversity Conservation Act 1999*
ERD	Environmental Review Document
FaMP	Fauna Management Plan
FEED	Front End Engineering and Design
FID	Final Investment Decision
FMP	Flora Management Plan
GDP	Ground Disturbance Permit
HSSE	Health, Safety, Security and Environment
LED	Light-Emitting Diode
LiMP	Light Management Protocol (Construction Protocol)
LMP	Light Management Plan (this Plan)
Mtpa	Million tonnes per annum
MAC	Murujuga Aboriginal Corporation
MNES	Matters of National Environmental Significance
nm	Nanometers
SCJV	Saipem, Clough Joint Venture (EPC)
Vmag	Visual Magnitude

9 Project Delivery Applicability

Proposals	☒ EPC	☒ Construction
Studies	☒ Project Management	☒ Commissioning
Preliminary Engineering	Technical Services	Site Services
FEED	Procurement	☒ Ops and Maintenance
☒ Detailed Design	☒ Construction Management	

Appendix 1 – Ministerial Statement (MS 1180) Conditions Compliance Table

Condition No.	Condition	Section of this Plan
10-1	The proponent shall implement the proposal to meet the following environmental objective: (1) avoid, where possible, and otherwise use best practice technology and risk-based management actions to minimise nightglow and light overspill from the proposal so that the environmental values of amenity at sensitive locations, including, but not limited to Hearson Cove and Deep Gorge, are protected.	Section 2.1 Table 2-1
10-2	At least six months prior to **Ground Disturbing Activities,** the proponent shall provide the **CEO** with a Lighting Management Plan which has been prepared in consultation with the Murujuga Aboriginal Corporation and that demonstrates that the proposed lighting design adopts best practice lighting control measures to meet the objective in condition 10-1 and which shall:	Section 1.1.1 Section 1.3
	(1) specify best practice technology and risk-based management actions that will be implemented to demonstrate compliance with the objective specified in condition 10-1;	Table 2-1 Section 1.5
	(2) specify measurable management target(s) to determine the effectiveness of the best practice technology and risk-based management actions	Table 2-1
	(3) specify monitoring to measure the effectiveness of best practice technology and management actions against management targets	Table 2-1 Section 2.2 Section 2.3.1 Section 2.3.2
	(4) specify a process for revision of best practice technology and management actions and changes to proposal activities, in the event that the management targets are not achieved, and this process must include an investigation to determine the cause of the management target(s) not being met	Section 3
	(5) provide the format and timing to demonstrate that condition 10-1 has been met for the reporting period in the Compliance Assessment Report required by condition 15-6 including, but not limited to: (a) verification of the implementation of best practice technology and management actions; and (b) reporting on the effectiveness of best practice technology and management actions against management target(s).	Section 2.4.3 Section 1
10-3	The proponent must not commence Ground Disturbing Activities until the CEO has confirmed in writing that the Light Management Plan satisfies the requirements of condition 10-2.	Section 1.1.3 Section 1
10-4	The proponent shall implement the most recent version of the Confirmed Light Management Plan.	Section 1.3
10-5	Without limiting condition 10-4 (implementation of the plan), the proponent must not cause or allow: (1) a failure to implement any best practice technology or management actions specified in the Confirmed Light Management Plan; and/or (2) non-compliance with the requirements of the Confirmed Light Management Plan.	Section 1
10-6	The proponent, in consultation with the Murujuga Aboriginal Corporation: (1) may review and revise the Confirmed Light Management Plan and submit it to the CEO; or (2) shall review and revise the Confirmed Light Management Plan and submit it	Section 3

Condition No.	Condition	Section of this Plan
	to the CEO as and when directed by the CEO.	
10-7	The proponent shall continue to implement the latest revision of the Confirmed Light Management Plan until the CEO has confirmed by notice in writing that the proponent has demonstrated that the environmental objective detailed in condition 10-1 have been met.	Section 1.3

Appendix 2 – Key Surveys & Findings

Key Environmental Factor	Report	Key Findings
Social Surrounds (Light Emissions to Cultural Heritage sensitive receptors)	Pendoley March 2022. Perdaman Urea Project: Benchmark Artificial Light Monitoring. Pendoley Environmental Pty Ltd. Booragoon, WA.	Benchmark Artificial Lighting and Artificial Light Modelling. Clough engaged Pendoley Environmental (PENV) to undertake benchmark artificial light monitoring to establish current light pollution levels, create a baseline for light modelling and future light monitoring surveys. The artificial light survey took place over four nights between the 28th of February and the 4th of March 2022. The survey captured all-sky imagery from three primary and four additional locations identified after consultation with MAC. There are several pre-existing, dominant sources of artificial light visible which are visible in the images captured from various monitoring locations. The artificial light sources were identified as: • Karratha Gas Plant • Pluto LNG • Yara • Karratha townsite and Karratha Airport • RTIO Dampier • Dampier Cargo Wharf • Point Sampson (only visible from Hearson Cove) Project Site C was the brightest in all location categories due to its proximity to artificial light sources. The existing lighting environment is very bright, and all the monitoring locations were heavily influenced by surrounding artificial light sources from Burrup industrial sites, the King Bay Port facilities, LNG plant gas flares, town of Dampier and the Karratha airport and townsite. Existing light pollution has degraded the natural night sky to that of a suburban equivalent, where many stars are no longer visible to the naked eye and the milky way is only partially visible. Data captured during this pre-development light monitoring survey will be utilised for the proposed artificial light modelling of the Perdaman development and can be used to compare with any post-development surveys to determine changes in light over time.
Social Surroundings (Aesthetics)	Cardno, 2020. Landscape and Visual Impact Assessment. Perdaman Pty Ltd. Fortitude Valley, QLD.	Characterizes the visual sensitivity of the Burrup Viewshed. Although the proposal will intensify the industrial use on the Peninsula, its operational requirements will not result in significant visual impacts or changes to landscape character as seen from most viewpoints, and the lighting at night and movement of vehicles will not be unduly dissimilar to the existing light sources and movement of vehicles along Burrup Road and Dampier Highway, servicing the industrial areas of the BSIA and the Port. Although the cumulative effect of industrial development may impact on the longer-term aspirations for the World Heritage listing of the Burrup Peninsula with respect to its aesthetic values (criterion vii), the proposed Project is generally outside of the NHL areas, and the existing industry is already likely to affect the ability of the Peninsula to meet this criterion.

Appendix 3 – Risks & Mitigation

Risk is the combination of the potential consequences arising from an environmental stressor, together with the likelihood of the stressor occurring and resulting in the consequence.

The potential impacts of lighting associated with the Project during both construction and operational phases are assessed using Cloughs HSSE matrix to maintain Risk Management consistency across the Project. This matrix can be modified to address specific environmental aspects.

During the risk assessment process, environmental stressors and sources, during construction, commissioning and operations are identified and subject to a risk assessment.

Stressor	Sources
Artificial Light	Construction lighting (including mobile task lighting) flaring during commissioning
	Operations lighting (including mobile task lighting) flaring (ongoing)

The impact assessment process is described in Table 8 with descriptions of the likelihood and consequence definitions provided in Table 9 and Table 10, respectively. In this section we assess the impacts before (inherent) and after (residual) mitigation measures outlined in the LMP are applied.

Table 8: Impact Assessment Matrix.

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

Table 9: 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 10 – Definition of Consequence

Description	Definition
Insignificant	Little to no impact on environmental values of amenity at sensitive locations.
Minor	Impacts are present, however impact on environmental values of amenity at sensitive locations are not visibly notable
Moderate	Impacts to environmental values of amenity at sensitive locations are present and visibly notable < 2 consecutive evenings.
Major	Impacts to environmental values of amenity at sensitive locations are present and visibly notable >2 but < 5 consecutive evenings
Catastrophic	Impacts to environmental values of amenity at sensitive locations are present and visibly notable > 5 consecutive evenings

Figure 11 Lighting Risk Assessment

Potential Impact	Mitigation Measures	Likelihood	Consequence	Residual Risk
OBJECTIVE:				
Construction phase lighting causing nuisance spillage into nearby sensitive receptors	• Set-up and operate lighting in accordance to AS/NZS 4282-2019 Control of the obtrusive effects of outdoor lighting. • Measures to be put in place to reduce light spill from the alignment, construction works and vehicle/machinery movements into adjacent natural habitat where practicable i.e. site entry and exit design, barricading, light positioning/directional lighting etc. • Complaints investigated and recorded. • Conduct weekly environmental inspections.	**4**	**2**	**8**
Operational phase lighting causing nuisance spillage into nearby sensitive receptors	• Set-up and operate lighting in accordance to AS/NZS 4282-2019 Control of the obtrusive effects of outdoor lighting. • Adjust remote light sensitivity. • Conduct light monitoring audit against this LMP • Complaints investigated and recorded. • Conduct environmental and safety inspections.	**4**	**3**	**12**

Attachment A. Perdaman Light Survey Report Rev A

Monitoring Event Completed - April 2022

Attachment B. Letter to EPA for MAC consultation on Project

See Attachment B

Attachment C. MAC Consultation - 24th Jan 2022

See Attachment C

Attachment D. GHD Peer Review

Document Title:	Lighting Management Plan, Perdaman Urea Project
Revision Number:	PCF 1, Rev B – 29 March 2022
Statement/Condition:	Ministerial Statement 1180 / Condition 10
Review Date:	4 April 2022

GHD Group Pty Ltd has reviewed the Lighting Management Plan, Perdaman Urea Project, Version PCF 1, 29 March 2022 (the Plan) against the requirements of Condition 10 in Ministerial Statement 1180.

GHD considers that the Plan requires amendments before it can be approved for implementation. Please address the comments in the following table and amend the Plan accordingly.

Item No.	EMP Section No.	GHD Comments	Proponent Response
1.	Section 1.1.4 and Table 2- 1	Noting that the proponent has proposed to adopt AS 4282-1997, the latest version of the standard (AS/NZS 4282-2019) should be referenced and adopted.	Addressed throughout
2.	Section 1.5.2.1 and 1.5.2.2	Consider either separating into own Section or moving these to Section 2 as part of the "best practice technology and risk management actions" to be undertaken.	Sections (1.5.2.1 and 1.5.2.2) moved from Section 1.5.2 'Rationale for Choice of Provisions' to Section 2.2 – 'Best Practice Technology and Risk Management Actions' Section references updated throughout
3.	Section 3 – paragraph 3	Consider rewording. This paragraph seems to equate the monitoring program with the Management Targets, while it is only one part of the Management Actions.	Paragraph 3 amended to reflect comment.