Glint and Glare Assessment

Boorowa Solar Farm

June 2021

ENGINEERING | STRATEGY | ANALYTICS | CONSTRUCTION

DOCUMENT CONTROL

Report Title	Glint and Glare Assessment – Boorowa Solar Farm				
ITP Project Number	Boorowa 1B				
Rev	**Date**	**Status**	**Author/s**	**Reviewed By**	**Approved**
1	8/02/2021	1st Revision	I Chawla	S Dedman	Approved
2	16/04/2021	2nd Revision	I Chawla	S Dedman	Approved
3	8/06/2021	3rd Revision	I Chawla	S Dedman	Approved

A person or organisation choosing to use documents prepared by ITP Renewables accepts the following:

(a) Conclusions and figures presented in draft documents are subject to change. ITP Renewables accepts no responsibility for use outside of the original report.
(b) The document is only to be used for purposes explicitly agreed to by ITP Renewables.
(c) All responsibility and risks associated with the use of this report lie with the person or organisation who chooses to use it.

ITP Renewables

Office: Level 1, 19-23 Moore St
Turner ACT 2612

Postal: PO Box 6127
O'Connor ACT 2602
Australia

Email: info@itpau.com.au
Phone: +61 (0) 2 6257 3511

itpau.com.au

ABOUT ITP RENEWABLES

ITP Renewables (ITP) is a global leader in renewable energy engineering, strategy, construction, and energy sector analytics. Our technical and policy expertise spans the breadth of renewable energy, energy storage, energy efficiency and smart integration technologies. Our range of services cover the entire spectrum of the energy sector value chain, from technology assessment and market forecasting right through to project operations, maintenance and quality assurance.

We were established in 2003 and operate out of offices in Canberra (Head Office), Sydney, North Coast NSW, Adelaide and Auckland, New Zealand. We are part of the international ITPEnergised Group, one of the world's largest, most experienced and respected specialist engineering consultancies focussing on renewable energy, energy efficiency, and carbon markets. The Group has undertaken over 2,000 contracts in energy projects encompassing over 150 countries since it was formed in 1981.

Our regular clients include governments, energy utilities, financial institutions, international development donor agencies, project developers and investors, the R&D community, and private firms.

ABBREVIATIONS

AC	Alternating current
CASA	Civil Aviation Safety Authority
DC	Direct current
FAA	Federal Aviation Administration (United States)
Ha	Hectare
ITP	ITP Renewables
MW	Megawatt, unit of power (1 million Watts)
MWp	Megawatt-peak, unit of power at standard test conditions used to indicate PV system capacity
NSW	New South Wales
OP	Observation point
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool

TABLES

FIGURES

TABLE OF CONTENTS

1 INTRODUCTION

1.1 Overview

ITP Development is proposing to develop a solar farm as described in Table 1. It will be located approximately 3km south of the town of Boorowa, NSW (see Figure 1).

Table 1. Site Information

Parameter	Description
Solar farm name	Boorowa Solar Farm
Site reference	Boorowa 1B
Lot/DP(s)	Parts of Lots 130-133 and 136-139 of DP 2493
Street address	Meads Lane, Boorowa, NSW 2586
Council	Hilltops Council
AC capacity	5 MW
DC capacity	6.4 MW
Project area	Approx. 11.99 ha
Current land use	Mixed cropping/Grazing

This report provides a desktop glint and glare assessment to support the Development Application for the project. It provides:

- Identification of potential receptors of glint and glare from the proposed solar farm; and
- Assessment of the glint and glare hazard using the Solar Glare Hazard Analysis Tool (SGHAT) GlareGauge analysis

1.2 Glint and Glare

Glint is defined as a momentary flash of bright light, while glare is a continuous source of excessive brightness relative to ambient lighting (Federal Aviation Administration [FAA], 2018). The GlareGauge analysis used to assess the glint and glare hazard (see Section 3) was run with a simulation interval of one minute, as sunlight reflection from PV modules typically lasts for at least one minute. Glint, which lasts for less than one minute, is unlikely to occur from the sun based on how slowly the sun and modules move, so has not been considered further in this assessment.

Solar photovoltaic (PV) modules are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, the modules are constructed from dark, light-absorbing material and the glass is treated with an anti-reflective coating. As a result, the glare generated from PV modules is lower than from many other surfaces, including cropping/grassland and concrete (an albedo of 20% is typically assumed for PV modules, compared to 25-30% for grass and up to 25% for concrete; Ramírez & Muňoz, 2012).

However, the glass modules still have the potential to generate glare. This needs to be assessed to ensure that visual receptors—such as road users, nearby buildings, air traffic control towers and aircraft pilots—are not impacted by the development of solar farms.

2 PROJECT DESCRIPTION

ITP Development is proposing to construct a solar farm with a DC capacity of 6.4 MW_p and AC output of 5 MW, on an approximately 11.99 ha site that is currently used for mixed cropping and grazing.

There are to be approximately 12,100 solar modules installed on around 150 mounting structures running north to south. Each row of solar photovoltaic (PV) modules will rotate to track the sun across the sky from east to west each day. The hub height of each tracker will be around 1.5m, with the peak of the modules reaching a height of approximately 2.75m when the array is fully tilted to 60 degrees from horizontal. The general arrangement of the solar farm is shown on drawing BOO1B-G-2100, and the array tracker details on drawing BOO1B-E-3400.

The solar farm will also comprise two 3.4MW inverter stations. These inverters are to be located within the array and are each mounted on a 20-foot skid. Each of these inverter stations incorporate the high voltage switchgear and transformers. The arrangement of the inverter station skid is shown in drawing BOO1B-E-4300.

The mounting system is constructed on piles that are driven into the ground. During construction, there is expected to be 50 personnel on site working from 7am- 4pm, Monday to Friday. The construction is expected to take approximately 3 months. Once operational, the site will be unmanned. Maintenance is expected to be carried out quarterly by a crew of 2- 3 people.

Solar panels and related infrastructure will be decommissioned and removed upon cessation of operations. This is likely to occur within two years of the end of the project. The site will be returned to the pre-development land use.

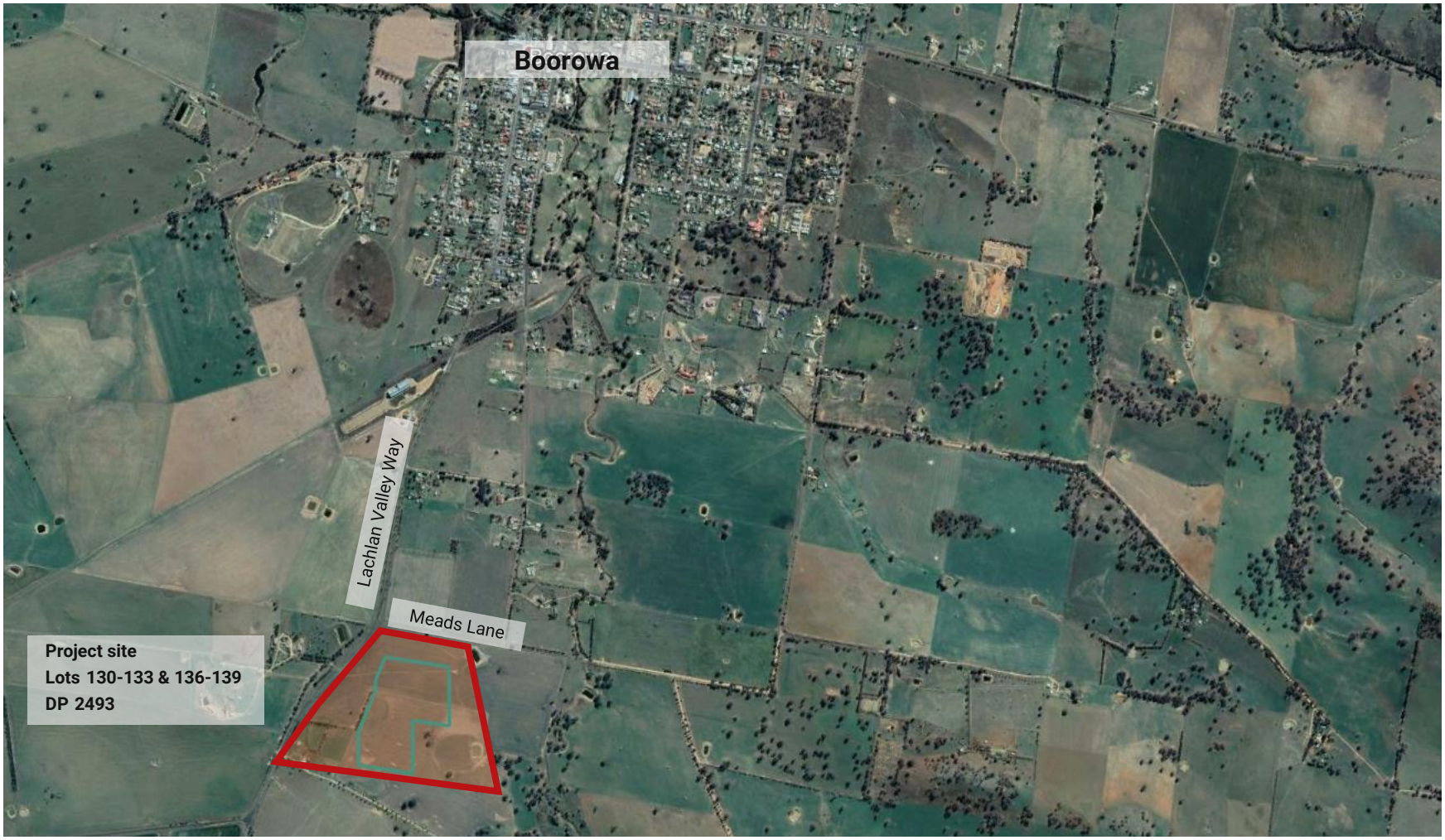

Figure 1. Proposed solar farm site (green boundary, 11.99 ha) and surrounding lot area (red boundary, total 38.4 ha)

3 ANALYSIS

3.1 Overview

In a fixed-tilt PV array, the angle of incidence at which direct sunlight hits the PV modules varies as the sun moves across the sky. It will be smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. If the PV array is mounted on a single-axis tracking system as proposed in this project, the variation in the angle of incidence will be much smaller since the modules rotate to follow the sun. The main variation will be seasonal, i.e. because the sun is higher in the sky during summer and lower during winter. A PV array that is mounted on a tracking system therefore has less potential to cause glare.

The SGHAT was developed by Sandia National Laboratories to evaluate glare resulting from solar farms at different viewpoints, based on the location, orientation and specifications of the PV modules. This tool is required by the United States FAA for glare hazard analysis near airports and is also recognised by the Australian Government Civil Aviation Safety Authority (CASA).

The GlareGauge analysis uses SGHAT to provide an indication of the type of glare that can be expected at each potential receptor. Glare is indicated by three colours according to severity:

- Green glare: Low potential for temporary after-image;
- Yellow glare: Potential for temporary after-image; and
- Red glare: Retinal burn, not expected for PV.

The parameters used in the SGHAT model for the project are detailed in Table 2. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The heights of the observation points were assumed to be 1.5m for a road user (i.e. sitting in a car) and 1.65m for a person (i.e. standing).

Table 2. SGHAT specification inputs

Parameters	Input
Time zone	UTC+10:00
Module tracking	Single axis
Module surface material	Smooth glass with ARC (anti-reflective coating)
Tracking axis tilt	0°
Tracking axis orientation	0°
Module offset angle (angle between module and tracking axis)	0°
Maximum tracking angle	60°
Resting angle	30°
Height of modules above ground	1.78m (height from the ground to the PV panel centroid)

3.2 Potential Receptors

For this project, visual receptors within 2 km of the site were considered including residences and road users. There is no formal guidance on the maximum distance at which glint and glare should be assessed; however, the significance of a reflection decreases with distance. This is due to the proportion of the observer's field of vision taken up by the reflective area decreasing as distance increases. In addition, as the separation distance increases, terrain and shielding by vegetation and other structures are more likely to obstruct the view of the reflective area. A 2-km radius from the site was considered appropriate based on it being highly unlikely for glint and glare impacts at distances greater than this. This is a conservative distance based on existing studies and assessment experience.

As shown in Figures 3, 4, 5 and 6, 50 residential observation points were identified as potential visual receptors of the site. The potential for glare was also assessed along 11 different road routes (see Figure 2).

While there was a greater number of residential/commercial properties considered, some were discounted based on large stands of trees and other structures acting as visual barriers.

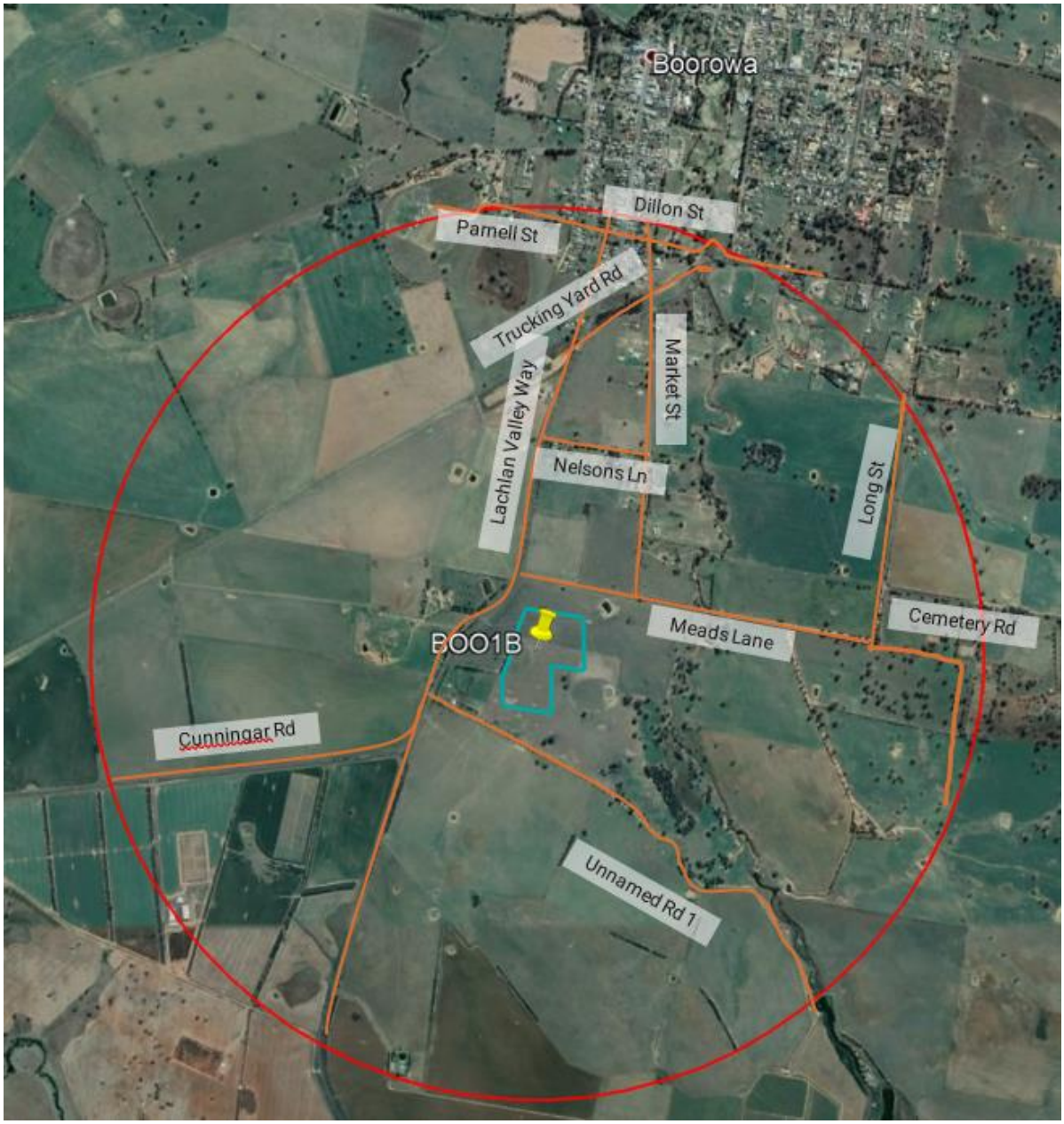

Figure 2. Map showing potential road receptors within 2km of the site

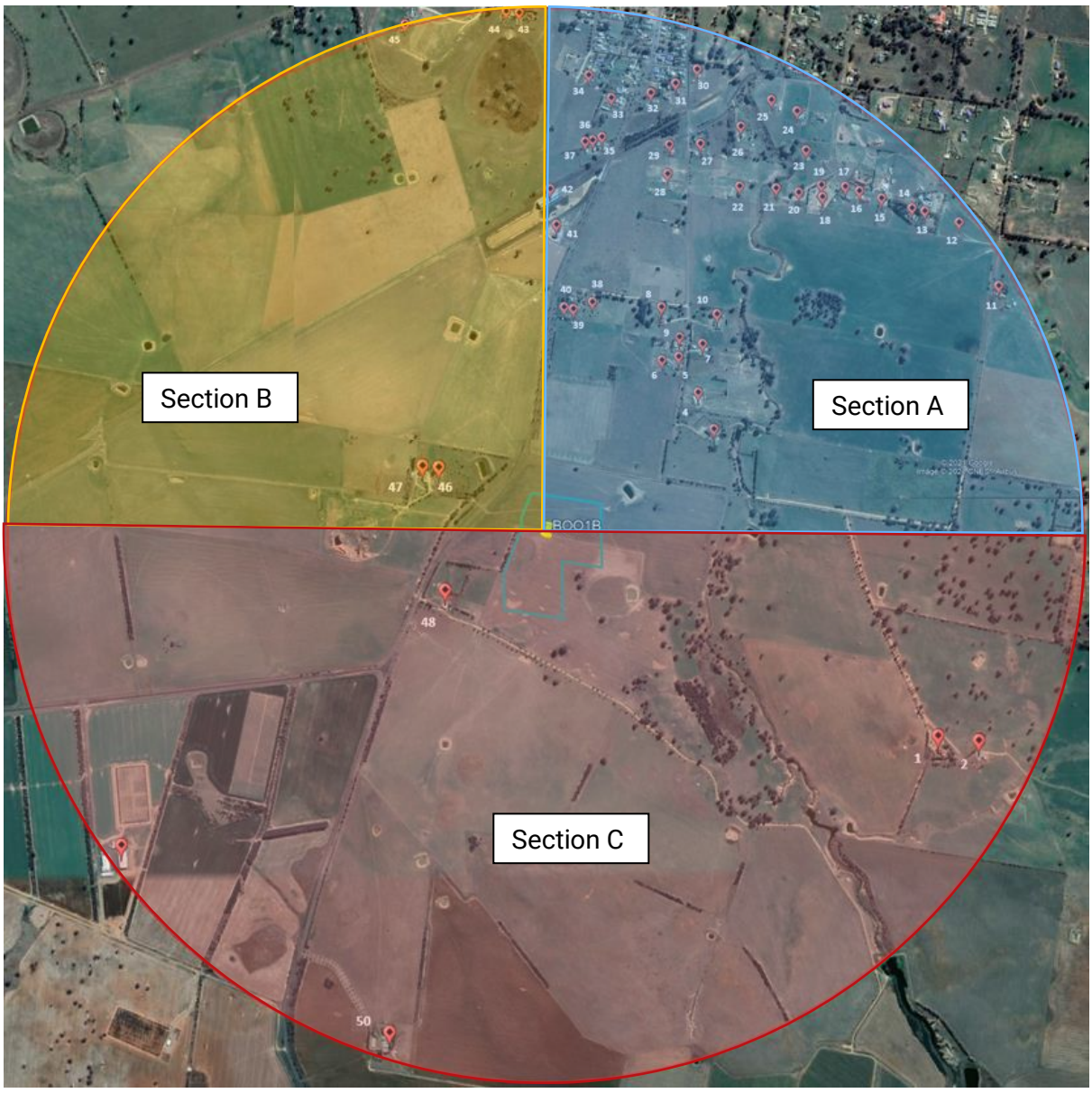

Figure 3. Map showing potential visual receptors within 2km of the site

Figure 4. Section A detail – showing visual receptors around the site

Figure 5. Section B detail – showing visual receptors around the site

Figure 6. Section C detail – showing visual receptors around the site

3.3 Assumptions

The visual impact of solar farm development depends on the scale and type of infrastructure, the prominence and topography of the site relative to the surrounding environment, and any proposed screening measures to reduce visibility of the site. Some potential viewpoints were discounted because of significant existing features (such as trees or buildings), however, minor screening—such as roadside vegetation—was not assessed in detail. The GlareGauge analysis results are therefore considered conservative as the model assumes there is no screening.

Atmospheric conditions such as cloud cover, will also influence light reflection and the resulting impact on visual receptors. The same is true of varying tilt angles of the modules. Varying atmospheric conditions have not been accounted for in the GlareGauge analysis, nor have the complexities of backtracking (due to the software's limitations). The GlareGauge analysis assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000 W/m2 which varies throughout the day.

3.4 Results

The results of the GlareGauge analysis (attached in Appendix A) at each of the observation points are summarised in Table 3. No potential for glare was identified.

The distances in the table below are provided as indication of the location of the receptor relative to the solar array, but are not direct inputs to the GlareGauge analysis, which utilises the PV array centroid for its calculations.

Table 3. Glare potential at observation points

	Type of Observation Point	Location relative to solar farm	Green glare (minutes)	Yellow glare (minutes)	Glare potential
OP1	Residential	1.64 km east	0	0	No glare
OP2	Residential	1.80 km east	0	0	No glare
OP3	Residential	0.73 km north east	0	0	No glare
OP4	Residential	0.77 km north east	0	0	No glare
OP5	Residential	0.81km north east	0	0	No glare
OP6	Residential	0.76 km north east	0	0	No glare

OP7	Residential	0.90 km north east	0	0	No glare
OP8	Residential	0.93 km north east	0	0	No glare
OP9	Residential	0.88 km north east	0	0	No glare
OP10	Residential	1.02 km north east	0	0	No glare
OP11	Residential	1.92 km north east	0	0	No glare
OP12	Residential	1.91 km north east	0	0	No glare
OP13	Residential	1.86 km north east	0	0	No glare
OP14	Residential	1.83 km north east	0	0	No glare
OP15	Residential	1.76 km north east	0	0	No glare
OP16	Residential	1.74 km north east	0	0	No glare
OP17	Residential	1.71 km north east	0	0	No glare
OP18	Residential	1.62 km north east	0	0	No glare
OP19	Residential	1.66 km north east	0	0	No glare
OP20	Residential	1.58 km north east	0	0	No glare
OP21	Residential	1.54 km north east	0	0	No glare
OP22	Residential	1.48 km north east	0	0	No glare
OP23	Residential	1.73 km north east	0	0	No glare
OP24	Residential	1.84 km north east	0	0	No glare

OP25	Residential	1.82 km north east	0	0	No glare
OP26	Residential	1.68 km north east	0	0	No glare
OP27	Residential	1.57 km north east	0	0	No glare
OP28	Residential	1.41 km north	0	0	No glare
OP29	Residential	1.52 km north	0	0	No glare
OP30	Residential	1.81 km north	0	0	No glare
OP31	Residential	1.73 km north	0	0	No glare
OP32	Residential	1.68 km north	0	0	No glare
OP33	Residential	1.64 km north	0	0	No glare
OP34	Residential	1.72 km north	0	0	No glare
OP35	Residential	1.50 km north	0	0	No glare
OP36	Residential	1.47 km north	0	0	No glare
OP37	Residential	1.47 km north	0	0	No glare
OP38	Residential	0.88 km north	0	0	No glare
OP39	Residential	0.85 km north	0	0	No glare
OP40	Residential	0.84 km north	0	0	No glare
OP41	Commercial	1.16 km north	0	0	No glare
OP42	Commercial	1.29 km north	0	0	No glare
OP43	Residential	1.94 km north	0	0	No glare
OP44	Residential	1.96 km north	0	0	No glare
OP45	Residential	1.97 km north west	0	0	No glare
OP46	Residential	0.45 km west	0	0	No glare
OP47	Residential	0.51 km west	0	0	No glare
OP48	Residential	0.43 km south west	0	0	No glare
OP49	Residential	1.96 km south west	0	0	No glare

OP50	Residential	1.96 km south	0	0	No glare
Boorowa Harden Rd/ Cunningar Rd	Road Route	South west	0	0	No glare
Cemetery Rd	Road Route	East	0	0	No glare
Dillon St	Road Route	North	0	0	No glare
Lachlan Valley Way	Road Route	Adjoining - west	0	0	No glare
Long St	Road Route	East	0	0	No glare
Market St	Road Route	North	0	0	No glare
Meads Ln	Road Route	Adjoining - north	0	0	No glare
Nelsons Ln	Road Route	North	0	0	No glare
Parnell St	Road Route	North	0	0	No glare
Trucking Yard Rd	Road Route	North	0	0	No glare
Unnamed Rd 1	Road Route	South	0	0	No glare

4 SUMMARY

The results of the GlareGauge analysis indicated that the selected observation points are unlikely to receive glare due to the proposed solar farm.

Existing roadside vegetation and structures are expected to provide a physical obstruction between the solar farm and road users, further minimising the visual impact of the project. However, it is noted that the site itself is fully cleared and there are no structures or vegetation in the road reserve or within the property.

5 REFERENCES

Federal Aviation Administration (FAA) (2018). Solar Guide: Technical Guidance for Evaluating Selected Solar Technologies on Airports. Retrieved from the FAA website: https://www.faa.gov/airports/environmental/

Ramírez, A. Z., & Muňoz, C. B (2012). Albedo effect and energy efficiency of cities. Sustainable Development – Energy, Engineering and Technologies – Manufacturing and Environment. Retrieved from https://www.intechopen.com/books/sustainable-development-energy-engineering-and-technologies-manufacturing-and-environment/albedo-effect-and-energy-efficiency-of-cities

APPENDIX A. FORGESOLAR GLARE ANALYSIS

FORGESOLAR GLARE ANALYSIS

Project: **Boorowa 1B**
Site configuration: **All Receptors - KMZ**
Analysis conducted by ITP Engineering (engineering@itpau.com.au) at 06:43 on 02 Feb, 2021.

U.S. FAA 2013 Policy Adherence

The following table summarizes the policy adherence of the glare analysis based on the 2013 U.S. Federal Aviation Administration Interim Policy 78 FR 63276. This policy requires the following criteria be met for solar energy systems on airport property:

- No "yellow" glare (potential for after-image) for any flight path from threshold to 2 miles
- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics (see list below)

ForgeSolar does not represent or speak officially for the FAA and cannot approve or deny projects. Results are informational only.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
2-mile flight path(s)	N/A	No flight paths analyzed
ATCT(s)	N/A	No ATCT receptors designated

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

FAA Policy 78 FR 63276 can be read at https://www.federalregister.gov/d/2013-24729

SITE CONFIGURATION

Analysis Parameters

DNI: peaks at 1,000.0 W/m^2
Time interval: 1 min
Ocular transmission coefficient: 0.5
Pupil diameter: 0.002 m
Eye focal length: 0.017 m
Sun subtended angle: 9.3 mrad
Site Config ID: 49045.8793

PV Array(s)

Name: PV1
Axis tracking: Single-axis rotation
Tracking axis orientation: 0.0°
Tracking axis tilt: 0.0°
Tracking axis panel offset: 0.0°
Max tracking angle: 60.0°
Resting angle: 30.0°
Rated power: 6400.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.463106	148.711887	510.08	1.78	511.86
2	-34.461177	148.711848	509.07	1.78	510.85
3	-34.461389	148.713472	507.05	1.78	508.83
4	-34.459252	148.713428	505.92	1.78	507.70
5	-34.458885	148.710620	508.07	1.78	509.85
6	-34.459725	148.710206	508.70	1.78	510.48
7	-34.460079	148.710213	509.05	1.78	510.83
8	-34.461606	148.709465	511.64	1.78	513.42
9	-34.462793	148.709489	514.03	1.78	515.81
10	-34.463106	148.711887	510.08	1.78	511.86

Discrete Observation Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 1	1	-34.467628	148.726968	533.10	1.65
OP 2	2	-34.467792	148.728612	532.43	1.65
OP 3	3	-34.457137	148.717668	503.04	1.65
OP 4	4	-34.455929	148.717045	503.11	1.65
OP 5	5	-34.454747	148.716275	502.14	1.65
OP 6	6	-34.454864	148.715601	501.53	1.65
OP 7	7	-34.454325	148.717247	500.81	1.65
OP 8	8	-34.453105	148.715602	498.99	1.65
OP 9	9	-34.454100	148.716314	500.77	1.65
OP 10	10	-34.453340	148.717832	499.96	1.65
OP 11	11	-34.452431	148.729435	513.97	1.65
OP 12	12	-34.450322	148.727853	506.80	1.65
OP 13	13	-34.449947	148.726480	504.87	1.65
OP 14	14	-34.449848	148.725964	503.88	1.65
OP 15	15	-34.449517	148.724737	502.07	1.65
OP 16	16	-34.449274	148.723844	501.28	1.65
OP 17	17	-34.449127	148.723277	499.92	1.65
OP 18	18	-34.449469	148.722360	497.92	1.65
OP 19	19	-34.449071	148.722312	497.14	1.65
OP 20	20	-34.449323	148.721400	497.57	1.65
OP 21	21	-34.449181	148.720487	495.07	1.65
OP 22	22	-34.449113	148.719015	495.24	1.65
OP 23	23	-34.447906	148.721688	496.92	1.65
OP 24	24	-34.446591	148.721317	495.66	1.65
OP 25	25	-34.446207	148.720269	491.51	1.65
OP 26	26	-34.447098	148.719041	491.69	1.65
OP 27	27	-34.447658	148.717221	496.78	1.65
OP 28	28	-34.448665	148.715890	494.39	1.65
OP 29	29	-34.447689	148.715959	496.81	1.65
OP 30	30	-34.445157	148.717105	495.41	1.65
OP 31	31	-34.445632	148.716225	497.15	1.65
OP 32	32	-34.445952	148.715219	496.79	1.65
OP 33	33	-34.446119	148.713621	495.61	1.65
OP 34	34	-34.445346	148.712712	492.63	1.65
OP 35	35	-34.447434	148.713235	496.81	1.65
OP 36	36	-34.447544	148.712858	496.82	1.65
OP 37	37	-34.447592	148.712551	496.87	1.65
OP 38	38	-34.452939	148.712816	500.46	1.65
OP 39	39	-34.453170	148.712049	501.45	1.65
OP 40	40	-34.453112	148.711673	501.91	1.65
OP 41	41	-34.450370	148.711373	504.59	1.65
OP 42	42	-34.449176	148.711124	499.29	1.65
OP 43	43	-34.443249	148.709889	493.14	1.65
OP 44	44	-34.443202	148.709360	493.68	1.65
OP 45	45	-34.443642	148.705251	493.77	1.65
OP 46	46	-34.458567	148.706866	515.92	1.65
OP 47	47	-34.458516	148.706208	516.61	1.65
OP 48	48	-34.462671	148.707100	519.49	1.65
OP 49	49	-34.471121	148.693963	527.56	1.65

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
OP 50	50	-34.477381	148.704783	544.94	1.65

Route Receptor(s)

Name: Boorowa Harden Rd - Cunningar Rd
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.466200	148.687157	513.72	1.50	515.22
2	-34.465652	148.694281	514.24	1.50	515.74
3	-34.465050	148.701062	515.76	1.50	517.26
4	-34.464749	148.704903	518.79	1.50	520.29

Name: Cemetery Rd
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.458014	148.728084	525.12	1.50	526.62
2	-34.458430	148.731077	538.81	1.50	540.31
3	-34.458633	148.732279	537.94	1.50	539.44
4	-34.458819	148.732665	538.12	1.50	539.62
5	-34.459058	148.732804	539.10	1.50	540.60
6	-34.460886	148.732450	548.19	1.50	549.69
7	-34.462180	148.732182	549.36	1.50	550.86
8	-34.463936	148.731785	534.66	1.50	536.16

Name: Dillon St
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.444568	148.716784	495.50	1.50	497.00
2	-34.444710	148.717557	494.13	1.50	495.63
3	-34.444780	148.718415	490.52	1.50	492.02
4	-34.444347	148.719059	488.84	1.50	490.34
5	-34.444347	148.719359	488.86	1.50	490.36
6	-34.444533	148.719574	489.56	1.50	491.06
7	-34.444780	148.719831	489.98	1.50	491.48
8	-34.444975	148.719971	490.29	1.50	491.79
9	-34.445055	148.721333	494.17	1.50	495.67
10	-34.445267	148.723007	494.82	1.50	496.32
11	-34.445568	148.725067	500.17	1.50	501.67
12	-34.445674	148.725990	503.77	1.50	505.27

Name: Lachlan Valley Way
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.480204	148.701982	533.99	1.50	535.49
2	-34.477480	148.700824	543.00	1.50	544.50
3	-34.476490	148.700566	543.00	1.50	544.50
4	-34.473872	148.701167	531.71	1.50	533.21
5	-34.469909	148.702712	525.46	1.50	526.96
6	-34.466583	148.704085	520.58	1.50	522.08
7	-34.463859	148.705072	518.71	1.50	520.21
8	-34.461350	148.706596	517.30	1.50	518.80
9	-34.460430	148.707239	515.97	1.50	517.47
10	-34.459498	148.708486	513.69	1.50	515.19
11	-34.458857	148.709263	510.60	1.50	512.10
12	-34.458304	148.709772	508.77	1.50	510.27
13	-34.457933	148.709992	507.38	1.50	508.88
14	-34.457491	148.710222	505.79	1.50	507.29
15	-34.456801	148.710474	504.24	1.50	505.74
16	-34.455840	148.710669	503.40	1.50	504.90
17	-34.454804	148.710837	503.94	1.50	505.44
18	-34.453851	148.711041	503.06	1.50	504.56
19	-34.452731	148.711247	501.11	1.50	502.61
20	-34.451631	148.711515	502.68	1.50	504.18
21	-34.450018	148.712370	502.35	1.50	503.85
22	-34.448902	148.712954	499.65	1.50	501.15
23	-34.447739	148.713566	497.16	1.50	498.66
24	-34.446864	148.714035	496.42	1.50	497.92
25	-34.446027	148.714453	496.08	1.50	497.58
26	-34.445068	148.714968	494.54	1.50	496.04
27	-34.444587	148.715265	494.47	1.50	495.97
28	-34.443180	148.715554	493.86	1.50	495.36
29	-34.442756	148.715629	493.83	1.50	495.33

Name: Long St
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.450502	148.729422	507.35	1.50	508.85
2	-34.453404	148.728993	519.03	1.50	520.53
3	-34.456684	148.728414	525.86	1.50	527.36
4	-34.460088	148.727513	523.51	1.50	525.01

Name: Market St
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.442936	148.716906	494.42	1.50	495.92
2	-34.444714	148.716691	495.56	1.50	497.06
3	-34.445555	148.716724	496.55	1.50	498.05
4	-34.446236	148.716745	497.58	1.50	499.08
5	-34.446983	148.716756	497.99	1.50	499.49
6	-34.447567	148.716734	497.10	1.50	498.60
7	-34.449204	148.716734	494.44	1.50	495.94
8	-34.450611	148.716713	496.99	1.50	498.49
9	-34.451929	148.716670	497.35	1.50	498.85
10	-34.452628	148.716681	498.64	1.50	500.14
11	-34.453212	148.716734	499.56	1.50	501.06
12	-34.454077	148.716653	500.85	1.50	502.35
13	-34.454706	148.716519	502.18	1.50	503.68
14	-34.455892	148.716289	503.80	1.50	505.30
15	-34.457263	148.716021	503.99	1.50	505.49
16	-34.458502	148.715785	503.84	1.50	505.34

Name: Meads Ln
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.457659	148.710201	506.31	1.50	507.81
2	-34.457951	148.712235	505.12	1.50	506.62
3	-34.458765	148.717578	504.00	1.50	505.50
4	-34.459420	148.721848	505.15	1.50	506.65
5	-34.460128	148.727491	523.31	1.50	524.81

Name: Nelsons Ln
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.451929	148.711494	501.69	1.50	503.19
2	-34.452282	148.713651	500.06	1.50	501.56
3	-34.452344	148.714327	498.79	1.50	500.29
4	-34.452371	148.714842	500.10	1.50	501.60
5	-34.452601	148.715797	498.24	1.50	499.74
6	-34.452663	148.716634	498.61	1.50	500.11

Name: Parnell St
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.443281	148.709291	493.80	1.50	495.30
2	-34.443502	148.710267	492.95	1.50	494.45
3	-34.443564	148.710546	492.49	1.50	493.99
4	-34.443466	148.711393	491.90	1.50	493.40
5	-34.443794	148.712048	493.24	1.50	494.74
6	-34.444165	148.712810	494.70	1.50	496.20
7	-34.444254	148.713464	494.93	1.50	496.43
8	-34.444431	148.714784	494.40	1.50	495.90
9	-34.444608	148.715814	494.70	1.50	496.20
10	-34.444705	148.716618	495.61	1.50	497.11

Name: Trucking Yard Rd
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.447900	148.713529	497.39	1.50	498.89
2	-34.447568	148.714339	496.04	1.50	497.54
3	-34.447360	148.714843	496.68	1.50	498.18
4	-34.447179	148.715277	497.21	1.50	498.71
5	-34.447046	148.716211	498.42	1.50	499.92
6	-34.447004	148.716623	498.33	1.50	499.83
7	-34.446805	148.717148	496.66	1.50	498.16
8	-34.446544	148.717669	494.00	1.50	495.50
9	-34.446274	148.718130	491.60	1.50	493.10
10	-34.446071	148.718420	490.31	1.50	491.81
11	-34.445827	148.718608	490.11	1.50	491.61
12	-34.445331	148.718992	490.47	1.50	491.97
13	-34.445075	148.719222	490.25	1.50	491.75
14	-34.444946	148.719496	490.05	1.50	491.55
15	-34.444912	148.719933	490.19	1.50	491.69
16	-34.444956	148.720684	492.29	1.50	493.79
17	-34.445107	148.721714	494.91	1.50	496.41
18	-34.445275	148.723077	494.86	1.50	496.36

Name: Unnamed Road 1
Path type: Two-way
Observer view angle: 50.0°

Note: Route receptors are excluded from this FAA policy review. Use the 2-mile flight path receptor to simulate flight paths according to FAA guidelines.

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-34.462383	148.706086	519.94	1.50	521.44
2	-34.462763	148.706612	519.97	1.50	521.47
3	-34.462887	148.707084	519.40	1.50	520.90
4	-34.463081	148.707373	518.70	1.50	520.20
5	-34.463329	148.708232	515.21	1.50	516.71
6	-34.464488	148.711021	513.28	1.50	514.78
7	-34.465709	148.713714	513.33	1.50	514.83
8	-34.466027	148.714412	513.85	1.50	515.35
9	-34.467007	148.715699	517.86	1.50	519.36
10	-34.467591	148.716525	519.07	1.50	520.57
11	-34.467812	148.716804	519.39	1.50	520.89
12	-34.468024	148.717416	518.81	1.50	520.31
13	-34.468210	148.717760	518.10	1.50	519.60
14	-34.468573	148.717975	518.99	1.50	520.49
15	-34.469051	148.718093	520.47	1.50	521.97
16	-34.469228	148.718189	520.24	1.50	521.74
17	-34.469962	148.719198	516.98	1.50	518.48
18	-34.470077	148.721483	513.69	1.50	515.19
19	-34.470157	148.721683	513.81	1.50	515.31
20	-34.470378	148.721886	514.14	1.50	515.64
21	-34.471741	148.722859	515.06	1.50	516.56
22	-34.472575	148.723541	515.67	1.50	517.17
23	-34.472876	148.723798	516.54	1.50	518.04
24	-34.473597	148.724067	517.82	1.50	519.32
25	-34.475437	148.724592	520.11	1.50	521.61

GLARE ANALYSIS RESULTS

Summary of Glare

PV Array Name	Tilt (°)	Orient (°)	"Green" Glare min	"Yellow" Glare min	Energy kWh
PV1	SA tracking	SA tracking	0	0	18,480,000.0

Total annual glare received by each receptor

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 1	0	0
OP 2	0	0
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0
OP 26	0	0
OP 27	0	0

Receptor	Annual Green Glare (min)	Annual Yellow Glare (min)
OP 28	0	0
OP 29	0	0
OP 30	0	0
OP 31	0	0
OP 32	0	0
OP 33	0	0
OP 34	0	0
OP 35	0	0
OP 36	0	0
OP 37	0	0
OP 38	0	0
OP 39	0	0
OP 40	0	0
OP 41	0	0
OP 42	0	0
OP 43	0	0
OP 44	0	0
OP 45	0	0
OP 46	0	0
OP 47	0	0
OP 48	0	0
OP 49	0	0
OP 50	0	0
Boorowa Harden Rd - Cunningar Rd	0	0
Cemetery Rd	0	0
Dillon St	0	0
Lachlan Valley Way	0	0
Long St	0	0
Market St	0	0
Meads Ln	0	0
Nelsons Ln	0	0
Parnell St	0	0
Trucking Yard Rd	0	0
Unnamed Road 1	0	0

Results for: PV1

Receptor	Green Glare (min)	Yellow Glare (min)
OP 1	0	0
OP 2	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
OP 3	0	0
OP 4	0	0
OP 5	0	0
OP 6	0	0
OP 7	0	0
OP 8	0	0
OP 9	0	0
OP 10	0	0
OP 11	0	0
OP 12	0	0
OP 13	0	0
OP 14	0	0
OP 15	0	0
OP 16	0	0
OP 17	0	0
OP 18	0	0
OP 19	0	0
OP 20	0	0
OP 21	0	0
OP 22	0	0
OP 23	0	0
OP 24	0	0
OP 25	0	0
OP 26	0	0
OP 27	0	0
OP 28	0	0
OP 29	0	0
OP 30	0	0
OP 31	0	0
OP 32	0	0
OP 33	0	0
OP 34	0	0
OP 35	0	0
OP 36	0	0
OP 37	0	0
OP 38	0	0
OP 39	0	0
OP 40	0	0
OP 41	0	0
OP 42	0	0
OP 43	0	0
OP 44	0	0

Receptor	Green Glare (min)	Yellow Glare (min)
OP 45	0	0
OP 46	0	0
OP 47	0	0
OP 48	0	0
OP 49	0	0
OP 50	0	0
Boorowa Harden Rd - Cunningar Rd	0	0
Cemetery Rd	0	0
Dillon St	0	0
Lachlan Valley Way	0	0
Long St	0	0
Market St	0	0
Meads Ln	0	0
Nelsons Ln	0	0
Parnell St	0	0
Trucking Yard Rd	0	0
Unnamed Road 1	0	0

Point Receptor: OP 1

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 2

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 3

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 4

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 5

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 6

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 7

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 8

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 9

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 10

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 11

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 12

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 13

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 14

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 15

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: OP 16

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 17

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 18

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 19

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 20

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 21

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 22

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 23

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 24

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 25

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 26

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 27

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 28

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 29

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 30

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 31

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 32

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 33

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 34

0 minutes of yellow glare

0 minutes of green glare

Point Receptor: OP 35

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 36

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 37

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 38

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 39

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 40

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 41

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 42

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 43

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 44

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 45

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 46

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 47

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 48

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 49

0 minutes of yellow glare
0 minutes of green glare

Point Receptor: OP 50

0 minutes of yellow glare
0 minutes of green glare

Route: Boorowa Harden Rd - Cunningar Rd

0 minutes of yellow glare
0 minutes of green glare

Route: Cemetery Rd

0 minutes of yellow glare
0 minutes of green glare

Route: Dillon St

0 minutes of yellow glare

0 minutes of green glare

Route: Lachlan Valley Way

0 minutes of yellow glare
0 minutes of green glare

Route: Long St

0 minutes of yellow glare
0 minutes of green glare

Route: Market St

0 minutes of yellow glare
0 minutes of green glare

Route: Meads Ln

0 minutes of yellow glare
0 minutes of green glare

Route: Nelsons Ln

0 minutes of yellow glare
0 minutes of green glare

Route: Parnell St

0 minutes of yellow glare
0 minutes of green glare

Route: Trucking Yard Rd

0 minutes of yellow glare
0 minutes of green glare

Route: Unnamed Road 1

0 minutes of yellow glare
0 minutes of green glare

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.
Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual results and glare occurrence may differ.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

ITP Renewables

Office: Level 1, 19-23 Moore St
Turner ACT 2612

Postal: PO Box 6127
O'Connor ACT 2602
Australia

Email: info@itpau.com.au
Phone: +61 (0) 2 6257 3511

itpau.com.au