PORT HEDLAND SOLAR FARM

Reflective Glare Assessment

Prepared for:

ALINTA Energy Development Pty Ltd
Level 18, Raine Square
300 Murray Street
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SLR

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with ALINTA Energy Development Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30511-R01-v2.1	25 January 2022	Peter Hayman	Dr Peter Georgiou	Dr Neihad Al-Khalidy
610.30511-R01-v2.0	16 December 2021	Peter Hayman	Dr Peter Georgiou	Dr Neihad Al-Khalidy
610.30511-R01-v1.0	8 November 2021	Peter Hayman	Dr Peter Georgiou	Dr Neihad Al-Khalidy

EXECUTIVE SUMMARY

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Alinta Energy Development Pty Ltd (Alinta) to carry out a Reflective Glare assessment of the proposed 90 MWac Port Hedland Solar Farm (the "Project"). The Project is located on Unallocated Crown Land near the existing Port Hedland Power Station (PHPS), comprising:

- Three 30 MWac blocks configured as a single facility, with approximately 220,000 solar panels on a fixed tilt support system - refer Figure 1.

The Project NE corner is located approximately 8 km from Port Hedland International Airport (PHIA) Runway 14/32, just over 4 km from the township centre of South Hedland and 1.5 km from the nearest residences at Boodarie to the east – refer Figure 8.

The report has modelled a more extensive "maximal theoretical" project in terms of potential site footprint than the final design that will be constructed and has hence adopted a conservative approach to glare prediction. Section 3.5 details the significant difference between the "maximal theoretical" footprint modelled in this study and likely final design footprint – refer Figure 7.

The following potential glare conditions have been considered:

- Daytime — Reflective glare (and glint) arising from the solar PV panels within the facility:
  - . Aviation Sector Reflective Glare;
  - . Motorist "Disability" Reflective Glare;
  - . Rail Operator "Disability" Reflective Glare;
  - . Industrial Machinery Operator "Disability" Reflective Glare; and
  - . Residential "Nuisance" Glare
- Night-time — Illumination glare for 24/7 operational security lighting within the Project.

Aviation-Related Potential Glare

Quantitative analysis was made using the FAA-SGHAT (Solar Glare Hazard Analysis Tool) software tool – refer Section 4.2 for details of the tool. The analysis has shown that there will be nil glare from the Project at Port Hedland International Airport (all runways) under ANY Fixed Tilt panel support mode ranging from 5° to 25° with the panels "facing" due north. The proposed solar farm will also comply with SGHAT requirements in a Fixed Tilt panel mode of around 15° if the perpendicular "pointing" axis of the panels (ie the direction they are facing) is allowed to vary from due north by ±10°.

The above result is due to the distance of the proposed solar farm from PHIA and the difference in line of sight of pilots on final approach for the airport's runways.

Recommendation: NIL

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Motorist and Rail Traffic "Disability" Glare

Quantitative analysis was made using the SLR's TI (Threshold Increment) Value Calculation tool - refer Section 5.2 for definition of the TI Value. The proposed solar farm will comply with the recommended TI Value criteria for both road and rail under ANY Fixed Tilt panel mode with an upwards tilt of at least 10°.

For a typical FIXED TILT position (say in the range 15°-20°), allowing the array to have a slight eastwards orientation (eg facing 10° east) increases the potential visibility of reflections to the adjacent FMG East Turner Rail Line, but still within the recommended TI Value criteria. Allowing the array to have a slight westwards orientation (eg facing 350° west) increases the potential visibility of reflections to Boodarie Station Access Road traffic, again still within the recommended TI Value criteria.

Recommendation: While not a glare issue per se, in order to minimise the visibility of reflections from the proposed facility, it is recommended that the orientation of the panels be aligned as close to North as possible, regardless of the FIXED TILT angles of the panels.

Residential Nuisance Glare

The TI Value calculations assessing residential nuisance glare were based on a receiver looking directly towards the proposed facility. The calculations conservatively assumed NO intervening "blocking" topography (eg from small, elevated earth mounding) and NO vegetation or any other physical barriers, such as perimeter fencing, etc.

These "idealised" calculations showed that there is potential for the visibility of reflections from the facility at some surrounding receivers – receivers #3, #4 & #5 for Boodarie and receivers, #6, #7 & #8 for South Hedland.

However, when taking into account (i) the low level of potential TI Values made with the above "idealised" calculations, (ii) the landscaping and fencing around all residences of interest, and (iii) the intervening areas of elevated mounding between the proposed facility and receivers of interest, it was concluded that there will be NIL residential glare from the proposed facility.

Recommendation: NIL

Industrial Machinery Disability Glare

There are currently no industrial operations in the immediate vicinity of the Project (eg mining operations, quarrying, etc) with the kind of machinery where the relevant operators have the potential to experience reflective glare from the Project, eg elevated cabins in draglines, etc.

Boodarie Strategic Industrial Area (SIA) is located to the west of the site – refer Figure 16. The proposed solar farm falls within the SIA buffer zone. SIA is being managed by the NT's JTSI (Department of Jobs, Tourism, Science and Innovation). No current operations within SIA or currently planned operations (as far as is known) involve elevated (industrial machinery) receivers.

EXECUTIVE SUMMARY

Recommendation: In terms of future Boodarie SIA developments, the orientation of the panels should be aligned as close to North as possible, regardless of the FIXED TILT angles of the panels. Moreover, the present analysis could be revisited to confirm the absence of solar farm glare, IF it understood that such development will involve elevated machinery operators with a clear line of sight to the solar farm.

Finally, it is noted that, any future potential issue associated with solar farm glare in relation to Boodarie SIA, could be straightforwardly addressed by adding a perimeter screen along the western boundary of the proposed solar farm, eg vegetation, fencing, etc, of sufficient height to block westbound reflections from the facility.

Night-Time Illumination Glare

Consideration has been given to the future potential for night-time lighting at the Project site related to equipment and/or buildings, fire access routes and egress, personnel safety, etc.

Recommendation: If 24/7 lighting is required in the future at the site for operational purposes, there should be negligible impact, assuming the lighting design is in accordance with AS 4282-2019 Control of the Obtrusive Effect of Outdoor Lighting. This would also address any potential adverse eco-lighting issues in relation to nocturnal fauna within and surrounding the site.

Recommendation for Detailed Design Stage

When key Project decisions are finalised during detailed design (eg final panel selection, mounting details, etc), the present analysis should be re-visited to confirm the conclusions set out above, IF key assumptions made in the present analysis change significantly.

Finally, as noted above, the present study has assessed the potential impact of a far more extensive project than is likely to be constructed – refer Section 3.5. The final design will be a much-reduced subset of the “maximal theoretical” footprint design modelled herein.

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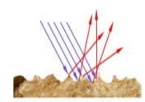
Abbreviations and Definitions

Terms relevant to Daytime Reflective Glare		
PV Panel	Photovoltaic (PV) panels are designed to absorb solar energy and retain as much of the solar spectrum as possible in order to produce electricity.	
Glare	Glare refers to the reflections of the sun off any reflective surface, experienced as a source of excessive brightness relative to the surrounding diffused lighting. Glare covers reflections: . Which can be experienced by both stationary and moving observers (the latter referred to as "glint"). . Which are either specular or diffuse.	
Specular	A reflection which is essentially mirror-like – there is virtually no loss of intensity or angle dispersion between the incoming solar ray and outgoing reflection.	 Specular Reflection
Diffuse	A reflection in which the outgoing reflected rays are dispersed over a wide ("diffuse") range of angle compared to the incoming (parallel) solar rays, typical of "rougher" surfaces.	 Diffuse Reflection
KVP	Key View Points (KVPs) are offsite locations where receivers of interest have the potential to experience adverse reflective glare.	

Terms relevant to Night-Time Illumination	
Luminous intensity	The concentration of luminous flux emitted in a specific direction. Unit: candela (Cd).
Luminance AS 1158.2:2020	This is the physical quantity corresponding to the brightness of a surface (eg a lamp, luminaire or reflecting material such as façade glazing) when viewed from a specified direction. Unit: Cd/m^2
Illuminance AS 1158.2:2020	This is the physical measure of illumination. It is the luminous flux arriving at a surface divided by the area of the illuminated surface – the unit is lux (lx) ... 1 lx = 1 lm/m^2 The term covers both "Horizontal Illuminance" (the value of illuminance on a designated horizontal plane at ground level) and "Vertical Illuminance" (the value of illuminance on a designated vertical plane at a height of 1.5m above ground level).
Glare AS 1158.2:2020	Condition of vision in which there is a discomfort or a reduction in the ability to see, or both, caused by an unsuitable distribution or range of luminance, or to extreme contrast in the field of vision. Glare can include: (a) Disability Glare – glare that impairs the visibility of objects without necessarily causing discomfort. (b) Discomfort Glare – glare that causes discomfort without necessarily impairing the visibility of objects.
Threshold Increment (TI) AS 4282:2019	TI is the measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with a source of glare present. Higher TI values correspond to greater disability glare.

1 INTRODUCTION

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Alinta Energy Development Pty Ltd (Alinta) to carry out a Reflective Glare assessment of the proposed 90 MWac Port Hedland Solar Farm (the "Project").

The Project is located on Unallocated Crown Land near the existing Port Hedland Power Station (PHPS), and will comprise:

- Three 30 MWac blocks configured as a single facility, with approximately 220,000 solar panels on a fixed tilt support system.

The following potential glare conditions have been considered:

- Daytime Reflective glare (and glint) arising from the solar PV panels within the facility
- Night-time Illumination glare from 24/7 operational security lighting within the facility

1.1 Structure of Report

The remainder of this report is structured as follows:

- Section 2 describes the Project and surrounding environment;
- Section 3 describes the input parameters needed to carry out the glare analysis;
- Section 4 presents the analysis and results covering aviation glare;
- Section 5 presents the analysis and results covering road and rail disability glare;
- Section 6 presents the analysis and results covering industrial machinery disability glare;
- Section 7 presents the analysis and results covering residential nuisance glare;
- Section 8 presents the analysis and results covering night-time illumination glare;
- Section 9 presents the conclusions of the study.

2 PROPOSED PORT HEDLAND SOLAR FARM PROJECT

2.1 Site Location

The Project is seeking approval for a 90 MWac photovoltaic (PV) solar plant as shown in Figure 1.

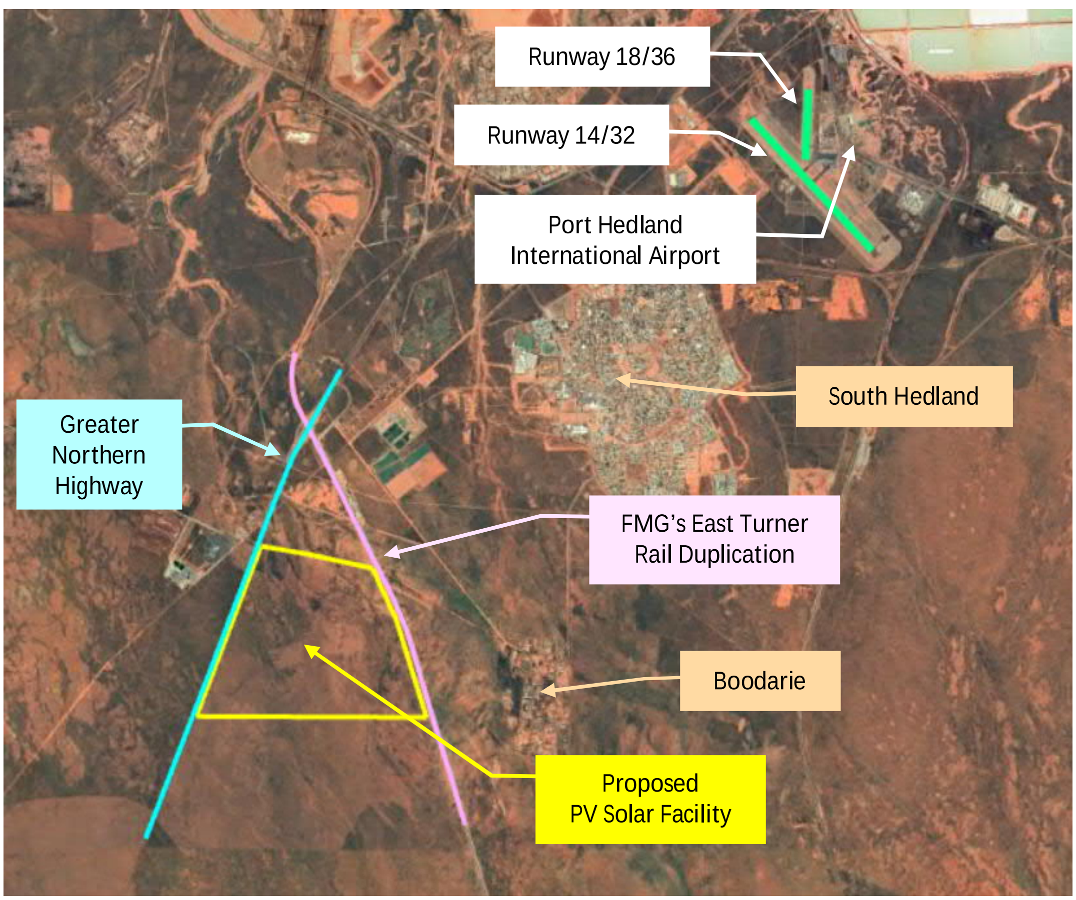
- The Project NE corner is located approximately 8 km from PHIA Runway 14/32.
- The Project lies just over 4 km from the township centre of South Hedland and 1.5 km from the nearest residences at Boodarie to the east.

In terms of the relative heights of the Project and surrounds:

- Ground elevations (ASL) at the Port Hedland Solar Farm range from 16 m to 18 m.
- Ground elevations (ASL) in the surrounds, extending out to Port Hedland airport to the northeast are similar or range down to 12 m.

From the above, it can be seen that the terrain in the vicinity of the Project site in all directions of interest is reasonably flat, with surrounding nearest receivers (aviation, motorists, rail, residences, etc) at similar elevations compared to the solar farm.

Figure 1 Port Hedland Solar Farm - Location Map



2.2 Site Description and Key Project Components

From a Reflective Glare point of view, the key components of the Project are:

- the photovoltaic (PV) modules in relation to their daytime reflective glare potential; and
- the facility's security/emergency lighting design in relation to potential night-time illumination glare issues, if such 24/7 lighting is incorporated into the Project – note: none is currently planned.

Array Footprint: Likely Final Design versus Assessed Array

The land required for the Project has been subject to ongoing constraints identification through various site investigations, eg native vegetation, areas of cultural or heritage significance, etc, which will help define the final array boundary.

The footprint of the Project has been refined as these site investigations have been completed and the assessment of any constraints and their impact, including issues surrounding glare.

Accordingly, this report has modelled a far more extensive "maximal" footprint project than is likely to be constructed. The final design will be a subset of the design modelled herein – refer Section 3.5.

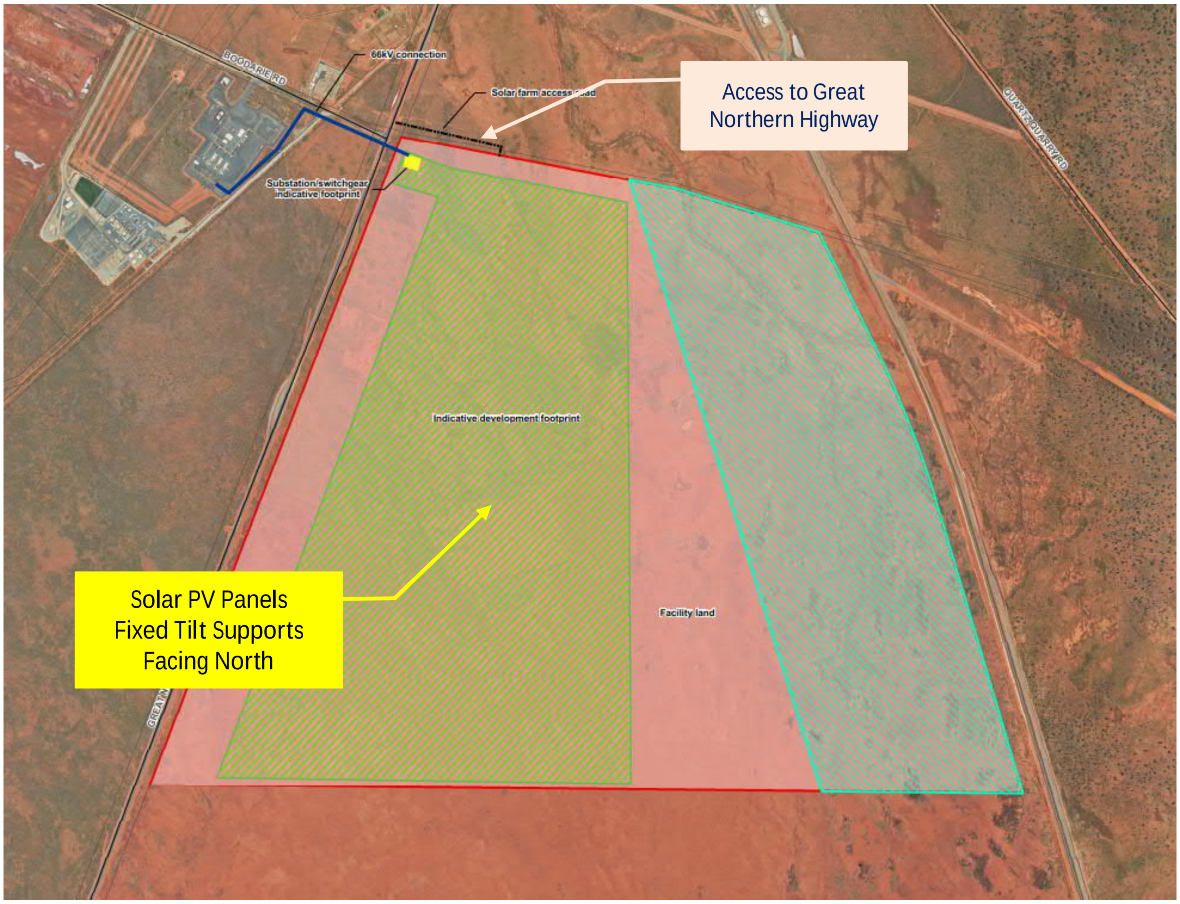
"Maximal Footprint" Solar Panel Mounted Array – refer Figure 2

The maximal footprint array assessed int this study is shown in Figure 2(a) and would consist of fixed mounting supports oriented in an east-west direction, each supporting solar panels tilted northwards (220,000 panels in total);

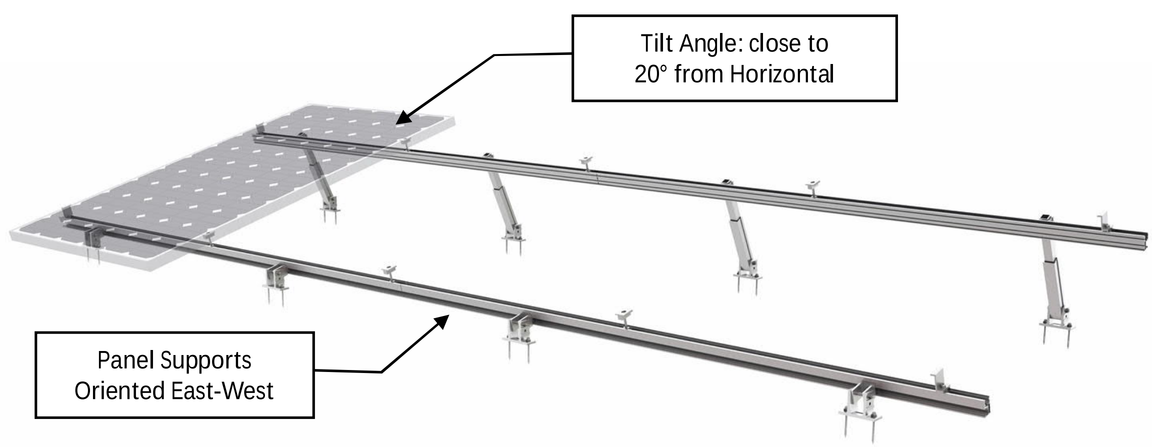
- The panel support system is a FIXED TILT system – currently assumed to be facing north with a likely tilt of close to 20° - refer Figure 2(b);
- The fixed tilt panel support system is oriented east-west;
- Individual panels (2.256 m x 1.133 m) will have a minimum ground clearance of 0.5 m at their fixed tilt position.

Figure 2 Port Hedland Solar Farm Site Layout of "Maximal Footprint" Array

(a) Indicative "Maximal Footprint" Site Layout



(b) Panel Mounting System (10° to 20° Slope to the North)



3 GLARE IMPACT ASSESSMENT - INPUTS

The following potential glare conditions have been considered:

- Daytime Reflective glare (and glint) arising from the solar PV panels
- Night-time Illumination glare if any 24/7 operational security lighting is located within the site

3.1 Project Site Solar Angles – Annual Variations

One of the challenging issues encountered with daytime solar panel glare is the varying nature of the reflections, whose duration will vary with time of day and day of the year as the sun's rays follow variable incoming angles between the two extremes of:

- summer solstice - sunrise incoming rays from just south of east, maximum angle altitude rays at midday, sunset incoming rays from just south of west
- winter solstice - sunrise incoming rays from the northeast, minimum angle altitude rays at midday, sunset incoming rays from the northwest

Any solar glare analysis must take into account the complete cycle of annual reflection variations noted above.

The potential range of incoming solar angles at the Project site relevant to daytime glare is shown in Figure 3 with relevant critical angles summarised in Table 1.

Table 1 Key Annual Solar Angle Characteristics for Project Site

Day of Year	Sunrise	Sunset	Azimuth Range (sunrise-sunset)	Max Altitude
Summer Solstice	5:31 am	6:45 pm	±115.1° East & West of North	86.5°
Equinox	6:12 am	6:13 pm	±90.6° East & West of North	69.9°
Winter Solstice	6:41 am	5:27 pm	±64.9° East & West of North	46.0°

3.2 Project Solar Reflections

The project will use fixed tilt panels (mounted on an east-west axis, ie facing north) as described in Section 2.2.

In "plan" view, reflections from the Project's panels will be directed as shown in Figure 4 for a representative area of panels, with the direction of reflected rays shown for the typical equinox day. For this example, the sunrise and sunset angles of incoming solar rays are due east and due west respectively.

Figure 3 Project Site Incoming Solar Angle Variations

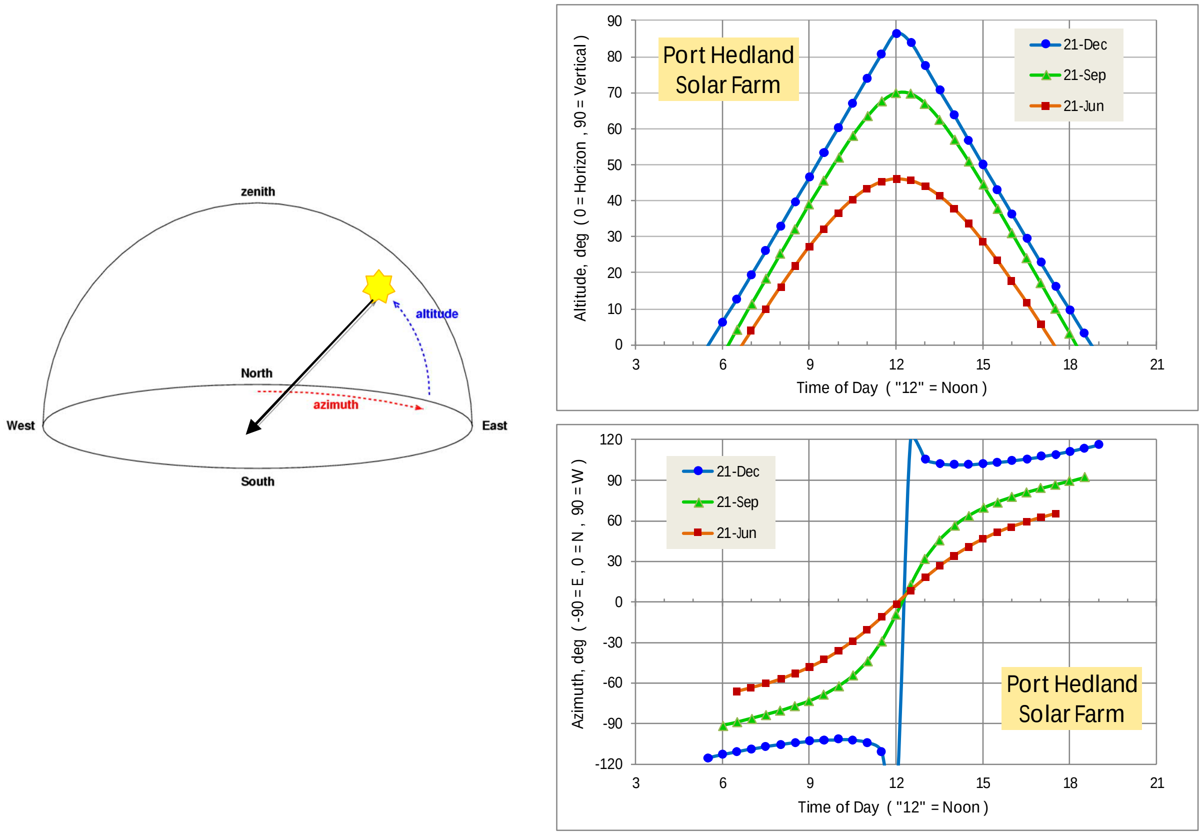
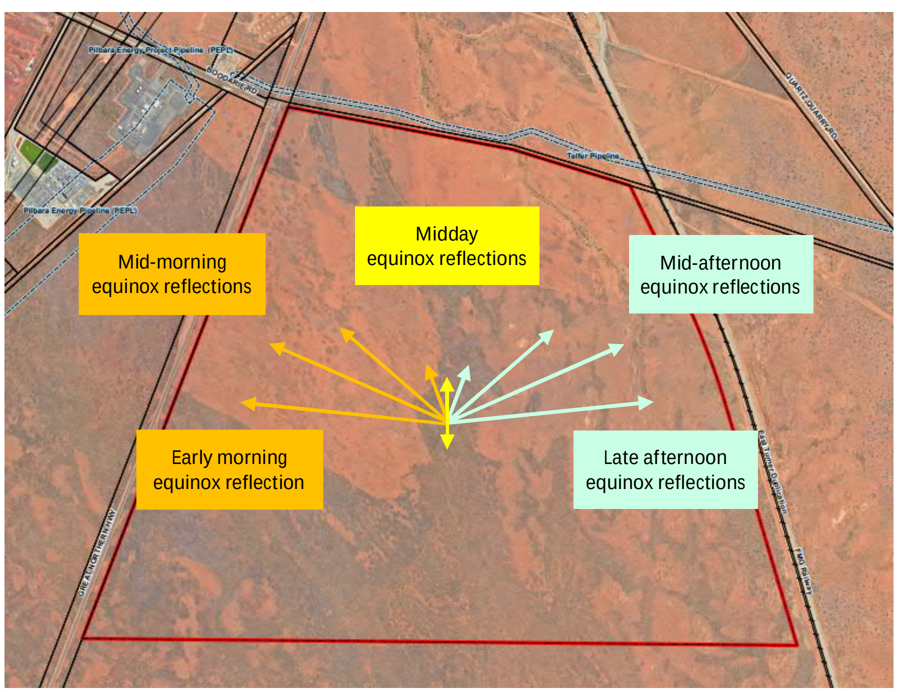


Figure 4 Representative Solar PV Panel Reflection Angles from the Project (around equinox)



3.3 Solar Panel Reflectivity

Solar PV panels are designed to capture (absorb) the maximum possible amount of light within the layers below the front (external) surface. Consequently, solar PV panels are designed to minimise reflections off the surface of each panel. Reflections are a function of:

- the angle at which the light is incident onto the panel (which will vary depending on the specific location, time of day and day of the year), and
- the index of refraction of the front surface of the panel and associated degree of diffuse (non-directional) versus specular (directional or mirror-like) reflection which is a function of surface texture of the front module (reflecting) surface.

Some typical reflectivity values (given in terms of the "n" refractive index value) are:

- Snow (fresh, flaky) n = 1.98
- Standard Window Glass n = 1.52
- Plexiglass, Perspex n = 1.50
- Solar Glass n = 1.33
- Solar Glass with AR Coating n = 1.25

Standard PV Solar Panels (Solar Glass; Solar Glass with AR Coating)

Representative reflectivity curves are shown in Figure 5.

Figure 5 Typical Reflectivity Curves as a Function of Incidence Angle

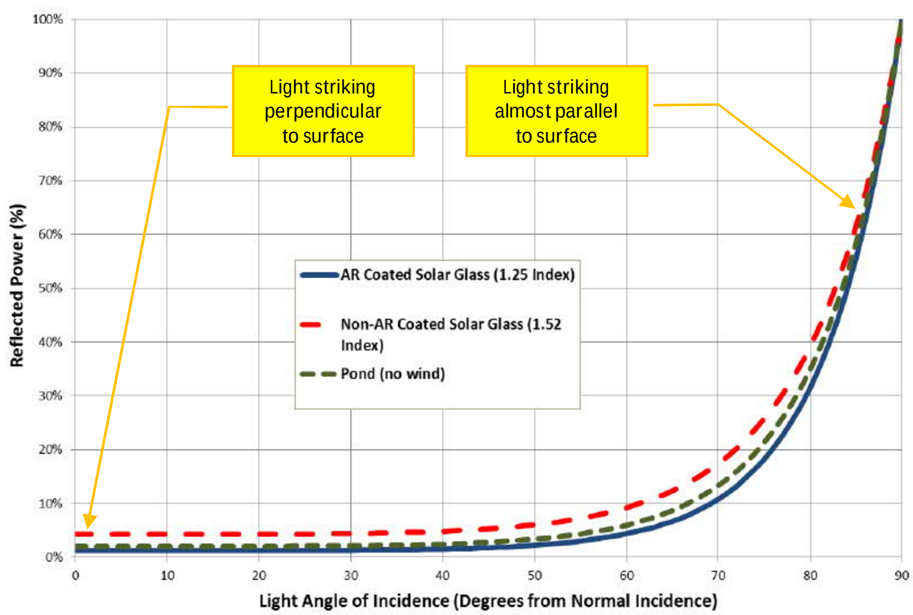


Figure 5 shows that:

- When an oncoming solar ray strikes the surface of a solar PV panel close to perpendicular to the panel surface (ie low "incident" angle), reflectivity is minimal, less than 5% for all solar panel surface types.
- It is only when an incoming solar ray strikes the panel at large "incidence" angles, ie closer to parallel to the panel, that reflectivity values increase. When this happens, reflections become noticeable and potentially at "glare" level for all solar panel surface types.
- However, for very high incidence angle, it would almost always be the case that the observer (motorist, train driver, resident, etc) would perceive reflections coming from virtually the same direction as the incoming solar rays themselves. Such a condition would not constitute a glare situation as the intensity of the incoming solar ray itself would dominate the field of vision perceived by the observer.

3.4 Modelling Real-World Tracking Axis Operational Modes

Commercially available software tools, eg SGHAT for Aviation Glare, are typically capable of modelling solar farm panel positions in one of three modes – as shown in Figure 6.

- Fixed Tilt Mode: in this mode, all panels are assumed to remain at a user-defined fixed angle all day long, eg horizontal, 5°North, 25°North, 10°East, 10°West, etc – refer Figure 6-A;
- Normal Tracking Mode: in this mode, panels move between maximum tilt angles once the sun reaches the relevant altitude angle (eg an altitude angle of 30° for ±60° single-axis trackers). They remain at the maximum tilt angles at all other times, switching over from west to east at midnight – refer Figure 6-B;
- Normal Tracking Mode / Fixed Tilt Stowed: in this mode, panels move during the day in "normal tracking" mode, but can then move (essentially instantaneously) to any user-defined fixed tilt angle at all other times – refer Figure 6-C, where in this case the panels move to a horizontal position (ie 0°) outside of "normal tracking" hours.

Figure 6 SGHAT Panel Mode Simulation Options

3.5 Project Ultimate Footprint

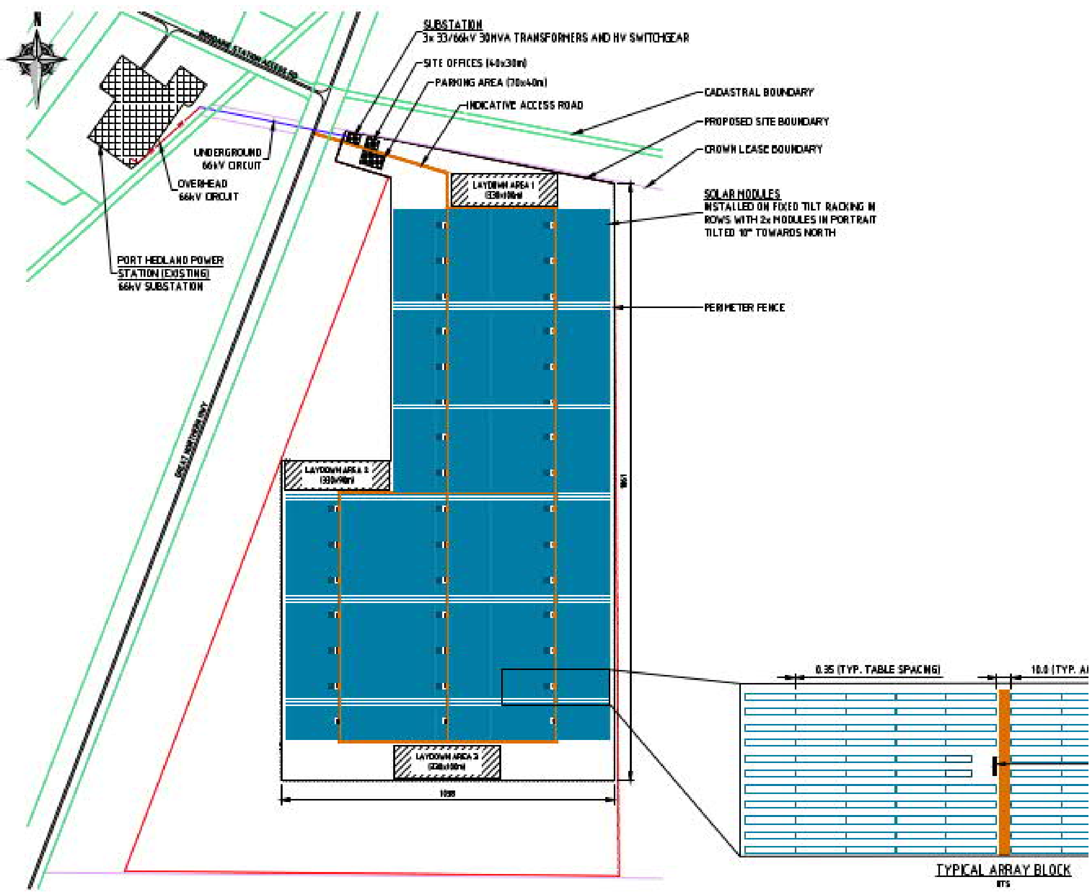
As previously stated, the land required for the Project has been subject to ongoing constraints identification through various site investigations, eg native vegetation, areas of cultural or heritage significance, etc, which will help define the final array boundary.

The footprint of the Project has been refined as these site investigations have been completed and the assessment of any constraints and their impact, including issues surrounding glare.

At the commencement of this study in mid-2021, the overall "maximal" footprint of the Project was as shown in Figure 1 and Figure 2. Accordingly, as a conservative approach, the analysis undertaken in this report adopted this "maximal" footprint.

As of December 2021, the most recent likely Project footprint is shown in Figure 7.

Figure 7 December 2021 Likely Footprint of the Project



Comparison of "Maximal" Footprint Modelled in this Study with Latest December 2021 Design Footprint

A comparison between Figure 2 and Figure 7 shows that the most recent December 2021 design footprint is a substantially-reduced subset of the "maximal" analysis footprint used in this study.

In particular the December 2021 design footprint of the proposed facility has:

- Eliminated almost the entire eastern half of the "maximal footprint" array;
- Eliminated a significant section of the "maximal footprint" array's southern section;
- Stepped back from the Great Western Highway; and
- Stepped back from the site's northern perimeter.

4 GLARE IMPACT – AVIATION GLARE

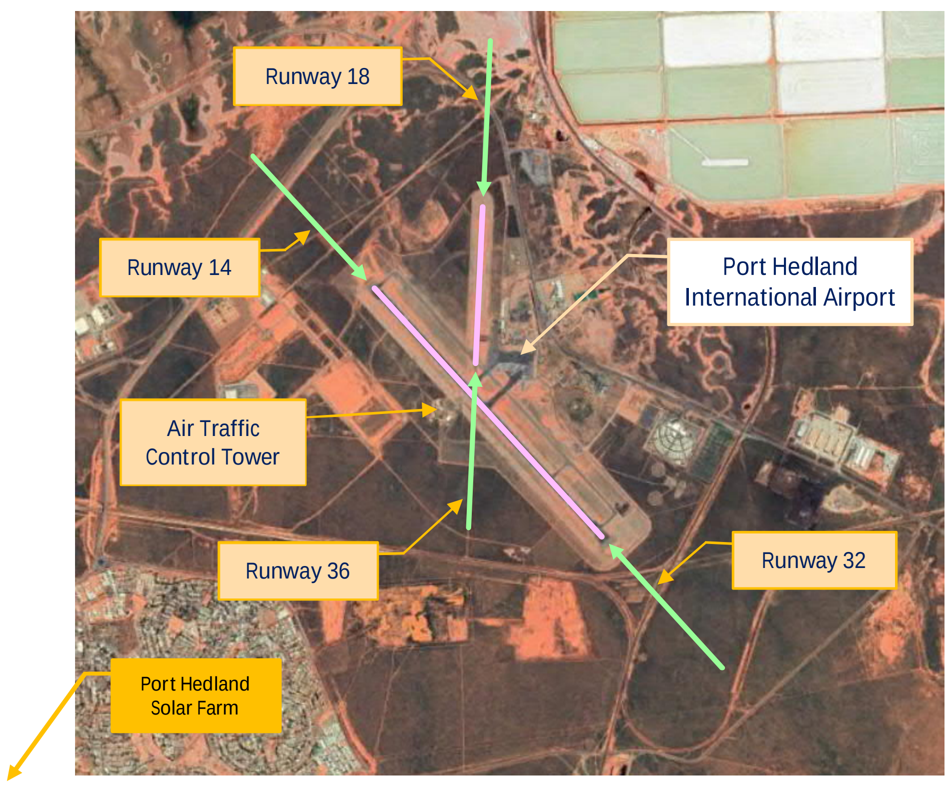
4.1 Nearest Aerodrome(s)

Port Hedland International Airport (IATA: PHE; ICAO: YPPD) is located to the northeast of the Project site. Figure 8 shows (landing) flight paths of interest.

- The aerodrome's main 2,500 m chipseal runway is Runway 14/32, oriented roughly northwest-southeast. The runway lies just over 8.1 km from the nearest Project boundary.
- In relation to aircraft approaching Runway 14 or Runway 32, the Project would be almost perpendicular to the line of sight of pilots during landing.
- The aerodrome's secondary 1,000 m chipseal runway is Runway 18/36, oriented roughly north-south. The runway's southern threshold lies just over 8.3 km from the nearest Project boundary.
- Aircraft approaching Runway 36 would have the Project "behind" their line of sight, whereas aircraft approaching Runway 18 would have the Project in their field of view, albeit with an angle difference of roughly 45° to the direct line of sight of pilots during landing.
- The aerodrome's air traffic control tower is located just to the west of Runway 14/32's midpoint and approximately 7.8 km from the nearest Project boundary.

On the basis of the above, it was concluded that a quantitative analysis should be carried out to assess the potential for aviation glare from the Project.

Figure 8 Nearest Aerodrome(s) to Project Site



4.2 Aviation Sector Reflective Glare – Analysis Tool and Criteria

The impact of solar PV systems on aviation activity is something that solar developers today are addressing more and more often, given the (global) proliferation of solar projects, in particular those located either within or around airport precincts.

US FAA - SGHAT

In relation to the potential impact of solar PV systems on aviation activity, guidance is available from the US FAA which regulates and oversees all aspects of American civil aviation. The FAA issued a Technical Guidance Policy in 2010 and a subsequent (over-riding) Interim Policy in 2013. The Technical Guidance Policy was updated in 2018.

- FAA, "Technical Guidance for Evaluating Selected Solar Technologies on Airports", Federal Aviation Administration, Washington, D.C., November 2010.
- FAA, "Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports", Federal Register, Oct. 23, 2013.
- FAA, "Technical Guidance for Evaluating Selected Solar Technologies on Airports", Federal Aviation Administration, Washington, D.C., Version 1.1, April 2018.

In support of the above, the FAA contracted Sandia Labs to develop their Solar Glare Hazard Analysis Tool (SGHAT) software as the standard tool for measuring the potential ocular impact of any proposed solar facility on a federally obligated airport. SGHAT utilises the Solar Glare Ocular Hazard Plot to determine and assess the potential for glare. SGHAT is described in the following references:

- Ho, C.K., Ghanbari, C.M. and Diver, R.B., "Methodology to Assess Potential Glint and Glare Hazards from Concentrating Solar Power Plants: Analytical Models and Experimental Validation", J. Solar Engineering, August 2011, Vol.133, 031021-1 to 031021-9.
- Ho, C.K. & Sims, C., "Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v2.0", Sandia National Laboratories, Albuquerque, NM. August 2013.

Australia's CASA (Civil Aviation Safety Authority) recommends SGHAT for aviation glare assessments related to solar facilities located near aerodromes.

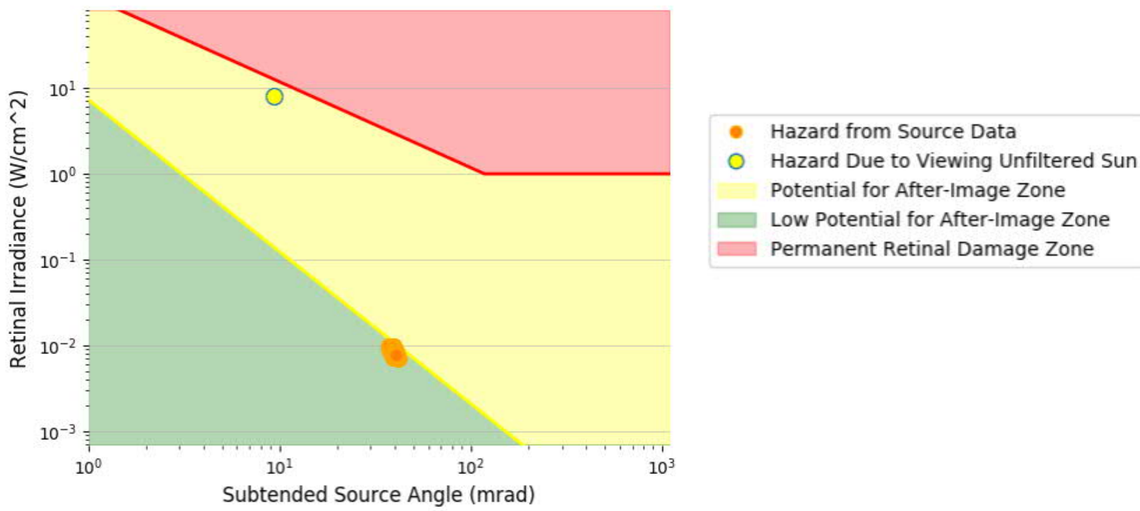
A sample Solar Glare Ocular Hazard Plot is shown in Figure 9.

The analysis contained in this plot is derived from solar simulations that extend over the ENTIRE CALENDAR YEAR in 1-MINUTE intervals, sunrise to sunset.

The SGHAT criteria state that a proposed solar facility should satisfy the following:

- Airport Traffic Control Tower (ATCT) cab: NO Glare
- Final approach paths for landing aircraft: Glare to NOT exceed "Low Potential for After-Image"
- SGHAT assessments should take into account planned (ie future) ATCTs and runways in glare studies.

Figure 9 Example Solar Glare Ocular Hazard Plot (SGHAT Software Output)



In Figure 9, the following is noted:

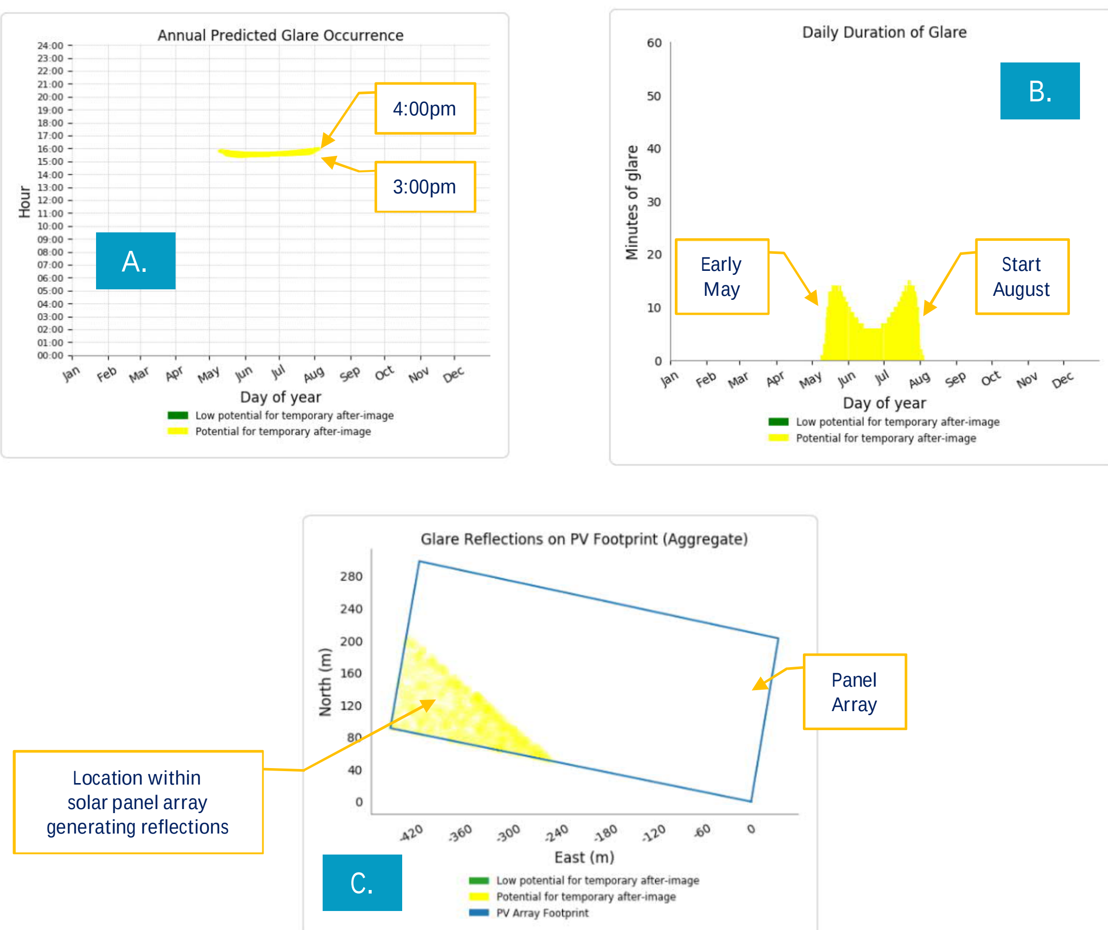
- SGHAT ocular impact is a function of both the "retinal irradiance" (ie the light seen by the eye) and "subtended source angle" (ie how wide an arc of view the light appears to be arriving from).
- SGHAT ocular impact falls into three categories:
  . GREEN: low potential to cause "after-image"
  . YELLOW: potential to cause temporary "after-image"
  . RED: potential to cause retinal burn (permanent eye damage)
- "After Image" is the term applied to a common retinal phenomenon that most people have experienced at some point or other, such as the effect that occurs when a photo with flash is taken in front of a person who then sees spots in front of their eyes for a few seconds. A more extreme example of "after-image" occurs when staring at the sun. "After-image" (also known as "photo bleaching") occurs because of the de-activation of the cells at the back of the eye's retina when subjected to a very bright light.
- The SGHAT plot provides an indication of the relative intensity of both the incoming reflection and the sources of light itself (ie the sun).
  . The occurrence of glare is shown in the plot as a series of orange circles, one circle for each minute that a reflection is visible.
  . A reference point is also shown in each SGHAT plot, the yellow circle with the green outline, representing the hazard level of viewing the sun without filtering, ie staring at the sun.
- In Figure 9, it can be seen that the reflection visible by the receiver is roughly 1,000 times less intense than the light from the sun.
- Finally, in relation to PV Solar facilities, it is important to note that the third SGHAT Ocular Plot "RED" category is not possible, since PV modules DO NOT FOCUS reflected sunlight.

Additional Information Available with the SGHAT Analysis Tool

In addition to the above "assessment" output, the SGHAT software package also produces information which reveals the extent of visibility of reflections at any chosen receiver position, regardless of whether the reflections constitute a glare condition or not – an example is shown in Figure 10.

- Figure 10-A: shows the am/pm time periods when reflections occur at a specific position throughout the year, in this case typically between around 3:30 pm and 4:00 pm.
- Figure 10-B: shows the months during the year and the minutes per day when reflections occur at a specific position, in this case from early-May to the start of August, for periods ranging up to 13 minutes per day.
- As noted above, this information is made possible because the SGHAT analysis covers the entire solar annual cycle in 1-minute intervals to ascertain any potential impacts on surrounding receivers.
- Finally, Figure 10-C shows WHERE within the solar farm panel array the reflection rays of interest are emanating from, in this case from panels near the southwest corner.

Figure 10 Example Solar Glare Output Plots (SGHAT Software Output)



4.3 SGHAT Analysis

On the basis of the proximity of Port Hedland Airport to the Project, a quantitative analysis was carried out using the SGHAT software tool to examine the potential for adverse glare (and glint) from the Project.

- Aircraft flight paths examined are landing scenarios (worst-case with the pilot looking downwards) – these are shown in Figure 8.

SGHAT Modelling Assumptions:

- All runway approaches shown in Figure 8 were examined.
- Landing flight paths are aligned with their respective runways.
- All aircraft landing flight paths are 2 miles in length, on a 3° glide angle (standard SGHAT protocol).
- Aircraft are assumed to be at a height of 5 m above ground elevation as they pass over the respective runway threshold.
- SGHAT was also used to analyse potential impacts on the aerodrome's Air Traffic Control Tower.
- The SGHAT analysis examines ALL possible solar angles throughout the year – in 1-minute intervals.
- The reflectivity of the PV panels was assumed to be the same as that shown in the standard solar glass shown in Figure 5.

A number of panel scenarios were assessed:

- "Fixed Tilt NORTH": panels tilted upwards 5°, 10°, 15°, 20° and 25°
  – panels support system running east-west
  – panels therefore "face north"
- "15° Fixed Tilt 10° Bias": panels tilted upwards 15°
  – panels support system rotated clockwise 10°
  – panels therefore face slightly east of north
- "15° Fixed Tilt 350° Bias": panels tilted upwards 15°
  – panels support system rotated anti-clockwise 10°
  – panels therefore face slightly west of north

4.4 SGHAT Results

The SGHAT Ocular Plot results for all scenarios and all flight paths shown in Figure 8 are presented in Table 2, along with the results for the Air Traffic Control Tower (ATCT). The results are presented in term of the total number of minutes in a year that solar panel reflections would be potentially visible within any relevant SGHAT "zone" (refer Figure 9).

It will be recalled that solar panel reflections (glint and glare) are acceptable according to the FAA-SGHAT protocol if there are no "Yellow" zone or "Red" zone results for aircraft flight landing paths and no "Green" zone, "Yellow" zone or "Red" zone results for the ATCT.

Table 2 SGHAT Analysis Results – FIXED TILT Scenarios

Panel Support Mode	SGHAT Results (minutes that reflections are in each zone per year)									
	Runway 14		Runway 32		Runway 18		Runway 36		ATCT	
	"Green" Zone	"Yellow" Zone	"Green" Zone	"Yellow" Zone	"Green" Zone	"Yellow" Zone	"Green" Zone	"Yellow" Zone	"Green" Zone	"Yellow" Zone
5° / North	0	0	0	0	0	0	0	0	0	0
10° / North	0	0	0	0	0	0	0	0	0	0
15° / 10°	0	0	0	0	0	0	0	0	0	0
15° / North	0	0	0	0	0	0	0	0	0	0
15° / 350°	0	0	0	0	0	0	0	0	0	0
20° / North	0	0	0	0	0	0	0	0	0	0
25° / North	0	0	0	0	0	0	0	0	0	0

Table 2 shows that:

- The proposed solar farm will comply with SGHAT requirements for ANY Fixed Tilt panel mode involving an upward tilt ranging from 5° to 25° with the panels "facing" due north.
- The proposed solar farm will also comply with SGHAT requirements for a Fixed Tilt panel mode of around 15° if the orientation of the panels (ie the perpendicular "pointing" axis of the panels) is allowed to vary from due north by ±10°.

The primary reasons for the above results are:

- The distance of the proposed solar farm from Port Hedland International Airport; and
- The difference in line of sight of pilots on final approach for the airport's runways.

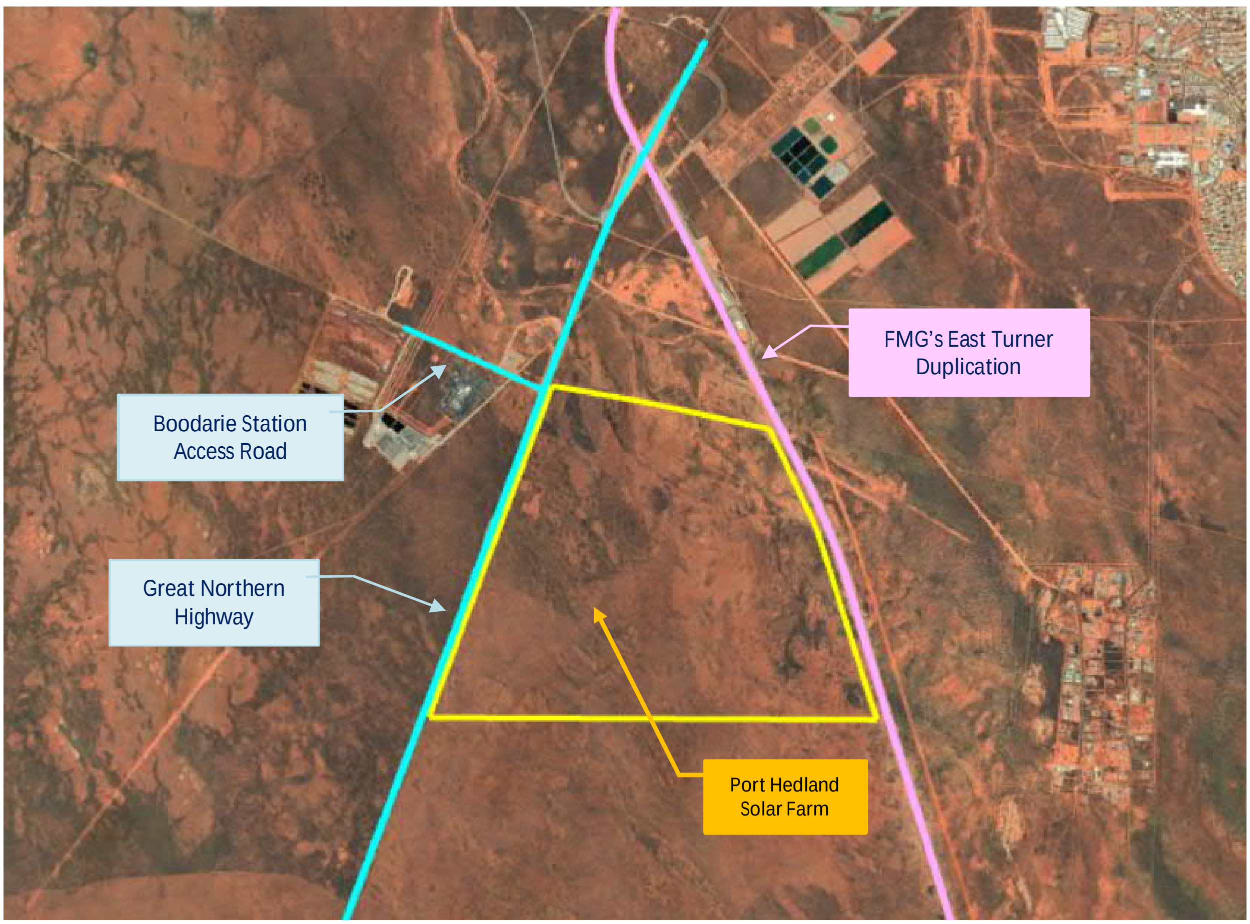
5 GLARE IMPACT – ROAD AND RAIL DISABILITY GLARE

5.1 Surrounding Road and Rail Network

The "major" and "minor" road thoroughfares in the immediate vicinity of the Project as well as nearby rail lines are shown in Figure 11:

- Great Northern Highway – northbound and southbound "major"
- Boodarie Station Access Road – eastbound and westbound "minor"
- FMG's East Turner Duplication – northbound and southbound

Figure 11 Surrounding Road and Rail Network



5.2 Motorist and Rail Operator “Disability” Glare – Analysis Tool and Criteria

The criteria commonly used by Australian Local Government Authorities to assess the acceptability or otherwise of potential adverse reflections from glazed façade systems onto surrounding roadways and pedestrian crossings utilise the so-called Threshold Increment (TI) Value of the reflection condition.

TI Value Definition

AS/NZS 4282:2019 and CIE 140-2019 define the Threshold Increment (TI) as:

> "the measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with a source of glare present. Note: Higher values of TI correspond to greater disability glare."

The TI Value is calculated as the ratio of “veiling” luminance (eg from a reflection) to the overall average background (“adaptation”) luminance, with the necessary constant and exponent parameters shown below …

$$TI\,\% = 65\frac{L_v}{{L_{ad}}^{0.8}} \qquad 0.05 < L_{ad} < 5.0$$

$$TI\,\% = 95\frac{L_v}{{L_{ad}}^{1.05}} \qquad L_{ad} > 5.0$$

where:

- L_v = veiling luminance from a source of interest (eg reflection) – Cd/m^2
- L_{ad} = so-called “adaptation” luminance (total background) – Cd/m^2
- The motorist eye height is taken to be 1.5 m above the road surface; their line of sight is taken to be 1° down relative to the plane of the road surface and the windshield (windscreen) cut-off angle can be assumed to be 20° above the horizontal.

TI Value Acceptability Criteria

The acceptability criteria adopted by Australian Local Government Authorities to assess the acceptability or otherwise of potential adverse reflections on roadways and pedestrian crossings utilise the above TI Value of the reflection condition (refer above for calculation equations).

For (Motorist) Traffic Disability Glare, the TI Value should remain:

- Below 10% for major roads
- Below 20% for minor roads

For Pedestrian Discomfort Glare, the TI Value should remain:

- Below 2% at critical locations such as pedestrian crossings
- Below 3% for other locations

Note: for the present study, Pedestrian Discomfort Glare provides a useful benchmarking tool for the assessment of potential nuisance glare at surrounding residential receivers.

Almost all Australian Rail Authorities have guidelines covering glare in general (ie not specific to solar PV panel glare) aimed at avoiding discomfort/distraction to train operators and obscuring train signals. Most guidelines refer either to Table 2.10 of AS 1158.3.1 for the TI Value criterion and/or Table 3.2 of AS 1158.4 for the Cd (Candela) criterion associated with the control of glare.

For Rail Traffic Disability Glare, the relevant criteria are:

- The TI Value should remain below 20% (this is the same as per "minor" roads)
- The Cd Value at 70° incidence should remain below 6,000.

5.3 TI Value Analysis and Results

Important factors influencing the potential for road and rail disability glare include:

- Any difference in elevation between the motorist or rail operator and the solar panel array;
- The potential for solar reflections of concern to be obstructed by intervening terrain and topography as well as dense vegetation; and
- The difference between the line of sight of a driver (ie in the direction of the road or rail line) and the line of sight relative to incoming reflections. Significant TI values can only occur when this difference is modest. In some cases, eg when traffic is moving away from the line of incoming reflections, such reflections become essentially invisible – this would apply for example to traffic on Boodarie Station Access Road travelling westwards after turning off the Great Northern Highway.

SLR has undertaken TI Value calculations for the roadways and rail lines shown in Figure 11. Calculation locations were varied along the relevant carriageways, focussing on positions where the difference between the line of sight of drivers and the angle of potential incoming solar reflected rays was at a minimum.

TI Value Results

Table 3 shows the results of the TI Value calculations for all panel support scenarios.

- Great Northern Highway: Reflections will be visible for a few minutes in May and August (two weeks each month) very early in the morning just for the 5° tilt north facing mode, with TI Values just reaching the recommended criteria. This occurs for section of the highway very close to the proposed solar farm, ie well to the south of the intersection of the highway and FMG's East Turner Duplication. TI Values are NIL for all other fixed tilt modes.
- Boodarie Station Access Road: Reflections will NOT be visible for WESTbound traffic for ANY FIXED TILT panel scenario. Reflections may be "visible" but below the relevant limiting TI Value for EASTbound traffic with TI Values increasing with an increase in panel tilt position. The highest TI Values were registered when the northerly orientation of the panels was allowed to shift westwards by 10° (the Fixed Tilt 15° / Orientation 350° scenario).
- FMG East Turner Duplication: Reflections will be visible for a few minutes in April and August (three weeks each month) very late in the afternoon for the 5° tilt north facing mode and for the 15° tilt mode which has a 10° east orientation bias. On these occasions, TI Values will be within the recommended criteria. TI Values are nil for all other fixed tilt modes.

Table 3 TI Value Results –Results for All Panel Support Scenarios

Carriageway Direction	TILT Scenario	TI Value	Occurrence		
			Months	Hour of Day	Ave Min / Day
Great Northern Highway	5° / North	TI ~ 10	May & Aug	~6:30am	2 min
	10° / North	nil	na	na	na
	15° / 10°	nil	na	na	na
	15° / North	nil	na	na	na
	15° / 350°	nil	na	na	na
	20° / North	nil	na	na	na
	25° / North	nil	na	na	na
Boodarie Station Access Road	5° / North	TI ~ 7	Oct-Feb	5:30-6:00am	3 min
	10° / North	TI ~ 9	Oct-Feb	5:45-6:15am	6 min
	15° / 10°	TI ~ 5	Sep-Feb	6:15-6:30am	5 min
	15° / North	TI ~ 11	Sep-Feb	6:00-6:30am	10 min
	15° / 350°	TI ~ 17	Sep-Mar	6:15-6:45am	12 min
	20° / North	TI ~ 13	Sep-Mar	6:15-6:45am	12 min
	25° / North	TI ~ 15	Sep-Mar	6:30-7:00am	15 min
FMG East Turner Duplication	5° / North	TI ~ 11	Apr & Aug	~6:00pm	3 min
	10° / North	nil	na	na	na
	15° / 10°	TI ~ 11	Apr & Aug	6:00pm	3 min
	15° / North	nil	na	na	na
	15° / 350°	nil	na	na	na
	20° / North	nil	na	na	na
	25° / North	nil	na	na	na

Recommendations:

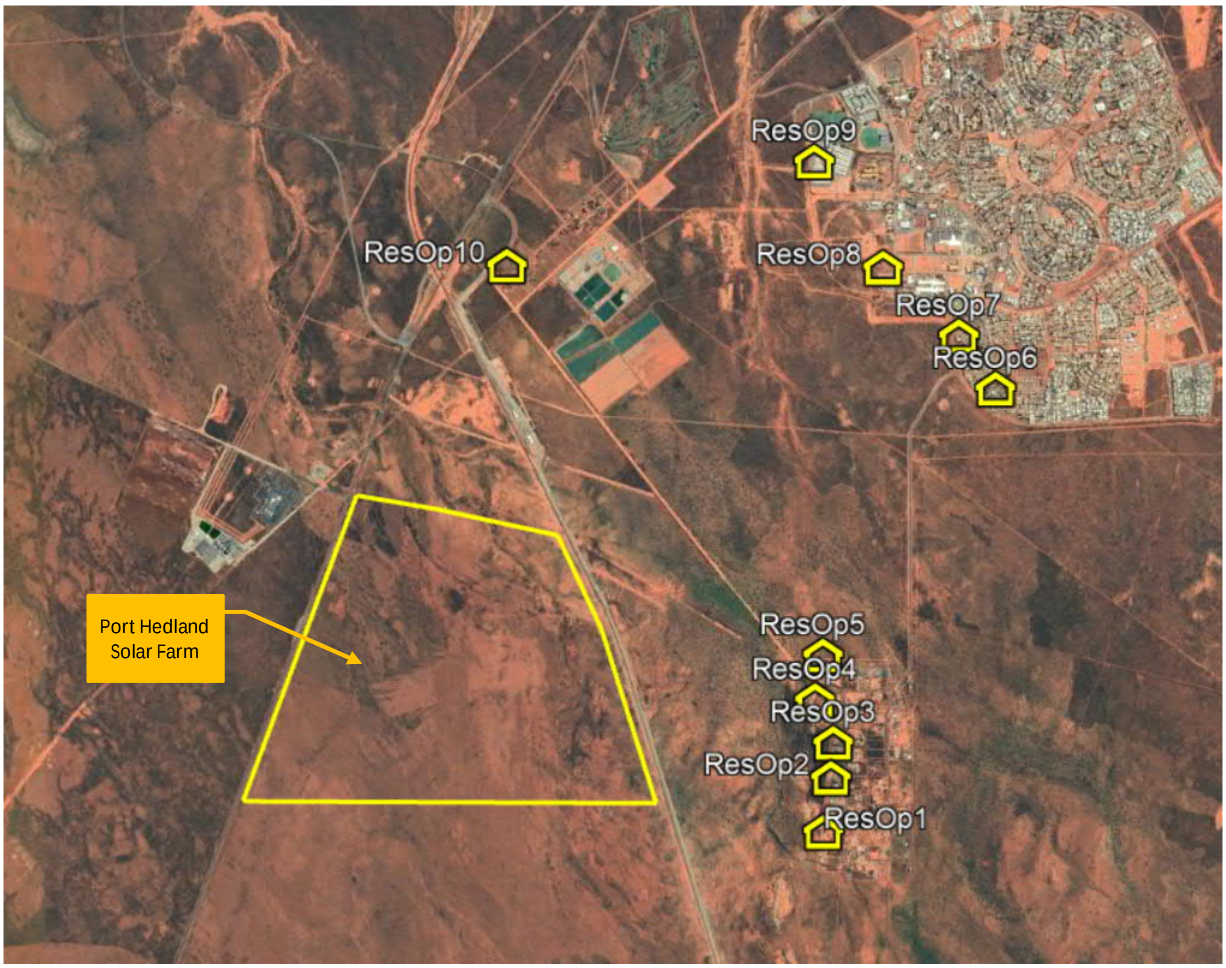
- The proposed solar farm will comply with the recommended TI Value criteria for both road and rail under any Fixed Tilt panel mode with an upwards tilt of at least 10°.
- For a typical FIXED TILT position (say in the range 15°-20°), allowing the array to have a slight eastwards orientation (eg facing 10° east) increases the potential visibility of reflections to the adjacent FMG East Turner Rail Line. Allowing the array to have a slight westwards orientation (eg facing 350° west) increases the potential visibility of reflections to Boodarie Station Access Road traffic. It is recommended therefore that the orientation of the panels be aligned as close to North as possible, regardless of the FIXED TILT angles of the panels.

6 GLARE IMPACT – RESIDENTIAL NUISANCE GLARE

6.1 Surrounding Representative Residences

Figure 12 shows a group of nearest representative residential receivers surrounding the Project site. 10 such receivers were selected, mostly running along the western perimeter of Boodarie and southwestern perimeter of South Hedland. They are located to the east and northeast of the Project site.

Figure 12 Nearest Representative Residential Receivers



6.2 Residential "Nuisance" Glare – Analysis Tool and Criteria

Instances of documented nuisance glare associated with solar PV panels (grid-scale, industrial or residential) and nearby residential receivers have been relatively infrequent globally, especially given the widespread and rapid increase in the take-up of residential solar panels in Australia and elsewhere.

> There are currently no national or state guidelines in Australia governing the acceptability or otherwise of residential nuisance glare specific to solar PV.

Existing guidance that exists in relation to solar panels from state governments typically covers installation audits and compliance checks. Additional guidance in relation to compliance with Australia Standards is provided by:

Clean Energy Council
Website: https://www.cleanenergycouncil.org.au/industry/products/modules

Accordingly, to assist in addressing residential nuisance glare, reference has been made of the concepts used for glare acceptability criteria outlined in the preceding sections, in particular the TI Value Pedestrian Discomfort Glare criteria as indicators of potential nuisance glare.

6.3 TI Value Analysis and Results

TI Value calculations were made for the representative receivers shown in Figure 12.

- The calculations were based on a receiver looking directly towards the facility.
- The calculations conservatively assumed NO intervening "blocking" topography (eg from small, elevated earth mounding) and NO vegetation or any other physical barriers, such as perimeter fencing, etc.

Table 4 shows the results of these "idealised" TI Value calculations for all panel support scenarios.

Table 4 TI Value Results –Results for ALL Panel Scenarios

Residence	TILT Scenario	TI Value	Occurrence		
			Months	Hour of Day	Ave Min / Day
Res-1, 2, 9 & 10	All scenarios	nil	na	na	na
Res-3, 4 & 5	5° / North	TI ~ 3	Feb & Oct	~6:30pm	1 min
	10° / North	TI ~ 3	Feb & Oct	~6:30pm	3 min
	15° / 10°	TI ~ 3	Feb/Mar & Sep/Oct	5:45-6:15pm	5 min
	15° / North	TI ~ 3	Feb & Oct	~6:15pm	5 min
	15° / 350°	nil	Feb & Oct	na	na
	20° / North	TI ~ 3	Feb & Oct	~6:15pm	6 min
	25° / North	TI ~ 3	Feb/Mar & Oct	~6:15pm	7 min
Res-6, 7 & 8	5° / North	TI ~ 3	Oct-Mar	~6:30pm	6 min
	10° / North	TI ~ 3	Oct-Mar	~6:30pm	6 min
	15° / 10°	TI ~ 3	Oct-Mar	~6:15pm	6 min
	15° / North	TI ~ 2	Oct-Mar	~6:15pm	6 min
	15° / 350°	TI ~1	Oct-Mar	~5:45pm	6 min
	20° / North	TI ~ 2	Oct-Mar	~6:00pm	6 min
	25° / North	TI ~ 2	Oct-Mar	~6:00pm	6 min

Observations

Table 4 indicates the following under the "idealised" TI Value calculations :

- There is potential for the visibility of reflections from the facility at some surrounding receivers – the northern Boodarie receivers #3, #4 & #5, and southern South Hedland receivers, #6, #7 & #8.
- The visibility of the solar farm reflections increases if the panel orientation is rotated slightly eastwards.

Actual Site Conditions

Figure 13 shows a typical Boodarie residential receiver, 171 Greenfield Street, on the west perimeter of Boodarie. The normal perimeter fencing and extensive vegetation around the property is evident. This is typical of northern Boodarie receivers #3, #4 & #5.

Figure 13 Representative Boodarie Residential Receivers

Figure 14 shows a typical South Hedland residential receiver, along Collier Drive, at the closest point to the proposed solar farm. Standard perimeter fencing and vegetation around the properties are evident. This is typical of South Hedland receivers #6, #7 & #8.

Figure 14 Representative South Hedland Receivers

There also appear to be numerous areas of slightly elevated terrain in between the residences of Boodarie and South Hedland and the proposed solar farm, in the form of low mounds which rise to an elevation ASL of around 21 m to 22 m.

Figure 15 shows two representative elevation profiles taken from the proposed solar farm to the residences of interest in Boodarie and South Hedland.

- In both cases, there are small mounds in between the solar farm and the residences which would effectively block incoming reflections from reaching the residences.

Figure 15 is a representative photo taken from the western edge of Boodarie, clearly showing the mounding present between Boodarie and the solar farm, evident in the above-mentioned elevation profiles.

Summary:

When taking into account …

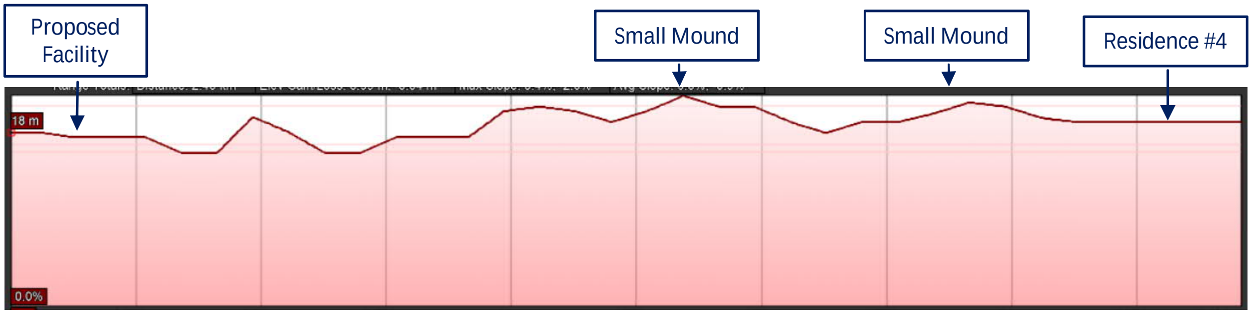
- The low level of the potential "idealised" TI Values shown in Table 4;
- The landscaping and fencing around all residences of interest – refer Figure 13 and Figure 14; and
- The intervening areas of mounding shown in Figure 15 …

… it is concluded that there will be NIL residential glare from the proposed facility.

Finally, it is noted that the vegetation around South-West Creek will be retained, providing an additional "blocking" barrier to any potential reflections for surrounding residential receptors.

Figure 15 Representative Elevation Profiles Between Proposed Facility and Some Nearest Residences

Elevation Profile A: Proposed Facility to Residence #4



Elevation Profile B: Proposed Facility to Residence #7

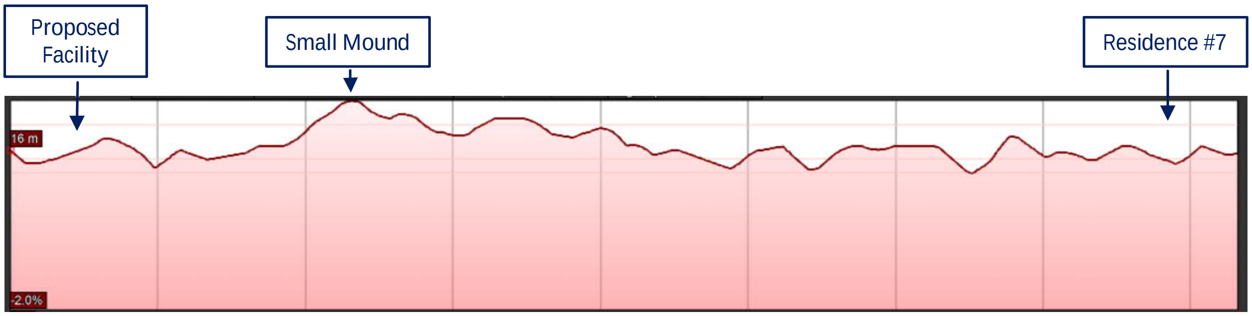


Photo Taken from Western Edge of Boodarie Residential Area

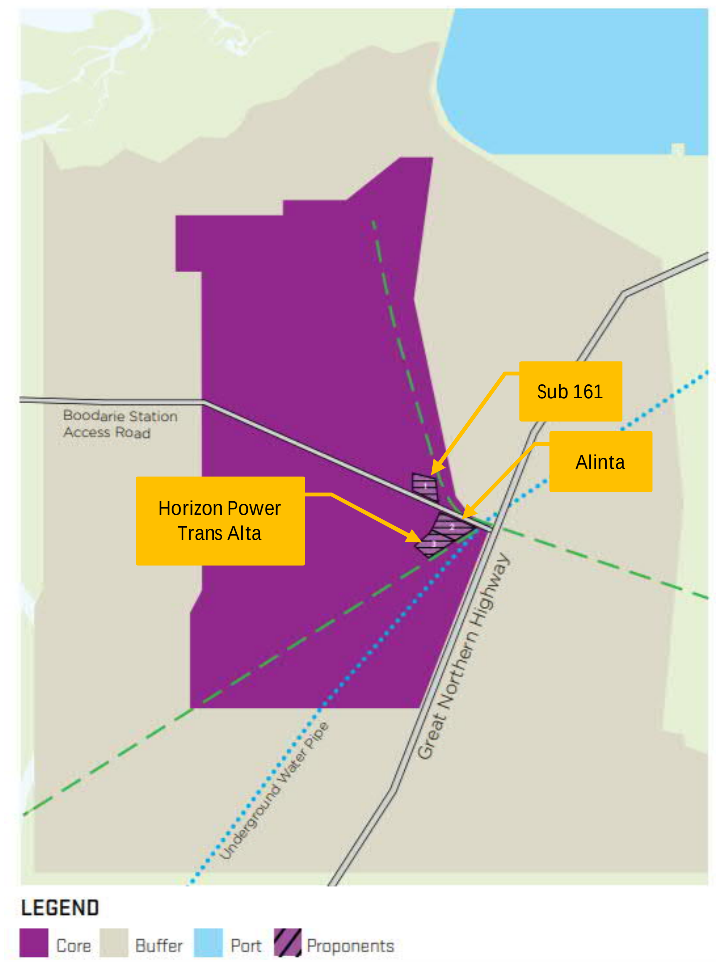
7 GLARE IMPACT – INDUSTRIAL MACHINERY DISABILITY GLARE

7.1 Surrounding Industrial Operations

There are currently no industrial operations in the immediate vicinity of the Project (eg mining operations, quarrying, etc) with the kind of machinery where the relevant operators have the potential to experience reflective glare from the Project, eg elevated cabins in draglines, etc.

Boodarie Strategic Industrial Area (SIA) is located to the west of the site – refer Figure 16. The proposed solar farm falls within the SIA buffer zone. SIA is being managed by the NT's JTSI (Department of Jobs, Tourism, Science and Innovation). No current operations within SIA or currently planned operations (as far as is known) involve elevated (industrial machinery) receivers.

Figure 16 Boodarie Strategic Industrial Area Site Plan



SLR

7.2 Industrial Machinery Operator Disability Glare – Analysis Tool and Criteria

There are currently no Australian guidelines (national or state) governing the acceptability or otherwise of reflective glare for industrial site critical operations. Instead, the concepts used for acceptability criteria in the preceding sections, in particular Road and Rail Disability Glare, can assist when dealing with this issue.

The issue most commonly arises in relation to mining operations where machinery operators can be located in elevated locations, eg dragline operations, where a line of sight may be possible to a solar facility located in close proximity. Ports with their observation towers are another potential source of elevated receivers of interest if located adjacent to a solar facility.

7.3 Industrial Machinery Operator Disability Glare – Analysis and Results

In relation to current industrial operations surrounding the Project, there will be nil glare for this category.

In relation to Boodarie SIA:

- The results of the Road and Rail Disability Glare TI Value analysis suggests that there may be potential for reflections to be visible for a theoretical observer in an elevated position looking towards the proposed solar farm located within this SIA.
- Again, on the basis of the Road and Rail Disability Glare TI Value analysis, especially the results for west-moving traffic along Boodarie Station Access Road, it appears extremely unlikely any such reflections would generate high enough TI Values that would be classed as “glare”.
- Such likelihood would increase if panels within the proposed solar farm had a Fixed Tilt panel mode with a slight westwards orientation.

Recommendations

Based on the above, the following is recommended:

- The orientation of the panels should be aligned as close to North as possible, regardless of the FIXED TILT angles of the panels.
- In relation to any future Boodarie SIA developments, the present analysis could be revisited to confirm the absence of solar farm glare IF it understood that such development will involve elevated machinery operators with a clear line of sight to the solar farm.

Finally, we note that, any future potential issue associated with solar farm glare, in relation to Boodarie SIA, could be straightforwardly addressed by adding a perimeter screen along the western boundary of the proposed solar farm, eg vegetation, fencing, etc, of sufficient height to block westbound reflections from the facility.

Moreover, as previously mentioned, the above comments are made on the basis of the potential impacts of the “maximal footprint” array assessed in this study. He actual impacts of the final design (refer Figure 7) will be significantly reduced, further diminishing the potential for glare impacts within the Boodarie SIA.

8 NIGHT-TIME ILLUMINATION GLARE

8.1 Night-Time Illumination Glare – Criteria

The effect of light spill from outdoor lighting impacting on residents, transport users, transport signalling systems and astronomical observations is governed by AS 4282-2019. The adverse effects of light spill from outdoor lighting are influenced by a number of factors:

- The topology of the area. Light spill is more likely to be perceived as obtrusive if the lighting installation is located higher up than the observer. Lighting installations are usually directed towards the ground and an observer could hence have a direct view of the luminaire.
- The surrounding area. Hills, trees, buildings, fences and general vegetation have a positive effect by shielding the observer from the light installation.
- Pre-existing lighting in the area. Light from a particular light source is seen as less obtrusive if it is located in an area where the lighting levels are already high, eg in cities. The same lighting installation would be seen as far more bothersome in a less well-lit residential area.
- The zoning of the area. A residential area is seen as more sensitive compared to commercial areas where high lighting levels are seen as more acceptable.

Typical illuminance levels for a variety of circumstances are given in Table 5 for comparison.

Table 5 Typical Illuminance Levels for Various Scenarios

Lighting Scenario	Horizontal Illuminance (lux)
Moonless overcast night	0.0001
Quarter Moon	0.01
Full Moon	0.1
Twilight	10
Indoor office	300
Overcast day	1,000
Indirect sunlight clear day	10,000-20,000
Direct sunlight	100,000-130,000

Recommended criteria of light technical parameters for the control of obtrusive lighting are given in Table 6. The vertical illuminance limits for curfew hours apply in the plane of the windows of habitable rooms or dwellings on nearby residential properties. The vertical illuminance criteria for pre-curfew hours apply at the boundary of nearby residential properties in a vertical plane parallel to the boundary.

Values given are for the direct component of illuminance, ie no reflected light is taken into account.

- Limits for luminous intensity for curfew hours apply in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained.
- Limits for luminous intensity for pre-curfew hours apply to each luminaire in the principal plane, for all angles at and above the control direction.

Table 6 Recommended Maximum Values of Light Technical Parameters (AS4282-2019)

Light Technical Parameter	Time of Operation	Zone "A4"	Zone "A3"	Zone "A2"	Zone "A1"	Zone "A0"
Illuminance in vertical plane (E_v)	Pre-curfew hours	25 lx	10 lx	5 lx	2 lx	ALARP [1]
	Curfew hours	5 lx	2 lx	1 lx	0.1 lx	1 lx
Luminous Intensity emitted by luminaires (I)	Pre-curfew hours	25,000 Cd	12,500 Cd	7,500 Cd	2,500 Cd	ALARP [1]
	Curfew hours	2,500 Cd	2,500 Cd	1,000 Cd	500 Cd	0 Cd

Zone A4 "High District Brightness", eg town and city centres and other commercial areas; residential areas abutting commercial areas

Zone A3 "Medium District Brightness", eg suburban areas in towns and cities

Zone A2 "Low District Brightness", eg sparsely inhabited rural and semi-rural areas

Zone A1 "Dark", eg relatively uninhabited rural areas; no road lighting, unless specifically required by the relevant road controlling authority

Zone A0 "Intrinsicall6y Dark", eg UNESCO Starlight Reserve; IDA Dark Sky Parks; major optical observatories; no road lighting, unless specifically required by the relevant road controlling authority

Note 1 ALARP = as low as reasonably practical (as close to zero as possible)

The Project is located in a semi-rural, but somewhat remote area with the potential, albeit limited, to impact on surrounding residential properties – refer Figure 12. As these properties are not located within township environs proper, they would therefore be classed as being in a Zone "A2" area - refer Table 6.

The applicable limits for adverse spill light will depend on the time of operation for the lighting installation.

For the Project, it is possible that internal access roads and any equipment buildings in particular, will be operational 24/7, suggesting the application of the more restrictive limit relevant to curfew hours.

Accordingly:

- Light spill from the Project onto the facades of the surrounding residential dwellings should be kept below 1 lux during curfew hours

Finally, it has been known for some time that night-time artificial lighting has the potential to disrupt the natural behaviour of nocturnal fauna species such as arboreal mammals, large forest owls and microbats. The standards mentioned above do not contain limiting lux levels in relation to the mitigation of such eco-lighting impacts.

Mitigation recommendations in relation to adverse eco-lighting therefore centre on feasible night-time lighting minimisation, bearing in mind the provision of appropriate health and safety and security conditions given the nature of the site. Biodiversity associated with the Project is discussed in the Flora and Fauna Assessment Report prepared for the Project.

8.2 Night-Time Illumination Glare – Assessment and Mitigation

Although presently not fully defined, it is assumed that an area within the Port Hedland Solar Farm Project site will be set aside for an Operation and Maintenance buildings, power conversion unit, fire access routes and egress, etc, and that some of these may need to be operational 24/7.

The only potential for any future night-time illumination glare would be associated with the nearest thoroughfares and residential and other sensitive receivers to the Project. Consideration has also been given to the potential for adverse eco-lighting impacts on nocturnal fauna habitats in close proximity to the Project site, especially within any close-by native vegetation areas.

The recommendations set out below are therefore made in the event that future 24/7 lighting is incorporated into the Project, to achieve the best lighting performance (taking into account safety considerations) while having a minimal impact on the surrounding properties, carriageways and nocturnal fauna.

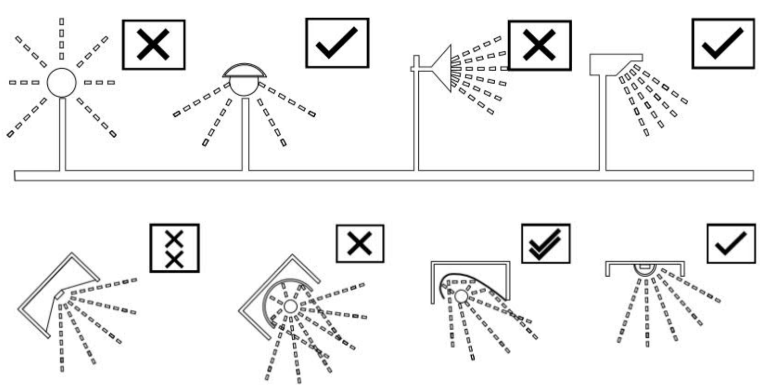
In terms of any future potential night-time lighting, the adopted goal of limiting night-time light spill to no more than 1 lux falling on the nearby residential facades during curfew hours will be easily achieved given the distances to the nearest residential and other receivers.

Accordingly, the potential for any future nuisance glare will be non-existent.

AS4282-1997 Control of the Obtrusive Effect of Outdoor Lighting sets out general principles that should be applied when designing outdoor light to minimise any adverse effect of the light installation.

- Direct lights downward as much as possible and use luminaires that are designed to minimise light spill, eg full cut-off luminaires where no light is emitted above the horizontal plane, ideally keeping the main beam angle less than 70°. Less spill-light means that more of the light output can be used to illuminate the area and a lower power output can be used, with corresponding energy consumption benefits, but without reducing the illuminance of the area – refer Figure 17.
- Do not waste energy and increase light pollution by over-lighting.
- Wherever possible use floodlights with asymmetric beams that permit the front glazing to be kept at or near parallel to the surface being lit.

Figure 17 Luminaire Design Features that Minimise Light Spill



9 CONCLUSION

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Alinta to carry out a Reflective Glare assessment of the proposed Port Hedland Solar Farm (the "Project").

The following potential glare conditions have been considered:

- Daytime — Reflective glare (and glint) arising from the solar PV panels within the facility:
  - Aviation Sector Reflective Glare;
  - Motorist "Disability" Reflective Glare and Pedestrian "Discomfort" Reflective Glare;
  - Rail Operator Reflective Glare;
  - Industrial critical machinery operators (heavy vehicles, etc) Reflective Glare; and
  - Residential "Nuisance" Glare
- Night-time — Illumination glare if any 24/7 operational security lighting is incorporate into the Project in the future (noting that lighting is not currently planned)

The Project NE corner is located approximately 8 km from PHIA Runway 14/32, just over 4 km from the township centre of South Hedland and 1.5 km from the nearest residences at Boodarie to the east.

The report has modelled a more extensive "maximal theoretical" project in terms of potential site footprint than the final design that will be constructed and has hence adopted a conservative approach to glare prediction. Section 3.5 details the significant difference between the "maximal theoretical" footprint modelled in this study and likely final design footprint – refer Figure 7.

Aviation-Related Potential Glare

Quantitative analysis using the FAA-SGHAT software tool has shown that there will be NIL glare from the Project at PHIA (all runways) under ANY Fixed Tilt panel support mode ranging from 5° to 25° with the panels "facing" due north. The proposed solar farm will also comply with SGHAT requirements for any Fixed Tilt panel mode involving an upward tilt of around 15° if the perpendicular "pointing" axis of the panels (ie the direction they are facing) is allowed to vary from due north by ±10°.

The above result is due to the distance of the proposed solar farm from PHIA and the difference in line of sight of pilots on final approach for the airport's runways.

Recommendation: NIL

Motorist and Rail Traffic "Disability" Glare

The proposed solar farm will comply with the recommended TI Value criteria for both road and rail under ANY Fixed Tilt panel mode with an upwards tilt of at least 10°.

For a typical FIXED TILT position (say in the range 15°-20°), allowing the array to have a slight eastwards orientation (eg facing 10° east) increases the potential visibility of reflections to the adjacent FMG East Turner Rail Line, but still within the relevant TI Value criteria. Allowing the array to have a slight westwards orientation (eg facing 350° west) increases the potential visibility of reflections to Boodarie Station Access Road traffic, again still within the relevant TI Value criteria.

Recommendation: While not a glare issue per se, in order to minimise the visibility of reflections from the proposed facility, it is recommended that the orientation of the panels be aligned as close to North as possible, regardless of the FIXED TILT angles of the panels.

Residential Nuisance Glare

The calculations assessing residential nuisance glare were based on a receiver looking directly towards the facility. The calculations conservatively assumed NO intervening "blocking" topography (eg from small, elevated earth mounding) and NO vegetation or any other physical barriers, such as perimeter fencing, etc.

These "idealised" calculations showed that there is potential for the visibility of reflections from the facility at some surrounding receivers – receivers #3, #4 & #5 for Boodarie and receivers, #6, #7 & #8 for South Hedland.

However, when taking into account (i) the low level of potential TI Values made with the above "idealised" calculations, (ii) the landscaping and fencing around all residences of interest, and (iii) the intervening areas of mounding between the proposed facility and receivers of interest, it was concluded that there will be NIL residential glare from the proposed facility.

Recommendation: NIL

Industrial Machinery Disability Glare

There are currently no industrial operations in the immediate vicinity of the Project (eg mining operations, quarrying, etc) with the kind of machinery where the relevant operators have the potential to experience reflective glare from the Project, eg elevated cabins in draglines, etc.

Boodarie Strategic Industrial Area (SIA) is located to the west of the site – refer Figure 15. The proposed solar farm falls within the SIA buffer zone. SIA is being managed by the NT's JTSI (Department of Jobs, Tourism, Science and Innovation). No current operations within SIA or currently planned operations (as far as is known) involve elevated (industrial machinery) receivers.

Recommendation: In terms of future Boodarie SIA developments, the orientation of the panels should be aligned as close to North as possible, regardless of the FIXED TILT angles of the panels. Moreover, the present analysis could be revisited to confirm the absence of solar farm glare, IF it understood that such development will involve elevated machinery operators with a clear line of sight to the solar farm.

Finally, it is noted that, any future potential issue associated with solar farm glare in relation to Boodarie SIA, could be straightforwardly addressed by adding a perimeter screen along the western boundary of the proposed solar farm, eg vegetation, fencing, etc, of sufficient height to block westbound reflections from the facility.

Night-Time Illumination Glare

Consideration has been given to the future potential for night-time lighting at the Project site related to equipment and/or buildings, fire access routes and egress, personnel safety, etc.

Recommendation: If 24/7 lighting is required in the future at the site for operational purposes, there should be negligible impact, assuming the lighting design is in accordance with AS 4282-2019 Control of the Obtrusive Effect of Outdoor Lighting. This would also address any potential adverse eco-lighting issues in relation to nocturnal fauna within and surrounding the site.

Recommendation for Detailed Design Stage

When key Project decisions are finalised during detailed design (eg final panel selection, mounting details, etc), the present analysis should be re-visited to confirm the conclusions set out above, IF key assumptions made in the present analysis change significantly.

Finally, as noted above, the present study has assessed the potential impact of a far more extensive project than is likely to be constructed – refer Section 3.5. The final design will be a much-reduced subset of the "maximal theoretical" footprint design modelled herein.

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