



# Appendix 6

## Lighting and Sky Glow Assessment

prepared by

Lighting, Art & Science Pty Limited

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# Dubbo Project

## Lighting and Sky Glow Assessment

Prepared by

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**March 2022**

# Lighting and Sky Glow Assessment

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## **COMMONLY USED ACRONYMS**

AHD	Australian Height Datum
AZL	Australian Zirconia Ltd
CCT	Correlated Colour Temperature
DPE	Department of Planning and Environment
LAS	Lighting, Art & Science Pty Limited
LED	Light Emitting Diode
LEP	Local Environmental Plan
LTP	Light Technical Parameters
RWC	R.W. Corkery & Co. Pty Limited
SAR	San Antonio Roswell
SSO	Siding Spring Observatory
ULR	Upward Light Ratio

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## EXECUTIVE SUMMARY

Lighting, Art and Science Pty Limited (LAS) has been engaged by RW Corkery & Co Pty Limited on behalf of Australian Strategic Materials (Holdings) Ltd (the Applicant) to complete Lighting and Sky Glow Assessment for the proposed Dubbo Project (the Project). The aim of this report is to assess the potential impacts of the Project on the Siding Spring Observatory.

The Project already has an approval for the operation of the mine processing on a 24 hour basis. This assessment is to look at what additional impact the of operating the construction phase of the operation on a 24 hour basis may have. The Project Site is located within the Dubbo Regional Council Area.

The purpose of the assessment is to form part of a Modification Report being prepared by RW Corkery & Co Pty Limited to accompany an application for development consent under Division 4.1 and 4.7 of Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the Project.

This assessment does not address the lighting associated with the existing approval for the operational lighting of the project but is limited to the additional impact of the night-time construction works.

We have not been provided with a lighting design for the final development nor have we received a construction program that indicates the nature of the night work and the associated lighting.

There is an Australian Standard, *AS/NZS4282:2019 Control of the obtrusive effects of outdoor lighting*<sup>[6]</sup> which LAS considers adequately addresses the requirements for dark rural environments with respect to the potential impact on residents in the area surrounding the Project Site, the impact on the other biota in the area surrounding the Project Site and the general impact on sky glow.

The Project Site falls within the Dark Sky Region defined by the *Dark Sky Planning Guideline*<sup>[2]</sup> which consists of the land within a 200km radius of the Siding Spring Observatory; and is triggered by Clause 92 of the *Environmental Planning and Assessment Regulation 2000*<sup>[1]</sup>.

The Project Site falls within the control of the *Dubbo Local Environmental Plan 2011*<sup>[2]</sup>. The relevant clause to this Project is:

*“(7) Development on land 18 kilometres or more from observatory. The consent authority must not (except with the concurrence of the Planning Secretary) grant development consent to development on land that is 18 kilometres or more from the Siding Spring Observatory if the consent authority considers that the development is likely to result in the emission of light of 1,000,000 lumens or more.”*

AS/NZS4282:2019 specifies limits for several lighting parameters. The limits vary according to the Environmental Zones and the time of night. There are 11 different Environmental Zones which reflect different ambient lighting conditions. The Standard also has a curfew period between 11:00pm and 6:00am, when lower limits are applied.

LAS has based the assessment on Zone A2, which is the third most stringent, being ‘Sparsely inhabited rural and semi-rural areas’, and has assessed both curfew and non-curfew periods.

As there is no design for the final operational lighting or the construction lighting at this stage, LAS have therefore assumed that the construction phase would basically comprise:

- Localised temporary tower lighting for earthworks and initial construction.

- As the road and facilities lighting is completed it will progressively be switched on and will act as construction lighting, gradually removing the need for special construction lighting.

It is therefore our opinion that the 24 hour operation of the construction will not need to increase the sky glow as experienced from the SSO, however it will bring forward the timing of the lighting so that it will commence with the start of construction and gradually build up to the normal operation lighting at the completion of construction.

### **Siding Spring Observatory and Significant Regional Observatories**

The Project Site is approximately 135 km from the Siding Spring Observatory (SSO) and falls within 200km limit.

AS/NZS4282:2019 specifies that the impact on significant community and scientific observatories should be considered and refers to the Australian Astronomical Societies List of Significant Observatories for guidance.

In addition to the SSO, are other observatories in the area that are included on the Australian Astronomical Societies List of Significant Observatories. The closest of these is in the Bathurst area and they are of a similar distance to Siding Springs Observatory. The Astronomical Societies list of significant observatories is divided in the following categories:

- Major Facilities, which includes Siding Springs.
- University/Publicly funded observatories.
- Significant Amateur Society/Private Observatories.

The observatories in the Bathurst area are in the Significant Amateur Society/Private Observatories category. We have assumed that as these are not significantly closer to the Project Site than Siding Springs, that acceptance by Siding Springs would also cover these sites.

## **CONCLUSIONS**

### **Local Environment**

The additional lighting associated with the construction of the Project would have negligible additional impact on the surrounding area.

### **The Siding Spring Observatory and other local Significant Observatories**

The proposed lighting for the construction of the Project will emit less than 1% of the light directly above the horizontal plane and be less than or equal to the permanent operational lighting.

### **Conclusion**

Based on the analysis carried out by LAS the Project could operate on a 24hour basis without generating excessive light obtrusion to the area surrounding the Project Site or the surrounding observatories.

## **1. INTRODUCTION**

Lighting, Art and Science Pty Limited (LAS) has been engaged by RW Corkery & Co Pty Limited on behalf of Australian Strategic Materials (Holdings) Ltd (the Applicant) to complete Lighting and Sky Glow Assessment for the proposed Dubbo Project (the Project). The aim of this report is to assess the potential impacts of the Project on the Siding Spring Observatory.

The Project already has an approval for the operation of the mine processing on a 24 hour basis. This assessment is to look at the additional impact of carrying out the construction phase of the operation on a 24 hour basis. The Project Site is located within the Dubbo Regional Council Area.

Any additional lighting has an impact on the environment and that impact is an inherent part of population expansion and industrialisation. The important criterion is one of reasonableness to determine whether the Project represents an unacceptable impact on the environment, the operation of the SSO or the amenity of the people in the surrounding area.

Our expertise does not extend to astronomy, so LAS has provided our base information and analysis for further analysis by the SSO, should it be required.

**Figure 1** shows the location of the Project Site in relation to the SSO.

**Figure 2** shows the Approved Project Site layout.

**Figure 3** shows the Approved Processing layout

**Figure 4** shows the Proposed Site Layout

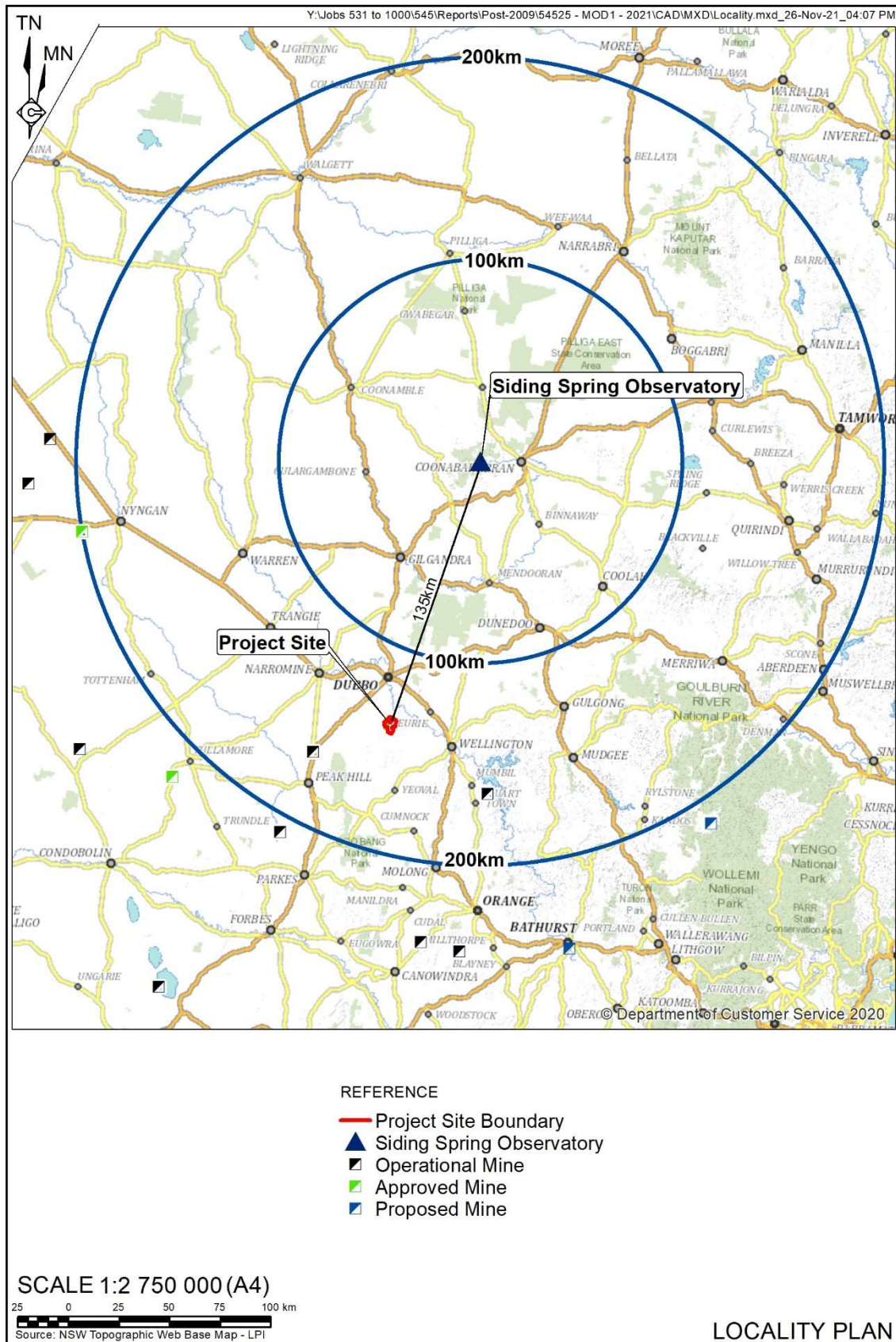
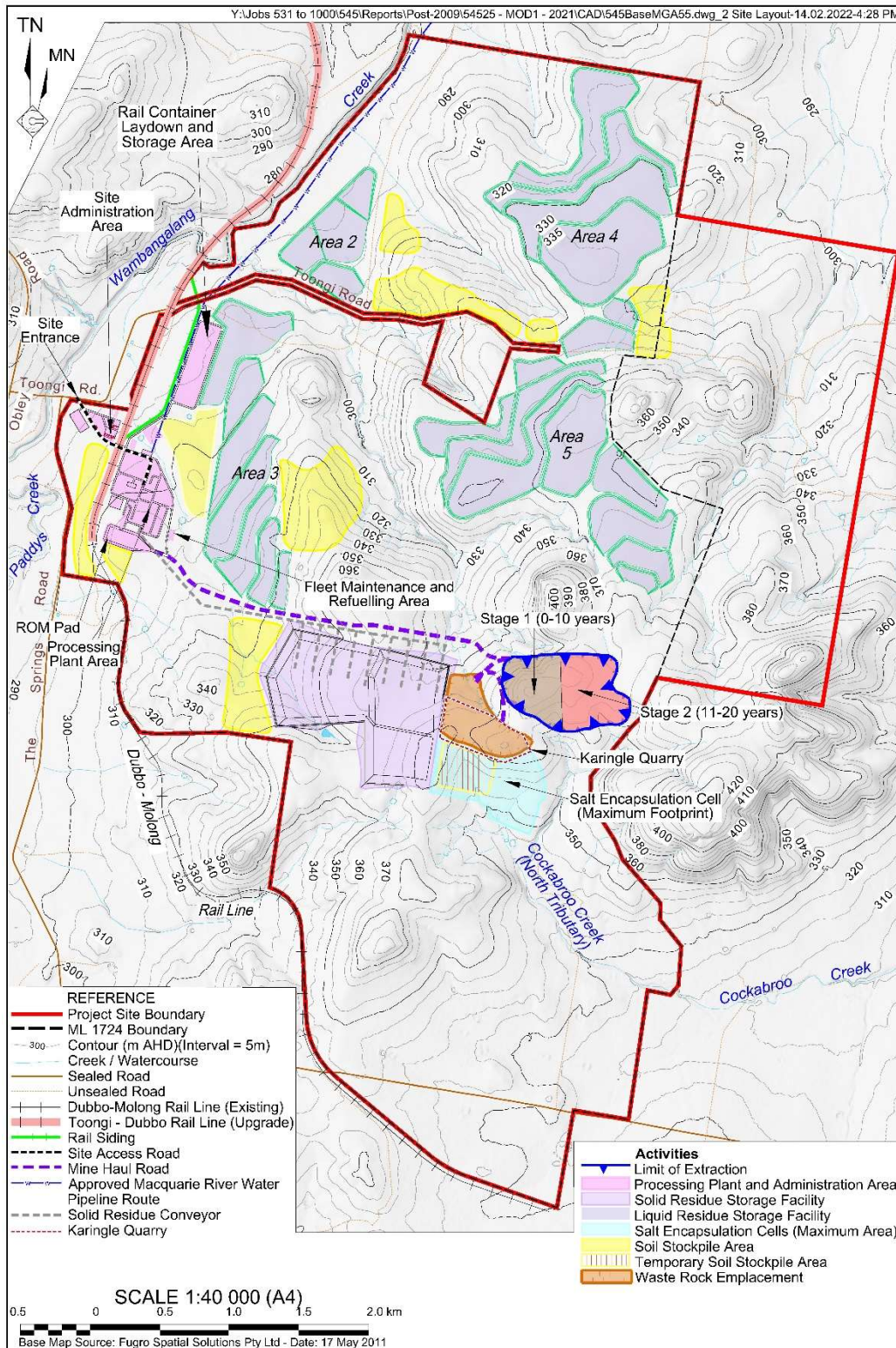
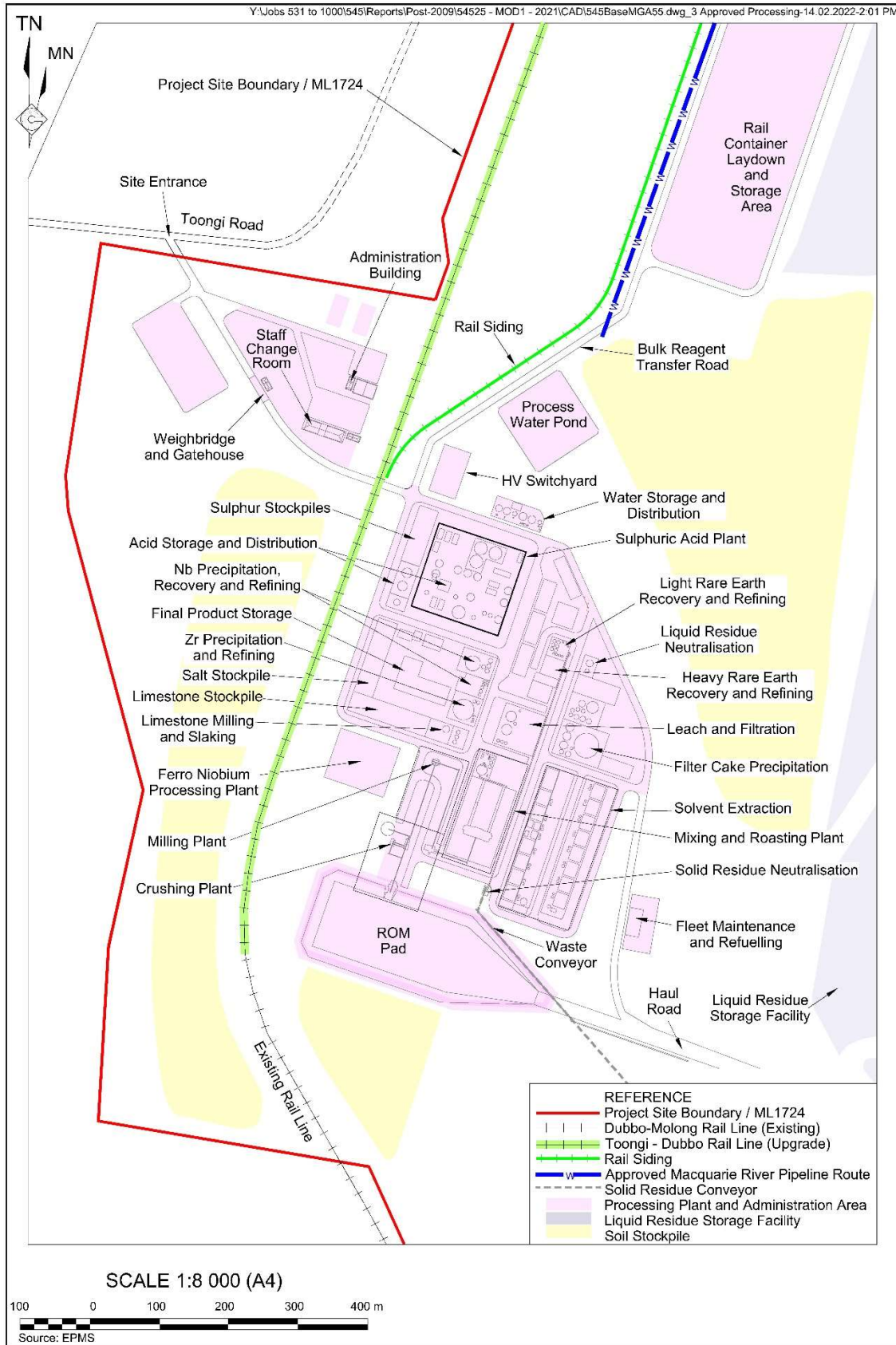


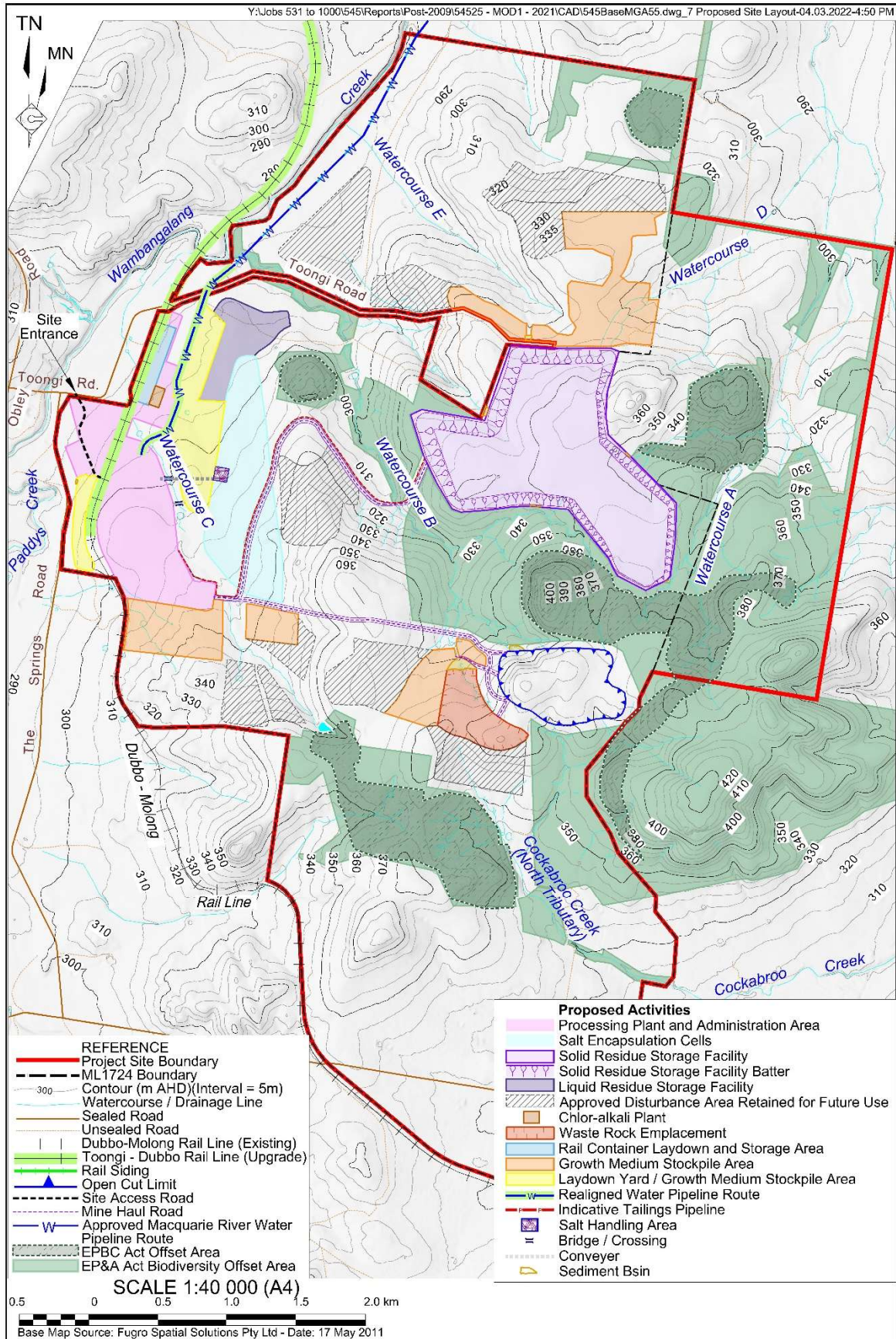
Figure 1 Location of the Project Site with respect to SSO



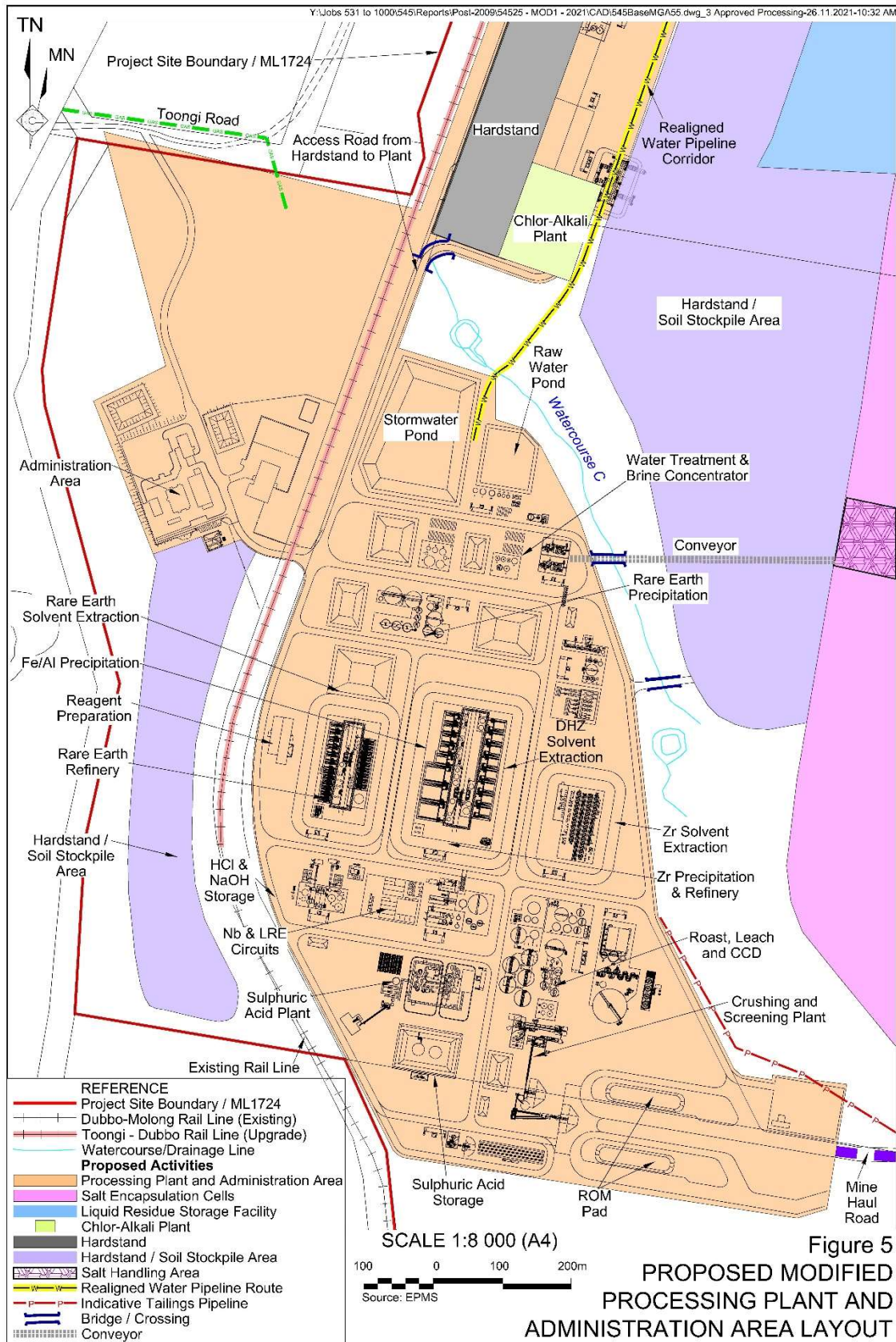
**Figure 2 Site Layout**



**Figure 3 Approved Processing Plant**



**Figure 4 Proposed Site Layout**



**Figure 5 Proposed Processing and Admin Area Layout**

## **2. SCOPE OF ASSESSMENT**

The *Dark Sky Planning Guideline 2016* sets out the requirements consent authorities must consider for developments within the Coonamble, Dubbo, Gilgandra and Warrumbungle Local Government Areas or 200km of the Siding Spring Observatory to minimise the impacts of artificial skyglow. The Project is located within the Dubbo Local Government Area and is situated approximately 135km from the Siding Spring Observatory (see Figure 1).

Therefore the Project Site is subject to the requirements of the Dubbo Local Environmental Plan 2011.

The Project has already been approved for 24hour processing operation. This assessment relates to the additional proposal the undertake the construction on a 24hour basis.

The assessment only looks at the impact on the observatories and has not assessed the impact on biota as we do not believe this will be any different to the normal operation of the project.

### 3. POLICIES, STANDARDS AND GUIDELINES

The following policies, standards, and guidelines are applicable to the Lighting and Sky Glow Assessment.

#### ***Environmental Planning and Assessment Regulation 2000***<sup>[1]</sup>

Clause 92, Additional matters that consent authorities must consider, states that:

*“(1) For the purposes of section 4.15(1)(a)(iv) of the Act, the following matters are prescribed as matters to be taken into consideration by a consent authority in determining a development application—*

- (a) (Repealed)*
- (b) in the case of a development application for the demolition of a building, the provisions of AS 2601,*
- (c) in the case of a development application for the carrying out of development on land that is subject to a subdivision order made under Schedule 7 to the Act, the provisions of that order and of any development plan prepared for the land by a relevant authority under that Schedule,*
- (d) in the case of the following development, the Dark Sky Planning Guideline—*
  - (i) any development on land within the local government area of Coonamble, City of Dubbo, Gilgandra or Warrumbungle Shire,*
  - (ii) development of a class or description included in Schedule 4A to the Act, State significant development or designated development on land less than 200 kilometres from the Siding Spring Observatory,”*

As the Project falls within the 200km zone, the Dark Sky Planning Guideline must be considered as part of the assessment for the Project.

#### ***Dubbo Local Environmental Plan 2011***<sup>[2]</sup>

The relevant clauses are:

*“5.14 Siding Spring Observatory—maintaining dark sky*

*(1) The objective of this clause is to protect observing conditions at the Siding Spring Observatory by promoting lighting practices that minimise light pollution.*

*(2) Light emissions—general considerations for all development Before granting development consent for development on land to which this Plan applies, the consent authority must consider whether the development is likely to adversely affect observing conditions at the Siding Spring Observatory, taking into account the following matters—*

*(a) the amount and type of light to be emitted as a result of the development and the measures to be taken to minimise light pollution,*

*(b) the impact of those light emissions cumulatively with other light emissions and whether the light emissions are likely to cause a critical level to be reached,*

*(c) whether outside light fittings associated with the development are shielded light fittings,*

*(d) the measures to be taken to minimise dust associated with the development,*

*Note. Dust tends to scatter light and increase light pollution.*

*(e) the Dark Sky Planning Guideline published in the Gazette by the Planning Secretary.*

.....

*(7) Development on land 18 kilometres or more from observatory The consent authority must not (except with the concurrence of the Planning Secretary) grant development consent to development on land that is 18 kilometres or more from the Siding Spring Observatory if the consent authority considers that the development is likely to result in the emission of light of 1,000,000 lumens or more.*

.....

*(10) Granting concurrence The Planning Secretary must take the following into account in deciding whether to grant concurrence under this clause—*

*(a) any comments made by the observatory director in relation to the development,*

*(b) the effect the development would have on observing conditions at the Siding Spring Observatory,*

*(c) the quantity of artificial light in the night sky measured through a telescope at the Siding*

*Spring Observatory on or about the date the development application is made and the relationship of that level to the critical level,*

*(d) whether any public interest in permitting the development outweighs the public interest in preserving the observing conditions at the Siding Spring Observatory.*

*(11) A reference in this clause to light emitted as a result of development for the purposes of a building or work includes light emitted from any other building or work that is to be used as part of or in connection with that building or work.*

*(12) A requirement in this clause to consult with the observatory director in respect of development is a requirement to give written notice of the development to the observatory director and to take into account any comments received from the observatory director within 21 days after the notice is given.*

*(13) Clause 4.6 does not allow development consent to be granted for development that would contravene this clause.”*

### **Dark Sky Planning Guideline** [3]

The *Dark Sky Planning Guideline* was published by the Department of Planning and Environment (DPE) and it referenced in the *Environmental Planning and Assessment Regulation 2000* above. The guideline informs the assessment of significant development within 200km of the SSO and provides guidance and technical information on good lighting design. The Project Site is located approximately 135km from the SSO.

### **State Environmental Planning Policy (Infrastructure) 2007** [4]

Under Clause 16(2)(g) of the *State Environmental Planning Policy (Infrastructure) 2007*, the Project is determined to be a Specified Development as it is within 200km of the Siding Spring Observatory, and therefore the Director of the Observatory is a Specified Authority.

### **State Environmental Planning Policy (Exempt and Complying Development Codes) 2008** [5]

Subdivision 13 of the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* lists the relevant LGAs to which the minimum standards outlined in the Dark Sky Planning Guideline are applicable.

### **AS/NZS 4282:2019 Control of the obtrusive effects or outdoor lighting** [6]

AS 4282:1997 was originally written to control the impact of sports lighting on the amenity of surrounding residents but has a much wider scope of application. It was republished in 2019 and includes restrictions for intrinsically dark areas and light emissions to the sky. The standard is not referred to in legislation but is commonly relied upon when formulating conditions of consent by local government and as a benchmark for what is reasonable.

AS/NZS 4282:2019 standard specifies limits for the vertical illuminance surrounding the Project Site, the upward light emitted and the glare from the luminaires. Although primarily written to limit the impact of light on people, the standard also includes limits relating to astronomy and the environment and, as such, is applicable to the Project.

The previous edition is referenced in The Dark Sky Planning Guidelines; however, it does not specify conformance.

### **CIE Technical Report 126:1997 Guidelines for minimising Sky Glow** [7]

This was one of the first reference documents on the minimisation of sky glow. The guidelines set out in CIE Technical Report 126:1997 provide a good explanation of the basic concepts of sky glow and available mitigation measures. It is still current and has been the basis for many later documents.

### **IAU/CIE 001 Guidelines for minimizing urban Sky Glow near astronomical observatories** [8]

This guideline overlaps with the CIE technical report but was produced in conjunction with the International Astronomical Union. It provides a more detailed account of the mechanisms and effects of Sky Glow.

## 4. LIGHTING TERMS AND CONCEPTS

### 4.1 INTRODUCTION

The following subsections provide a summary of lighting terms and concepts relevant to this report.

### 4.2 LIGHTING PARAMETERS

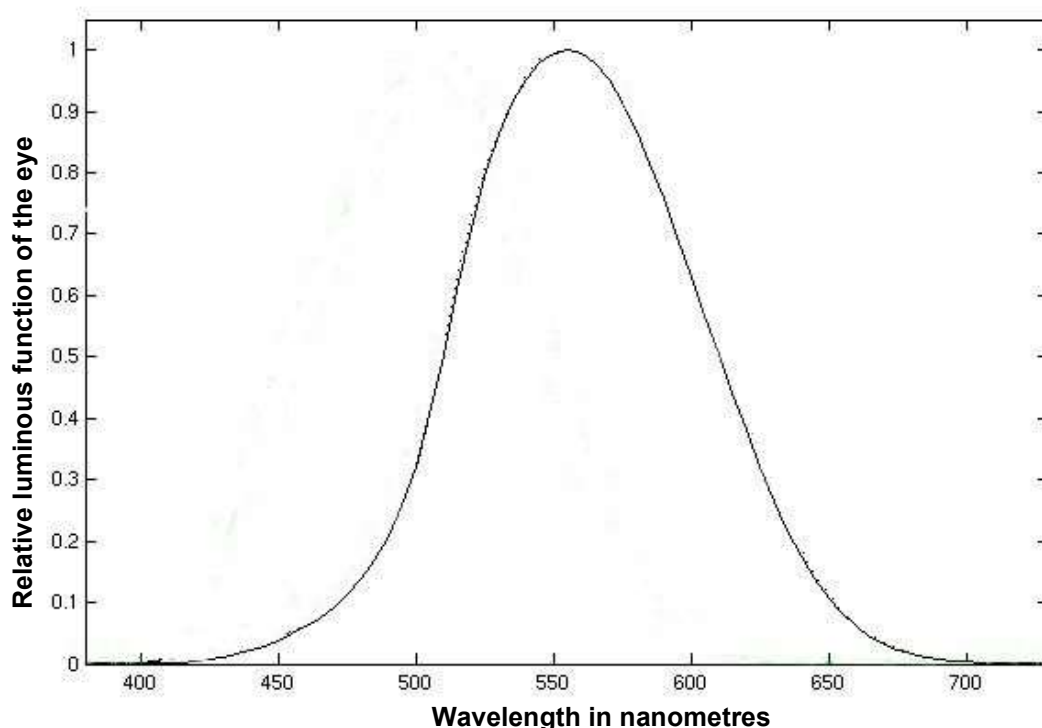
#### Visible Spectrum

The visible spectrum is the band of wavelengths of electromagnetic radiation that is visible to the human eye. This is normally accepted as the band between 380 (violet) and 740 (red) nanometres.

The eye does not have equal sensitivity across the visual spectrum. The spectral response of the eye is standardised as the  $V(\lambda)$  as shown in **Figure 6**.

The curve is the photopic response which occurs under normal lighting levels. The  $V(\lambda)$  curve shows the variation in the sensitivity of the eye at different wavelengths across the visual spectrum.

**Figure 6 Proposed Processing and Admin Area Layout**



#### Light Source

A light source is any surface or object that emits light. The source may generate light, or it may reflect or transmit the light.

### **Radiant Flux**

Radiant flux is the radiant energy emitted by a source, per unit time and is measured in **Watts**. For the purpose of this study the radiant flux has been limited to the visible spectrum.

Radiant flux is not modified for the response of the human eye.

### **Luminous Flux**

Luminous flux is the radiant flux emitted by a source, per unit time multiplied by  $V(\lambda)$  so that it reflects what is seen by the eye. Luminous flux is measured in **lumens**.

The luminous flux therefore understates the intensity of the red and blue end of the spectrum.

### **Luminous Intensity**

Luminous intensity is the amount of luminous flux leaving the light source in a given direction.

It is measured in lumens/steradian or **candelas**.

### **Illuminance**

Illuminance is the amount of light that falls on a surface or plane. The illuminance is independent of the characteristics of that surface or plane.

Illuminance from a small source reduces inverse proportionally to the square of the distance. As a result, the illuminance falls off rapidly with distance.

Illuminance is measured in Lumens/metre<sup>2</sup> or **lux**.

### **Luminance**

The luminance is the amount of light leaving a surface. It may be reflected or transmitted.

The luminance is usually measured in **candelas/metre<sup>2</sup>**.

### **Upward Light Ratio (ULR)**

Upward Light Ratio is a light technical parameter used in AS/NZS 4282:2019 and other Australian external lighting standards.

It is defined as “The proportion of the flux of a luminaire and/or installation that is emitted at or above the horizontal, excluding reflected light, when the luminaire(s) is/are mounted in its installed position(s).  $ULR = \text{upward flux} / \text{total flux from the luminaire}$ ”.<sup>[6]</sup>

Some standards also refer to it as Upward Waste Light Output Ratio (UWLR). The terms are interchangeable.

As ULR is a ratio, it is unitless.

### **Glare**

Glare is any light that reduces the visual performance.

### **Correlated Colour Temperature (CCT)**

This is an assessment of the colour appearance of the light source with reference to the appearance of a black body radiator at a specific temperature. While it is indicative of the tendency of the light to warm or cool, it does not provide definitive information with respect to the spectral distribution.

It assumes that the light source colour is close to white.

CCT is expressed in **Kelvin** units (K). Kelvin is a temperature scale. The units are the same as Celsius except that Kelvin uses absolute zero as a base rather than the freezing point of water.

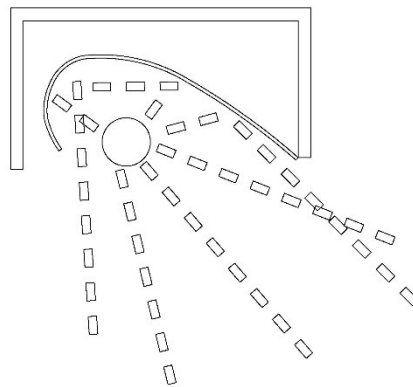
### **Luminaire**

Luminaire is the technical term for a light fitting, and it includes the light source, the enclosure and optical control mechanism and the control equipment.

### **Forward Throw Luminaire**

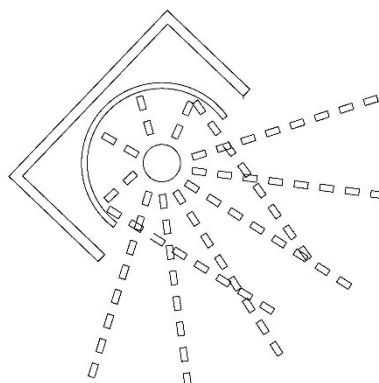
A forward throw luminaire is a fitting designed to be mounted with the front glass near horizontal and use reflectors or lenses to project the light forward without having to raise the tilt or upcast of the fitting. These fittings have minimal upward light contribution when used as designed (see **Figure 7**).

**Figure 7 Forward Throw Floodlight**



A luminaire with a symmetrical distribution throws the same amount of light above and below the axis of the luminaire. Because the peak intensity is perpendicular to the glass the luminaire has to be tilted up to light the area in front of the luminaire. As a result, a significant part of the light is projected into the sky (see **Figure 8**).

**Figure 8 Symmetrical Distribution Floodlight**



A forward throw luminaire is also more efficient as less light is wasted.

### **4.3 SKY GLOW**

Sky glow is the brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter) in the direction of observation. It comprises two separate components. [8]

1. Natural sky-glow - that part of the sky-glow which is attributable to radiation from celestial sources and luminescent processes in the Earth's upper atmosphere. [8]
2. Man-made sky-glow - that part of the sky-glow which is attributable to man-made sources of radiation (e.g. artificial outdoor lighting), including radiation that is emitted directly upwards and radiation that is reflected from the surface of Earth. [8]

#### **Units**

"Lighting engineering and astronomy both rely on photometry. The fundamentals are the same, but the conventions and the practical units differ. In lighting engineering, photometric units are usually related to photopic vision."

"In astronomy, the visual classification of cosmic objects is based on the 'magnitude' of the luminous objects like e.g. stars as they present themselves to the (mesopic) eye.

The magnitude scale is essentially a logarithmical one, where the magnitude difference of 5 relates to a flux ratio of 100." [8]

There is therefore not direct conversion factor between magnitude and  $\text{cd/m}^2$ .

#### **Upcast**

The angle of adjustment of the luminaire in the vertical plane above the horizontal, face down position; also referred to as tilt.

## **5. METHODOLOGY**

### **5.1 INTRODUCTION**

The sky glow information required by the Dark Sky Planning Guideline [3] for the assessment by the SSO requires the total luminous flux (lumens) generated by the installation. This is an overall figure and is independent of where the lights are aimed. It is a reasonably rough tool but is designed principally as a screening test.

AS/NZS4282:2019 has a different approach to the control for the obtrusive light.

The standard principally addresses the impact of the lighting on things at ground level including the impact on residential dwellings and drivers on roads.

The skyglow is calculated on the basis of the proportion of the light from the luminaires, in their normal aiming position, that directly leaves above the horizontal plane. This is the Upward Light Ratio.

None of the AS/NZS4282:2019 calculations include light reflected from the ground or other objects.

### **5.2 BACKGROUND INFORMATION**

The following background information was provided by the Applicant.

- a) Project Site Layout
- b) Site plan showing the site location with respect to the SSO.
- c) Proposed layout of the additional processing plant and administration area.

### 5.3 SITE INSPECTION

As there is no construction on the site and the site is pastoral land we did not believe that it was necessary to carry out a site meeting.

### 5.4 LOCAL ENVIRONMENT LIGHTING CRITERIA

The local environment is principally controlled by the requirements of AS/NZS 4282:2019 which recommends limits for specific light technical parameters based on the ambient lighting conditions.

LAS considers that the current edition of AS/NZS4282:2019 adequately addresses the requirements for a rural environment.

#### 5.4.1 Environmental Zone

AS/NZS4282:2019 nominates 11 Environmental Zones – see **Table 1**.

**Table 1**  
**Environmental Zones Identified in AS/NZS 4282:2019<sup>[6]</sup>**

Zones	Description	Examples
A0	Intrinsically dark	UNESCO Starlight Reserve. IDA Dark Sky Parks. Major optical observatories No road lighting -unless specifically required by the road controlling authority
A1	Dark	Relatively uninhabited rural areas No road lighting - unless specifically required by the road controlling authority
A2	Low district brightness	Sparsely inhabited rural and semi-rural areas
A3	Medium district brightness	Suburban areas in towns and cities
A4	High district brightness	Town and city centres and other commercial areas Residential areas abutting commercial areas
TV	High district brightness	Vicinity of major sports stadium during TV broadcasts
V	Residences near traffic routes	Refer AS/NZS 1158.1.1
R1	Residences near local roads with significant setback	Refer AS/NZS 1158.3.1
R2	Residences near local roads	Refer AS/NZS 1158.3.1
R3	Residences near a roundabout or local area traffic management device	Refer AS/NZS 1158.3.1
RX	Residences near a pedestrian crossing	Refer AS/NZS 1158.4

Source: AZ/NZ4282:2019 – Table 3.1

Based on **Table 1**, the area immediately surrounding SSO would be classified as an A0 zone as it is a Dark Sky Park. The Project Site and surrounding area would be an A2 zone.

As the Project Site surroundings have been assessed to be within an A2 Zone, the required limits in AS/NZS4282:2019 adequately protect the night environment of the area surrounding the Project Site.

#### 5.4.2 Curfew

AS/NZS 4282:2019 also specifies a curfew period between 11:00pm and 6:00am when a lower set of limits are specified.

An assessment for both the pre-curfew and curfew periods has been undertaken at the Project Site boundary. The curfew limits are required to be calculated at the windows of habitable rooms of the buildings, however if the limits are achieved at the Project Site boundary it is deemed that they will comply beyond that point.

#### 5.4.3 Light Technical Parameters

The light technical parameters that are controlled by AS/NZS 4282:2019 are listed in **Tables 2** and **3**.

**Table 2**  
**Maximum Values of Light Technical Parameters in AS/NZS 4282:2019 [6]**

Zones	Vertical illuminance levels ( $E_v$ ) lx		Threshold increment (TI)		Sky glow
	Non-curfew	Curfew	%	Default adaptation level ( $L_{ad}$ )	Upward light ratio
A0	See Note 1	0	N/A	N/A	0
A1	2	0.1	N/A	N/A	0
A2	5	1	20%	0.2	0.01 (1%)
A3	10	2	20%	1	0.02 (2%)
A4	25	5	20%	5	0.03 (3%)
TV	N/A	N/A	20%	10	0.08 (8%)
V	N/A	4	Note 2	Note 2	Note 2
R1	N/A	1	20%	0.1	Note 3
R2	N/A	2	20%	0.1	Note 3
R3	N/A	4	20%	0.1	Note 3
RX	N/A	4	20%	5	Note 4

Note: Grey colour indicates values applicable to the Project Site.

Source: AZ/N 4282:2019 – Table 3.2

**Table 3**  
**Maximum Luminous Intensities per Luminaire in AS/NZS 4282:2019<sup>[6]</sup>**

Zone	Luminous intensity ( <i>I</i> ), cd		
	Non-curfew L1	Non-curfew L2	Curfew
A0	See Note	See Note	0
A1	2 500	5 000	500
A2	7 500	12 500	1 000
A3	12 500	25 000	2 500
A4	25 000	50 000	2 500
TV	100 000	150 000	0

Note: Grey colour indicates values applicable to the Project Site.  
Source: AZ/NZ 4282:2019 – Table 3.3

#### 5.4.3.1 Vertical Illuminance

The vertical illuminance relates to the impact of the lighting on residences. As there are no residences within proximity there is no assessment plane to calculate.

#### 5.4.3.2 Threshold Increment

Threshold increment (TI) is a measure of the disability glare caused by the lighting to drivers of vehicles outside the site.

The TI is calculated using the illuminance at the eye of the driver from the light sources compared with the background luminance. The magnitude is also reduced as the angle of offset from the driver's direction of view increases.

This would be assessed with respect to the rail link in the design of the facility however will not be relevant during construction.

#### 5.4.3.3 Upward Light Ratio

Upward light ratio limits the light emitted into the sky to limit the impact on sky glow. For an A2 zone, the limit is 0.01 (1%) This does not mean that there is no light emitted into the sky because the calculations in AS/NZS 4282:2019 do not include the light reflected off surfaces.

To achieve this the lighting will need to have a sharp cut-off at the horizontal plane and minimal tilt.

#### 5.4.3.4 Luminous Intensity

This is an indication of the glare caused to people located outside of the Project Site, who have direct view of the lights within the Project Site.

The limits for an A2 zone would be 7,500cd and 1,000cd, respectively.

There is good correlation between luminous intensity and glare for lights with a small source within a range of a few hundred metres. The correlation is not as accurate when the light source is large or the distance to the light source is large.

Luminous Intensity is again assessed at residential sites. As there are no residential sites the parameter is not relevant. If the 1% upward light ration is maintained, then there will be minimal opportunity to see the light source.

#### **5.4.4 Conformance to AS/NZS 4282:2019**

Conformance calculations for AS/NZS 4282:2019 were not carried out as there is no lighting design at this stage to assess.

### **5.5 ASTRONOMICAL OBSERVATIONS**

The requirements for the SSO are different to the local environment as they are concerned about light much higher in the atmosphere. The standard angle for assessment for the observatory, nominated in the Dark Sky Planning Guideline [2] is 30 degrees above the horizontal. This would mean that this would be 93km above the Project Site.

#### **5.5.1 Upward Light Ratio**

The ULR has is limited under AS/NZS4282:2019.

#### **5.5.2 Total Lumens Produced**

This is a total lumen output of all the additional external fittings that would likely be used on the Project Site. It does not consider the aiming, shielding or the efficiency of the fittings. It is only useful as an overall benchmark of the size of the Project.

## **6. ASSESSMENT**

### **6.1 SITE INFORMATION**

There is no design for the lighting at this stage. As a result, we have made some assumptions with respect to the type and wattage of the lights and the distribution of the lights.

The assessment was made on the following assumptions:

- a) All roads on the site will be used by heavy vehicles so the roads would be illuminated as V category roads to AS/NZS1158.3.1
- b) The light poles will be spaced at an average of 40 metres and shall each have a 150Watt LED streetlight with an efficacy of 100lumens per Watt.
- c) The streetlights shall have full cut off and zero tilt so that there is zero light emitted above the horizontal.
- d) The admin area shall have floodlighting of the open areas and local area lights mounted on the façade of the buildings.
- e) As we do not know the details of the plant structures or the areas that would be enclosed, we have assumed an average illuminance on the horizontal plane of 50 lux. This will allow higher levels in critical areas as some of the area will be covered by equipment.
- f) All luminaires shall emit no light above the horizontal plane and shall be mounted with a minimum upcast.

The total lumens relate to the requirement of the *Dubbo Local Environmental Plan 2011*<sup>[2]</sup>.

Clause “5.14 Siding Spring Observatory—maintaining dark sky (7), which states that “Development on land 18 kilometres or more from observatory The consent authority must not (except with the concurrence of the Planning Secretary) grant development consent to development on land that is 18 kilometres or more from the Siding Spring Observatory if the consent authority considers that the development is likely to result in the emission of light of 1,000,000 lumens or more.”

As the operational lighting has been approved the total lumens for the installation is only relevant if total lumens during construction exceeds the lighting of the approved installation by 1,000,000 lumens. We do not believe that there is the need exceed the approved lighting.

## **6.2 AS/NZS 4282:2019 CALCULATIONS**

As there is no design we cannot calculate the conformance of the installation, however we can recommend some limiting parameters that will ensure conformance.

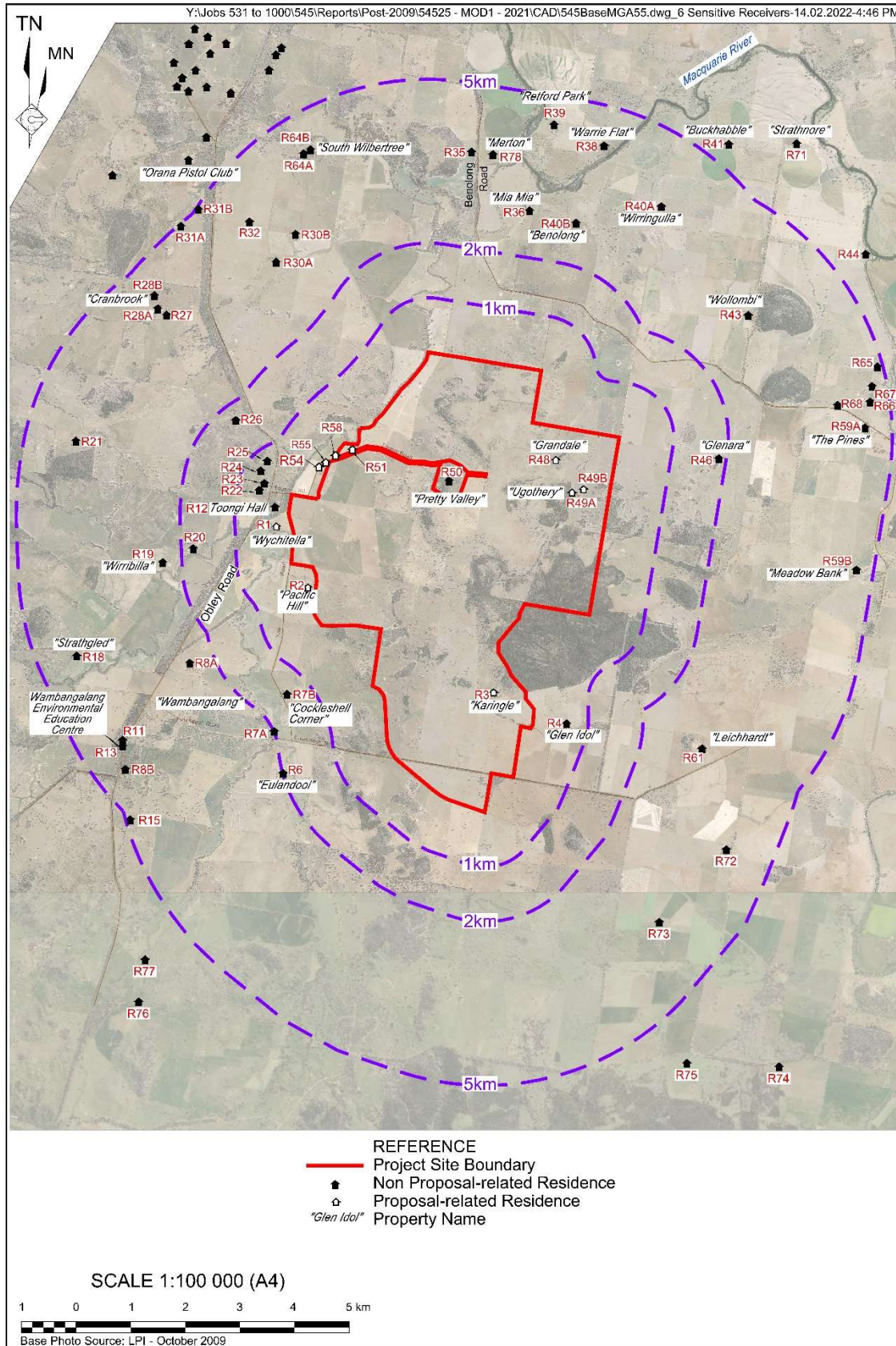
### **6.2.1 Impact on Residential Buildings**

There are no residential buildings in the area immediately surrounding the site.

The approximate distances from the site boundary to the nearest residential buildings are R22 ,544 metre west of the boundary and R4, 518 metres east of the boundary.

R12, Toongai Hall, 307 metres is a function hall and therefore is not classed as a habitable room under AS/NZS 4282:2019.

If the lighting is installed with full cut off fittings and zero tilt, there will be negligible vertical illuminance at the residential buildings and no luminous intensity problems as the light sources will not be visible from that distance.



**Figure 9 Location of the Surrounding Residences**

## 6.2.2 Upward Light Ratio

The ULR requirements for pre-curfew and curfew are the same. This requirement was introduced in the AS/NZS 4282:2019 standard.

For an A2 Environmental Zone the maximum Upward Light ratio is 1%. This means that the total light that is emitted above the horizontal from all the lights in their normal aiming position, must be less than 1% of the total light emitted by all the lights on the site.

If full cut off fittings with zero upcast are used the Upward Light Ratio will be zero and will therefore meet the requirements of the standard.

### 6.2.2.1 Threshold Increment

The threshold increment will need to be calculated for the final design; however the lighting can be aimed to minimise the impact.

### 6.2.2.2 Impact on Observatories

Clause 2.4.4. of AS/NZS 4282:2019 states that where the installation is in close proximity of an observatory, then close consultation is required. The Standard then references the Astronomical Society of Australia’s List of Designated Observatories [9].

Although these are referenced in AS/NZS 4248:2019 as observatories that should be taken into account as part of an assessment. AS/NZS4282:2019 does not recommend additional parameters or limits that should be applied, but simply raises awareness of the observatories.

The nearest designated observatories on the list are listed on **Table 4**.

**Table 4**  
**Astronomical Observatories Considered in Lighting Assessment**

<b>Observatory</b>	<b>Distance from the Mine Site</b>
<b>Major Facilities</b>	
Siding Spring Observatory	135km
<b>University/Publicly funded facility</b>	
UWS Penrith Observatory	272km
<b>Significant Amateur Society/Private Observatories</b>	
Bathurst Observatory (20km northeast of Bathurst NSW)	139km
Mt Tarana Observatory - Mr Colin Bembrick (25km east-southeast of Bathurst NSW)	140km
Wiruna Observatory, (Astronomical Society of NSW, Ilford)	160km
Grove Creek Observatory – (40km south of Bathurst NSW)	179km
Linden Observatory (Blue Mountains near Sydney)	249km
Crago Observatory - (Astronomical Society of NSW, Bowen Mountain NSW)	251km
Kirby Observatory - (UNE and Northern Tablelands Astronomical Society, Armidale NSW)	296km
Koolang Observatory (Bucketty, near Newcastle NSW)	328km

Other than the observatories in the vicinity of Bathurst the observatories are further from the Project Site than the SSO. While the SSO is a major facility that is protected, the Bathurst observatories are Amateur Society or Private facilities and are only marginally closer to the Project Site than SSO.

Although the term 'close proximity' is not defined in AS/NZS4282:2019 the distance that is used in the SEPP and the LEPs of the areas surrounding the SSO use 18km as the indicator of 'close proximity'. None of the observatories fall within this distance. We have therefore assumed that if the Project is acceptable to the SSO then the impact on the other observatories would also be acceptable.

## **7. RECOMMENDED MITIGATION MEASURES**

This assessment indicates that the impact of the proposed construction lighting of the Project Site on the local environment and SSO would be significantly less than the limits contained in AS/NZS 4282:2019 and the SSO Dark Sky Planning Guidelines<sup>[3]</sup>.

Provided that the detailed design and implementation of the lighting for the Project is in accordance with AS/NZS 4282:2019 *Control of obtrusive outdoor lighting*<sup>[6]</sup>, and is consistent with the general design recommendations listed in Section 7.1, and the information on which this assessment is based, there would be no need for additional mitigation measures.

### **7.1 GENERAL DESIGN RECOMMENDATIONS**

- a) All construction lighting within the Project Site should be designed to meet the criteria of Zone A2 in AS/NZS 4282:2019.
- b) All light sources should have CCT of 3000K or less.
- c) Streetlights and catwalk lights should be full cut-off fittings with zero tilt.
- d) All fixed floodlights should be forward throw luminaries with a maximum upcast of 5 degrees. Wherever possible the upcast should be zero.
- e) Lights with diffusing covers or with visible bare lamps that emit light above the horizontal plane should not be used on the outside of buildings or structures
- f) Where lighting towers are used, they should have a maximum upcast of 5 degrees and use a forward throw distribution.

## **8. CONCLUSION**

### **8.1 LOCAL ENVIRONMENT**

The provisions of AS/NZS 4282:2019 are adequate to protect the amenity of the Residential Receivers in the area surrounding the Project Site.

#### **8.1.1 Illuminance**

The illuminance calculations are redundant as the nearest residential receivers will be too far from the site to exceed the curfew limits.

### **8.1.2 Luminous Intensity**

The illuminance calculations are redundant as as the nearest residential receivers will be too far from the site to exceed the curfew limits.

### **8.1.3 Upward Light Ratio**

The selection and aiming of the temporary construction lighting should be controlled to minimise the percentage of light directly into the sky.

### **8.1.4 Luminous Flux**

While the total luminous flux is not a parameter that is controlled by AS/NZS4282:2019, it is a parameter that is used in the Dubbo Local Environmental Plan. There should be no reason to increase the luminous flux of the construction related works beyond the luminous flux of the final operational site.

### **8.1.5 Summary**

LAS considers that the lighting associated with proposed 24hour construction activities the of the Project Site, should not increase the total lumens emitted into the sky, but will bring forward when the light starts to be produced to the beginning of the night construction activities.

## **8.2 IMPACT ON SIDING SPRING OBSERVATORY**

LAS considers that the lighting associated with proposed 24hour construction activities the of the Project Site, should not increase the total lumens emitted into the sky, but will bring forward when the light starts to be produced to the beginning of the night construction activities.

## **9. REFERENCES**

- 1 *Environmental Planning and Assessment Regulation 2000.*
- 2 *Dubbo Local Environmental Plan 2011*
- 3 *Dark Sky Planning Guideline, Protecting the observing conditions at Siding Spring — NSW Department of Planning and Environment, June 2016*
- 4 *State Environmental Planning Policy (Infrastructure) 2007*
- 5 *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008*
- 6 *AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting*  
Standards Australia Feb 2019
- 7 CIE 126, *Guidelines for minimizing sky glow*
- 8 CIE 001-1980, *Guidelines for Minimizing Urban Sky Glow Near Astronomical Observatories* (Joint Publication IAU/CIE)

- 9 *Current List of Designated Observatories* The Astronomical Society of Australia.  
<http://asa.astronomy.org.au/observatories.php>

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