Ongaonga Solar Farm
Glint and glare study

Final Report

Revision 01
November 2023

ENGINEERING | STRATEGY | ANALYTICS | CONSTRUCTION

DOCUMENT CONTROL

Report Title	Ongaonga Solar Farm – Glint and glare study				
Client Contract No.	n/a		ITP Project No.	23103	
File Path	https://itprenewables.sharepoint.com/sites/Projects/External/23103 - Greytown & Ongaonga GG/Project/4 Work/4 Reports/23103 - Ongaonga Solar Farm Glare Study.docx				
Client	Helios Energy		Client Contact	Sarah Brooks	
Rev	Date	Status	Author/s	Reviewed By	Approved
0	27/10/2023	Draft	Drew Thompson	N Logan	N Logan
1	9/11/2023	Final	Drew Thompson	N Logan	N Logan

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, and Adelaide. 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.

ABOUT THIS REPORT

This report assesses the glint and glare impact of the proposed Ongaonga Solar Farm located west of Waipawa, in the Central Hawkes Bay. It was commissioned by Helios Energy Limited (Helios).

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
OP	Observation point
PV	Photovoltaic
SGHAT	Solar Glare Hazard Analysis Tool

TABLES

FIGURES

TABLE OF CONTENTS

EXECUTIVE SUMMARY

ITP have assessed the glare impact in two scenarios for the proposed Ongaonga Solar Farm, as below.

1. **Year 1:** With vegetation screens as planted.
2. **Year 5:** With vegetation screens after five years of growth.

The results of the GlareGauge analysis for year 1 indicated two observation points and five road routes received green glare, while three road routes received yellow glare (Taylor Road, Ongaonga Waipukurau Road, and Fairfield Road). Yellow glare has the potential to cause after-image to observers, while green glare has low potential to cause after-image. In year 5, the growth of the vegetation screens reduced the glare impact for all receptors.

Taylor Road received the most glare, with up to 5 minutes of yellow glare in a single day. The yellow glare received by Taylor Road was limited to the section immediately before it turns into a paper road. We expect very low traffic volume along this section of road. Combined with the short daily duration, we consider this glare to be low impact, and further mitigation is not required.

1 INTRODUCTION

1.1 Overview

Helios Energy Limited (Helios) has requested a glint and glare assessment for a proposed solar photovoltaic (PV) installation located west of Waipawa, in the Central Hawkes Bay. This assessment will be submitted as part of the resource consent process for the project. It includes:

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

1.2 Glint and Glare

The United States Federal Aviation Administration (FAA) defines glint and glare as follows:[1]

- **Glint** is a momentary flash of bright light
- **Glare** is a continuous source of excessive brightness relative to ambient lighting.

Glint and glare can occur when light reflected off a surface (reflector) is viewed by a person (receptor). Glint typically occurs when either the receptor or the reflector is moving, while glare typically occurs when the reflector and receptor are completely, or nearly, stationary. For a transparent material (e.g., glass, water) the quantity of light reflected depends on the surface itself (i.e., material and texture), and the angle at which the light intercepts it (angle of incidence). More light is reflected at higher angles of incidence as shown in Figure 1.

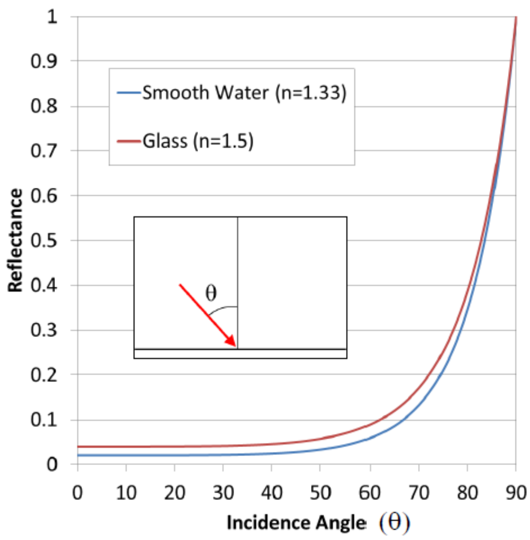

Figure 1: Angles of incidence and increased levels of reflected light

[1] Federal Aviation Administration [FAA], 2018

Potential visual impacts from glint and glare include distraction and temporary afterimage; at its worst, it can cause retinal burn. The ocular hazard caused by glint or glare is a function of:

1. The intensity of the glare upon the eye (retinal irradiance)
2. The subtended angle of the glare source (i.e., the extent to which the glare occupies the receptor's field of vision; dependent on size and distance of the reflector).

The severity of the ocular hazard can be divided into three levels, as shown in Figure 2:

- **Green glare**, which has low potential to cause temporary afterimage
- **Yellow glare**, which has potential to cause temporary afterimage
- **Red glare**, which can cause retinal burn and is not expected for PV.

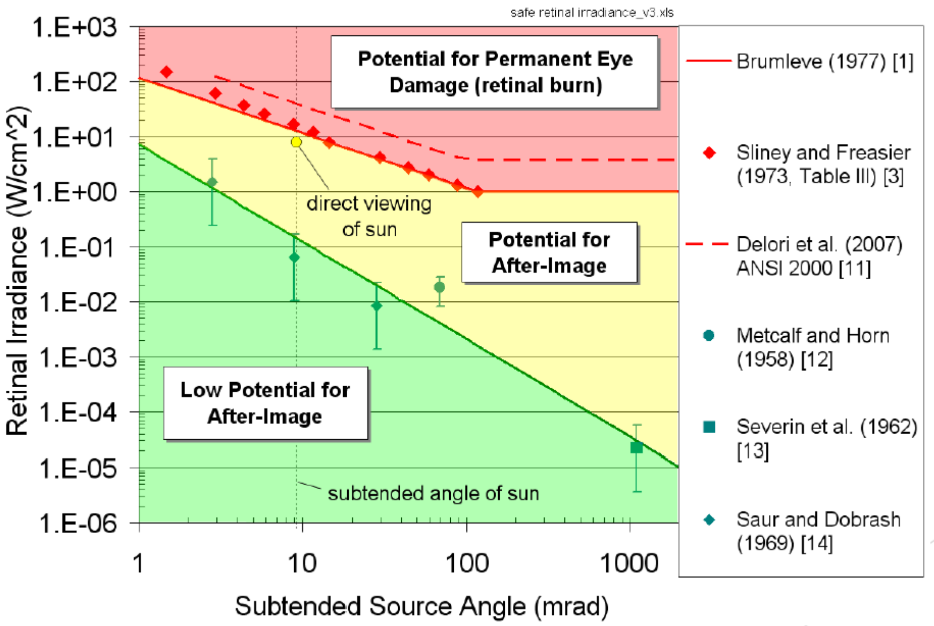

Figure 2: Classification of glare based on severity of ocular effects

1.3 Glare from Solar PV

Solar photovoltaic (PV) cells are designed to absorb as much light as possible to maximise efficiency (generally around 98% of the light received). To limit reflection, solar cells are constructed from dark, light-absorbing material and are treated with an anti-reflective coating. PV modules generate less glare than many other surfaces, as shown in Figure 3.

The small percentage of light reflected from PV modules varies depending on the angle of incidence. Figure 4 shows an example of this with a solar module. A larger angle of incidence will result in a higher percentage of reflected light.

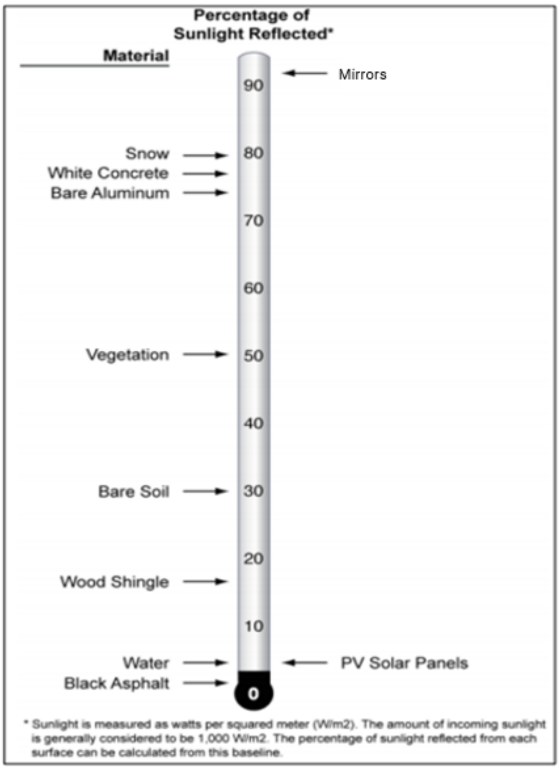

Figure 3: Typical percentage of sunlight reflected from different surfaces (Source: Adapted from Journal of Airport Management, 2014)

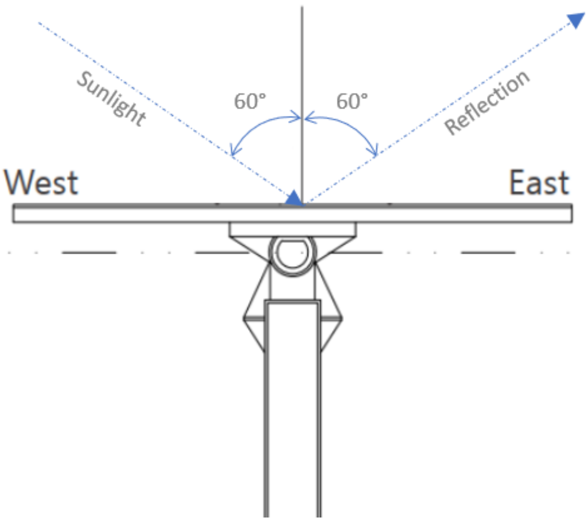

Figure 4: Typical sunlight reflection off the surface of a solar module

The two most common PV mounting structures are fixed tilt and single axis tracking. Fixed tilt arrays are stationary, while single axis tracking arrays rotate the receiving surface of the modules from east to west throughout the day as the sun moves across the sky.

In a fixed tilt PV array, since the sun is moving but the modules are stationary, the angle of incidence varies as the sun moves across the sky. It is smallest around noon when the sun is overhead and largest in the early morning and late afternoon when the sun is near the horizon. There is therefore a higher potential for glare at these times.

The angle of incidence for a single axis tracking system varies less as the reflective surface of the modules rotates on a horizontal axis to follow the sun. Single axis tracking arrays therefore generate less glare than fixed tilt arrays. The tracking varies throughout the year to match seasonal changes in the sun's path (see Figure 5).

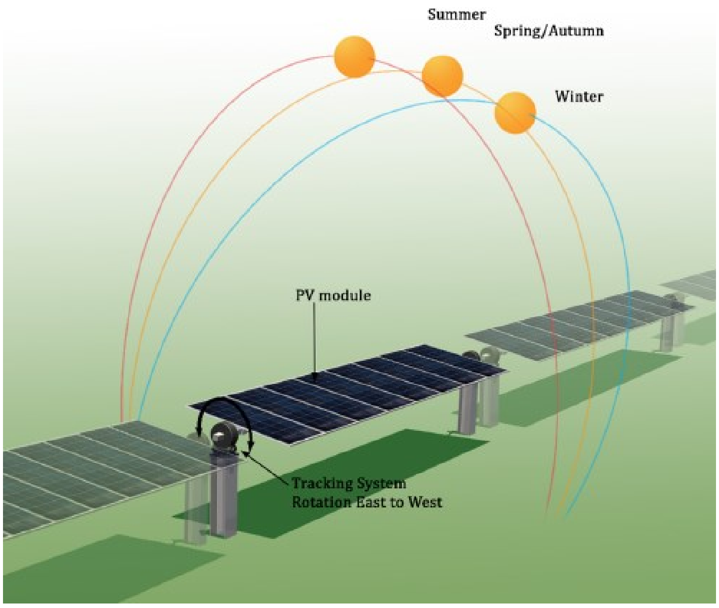

Figure 5: Sun position relative to PV modules on a horizontal single-axis tracking system

2 PROJECT DESCRIPTION

2.1 Site Overview

Helios is proposing a solar farm at the location described in Table 1. The site is located approximately 14 km west of Waipawa in the Central Hawkes Bay. An indicative layout is displayed in Figure 6.

Table 1: Site Information

Parameter	Description
Title No.	Lot 2 DP 21496, Lot 1 DP 27344, Lot 4 DP 568563
Address	Taylor Rd, Ongaonga 4278
Council	Central Hawke's Bay District Council
Project area	240 ha

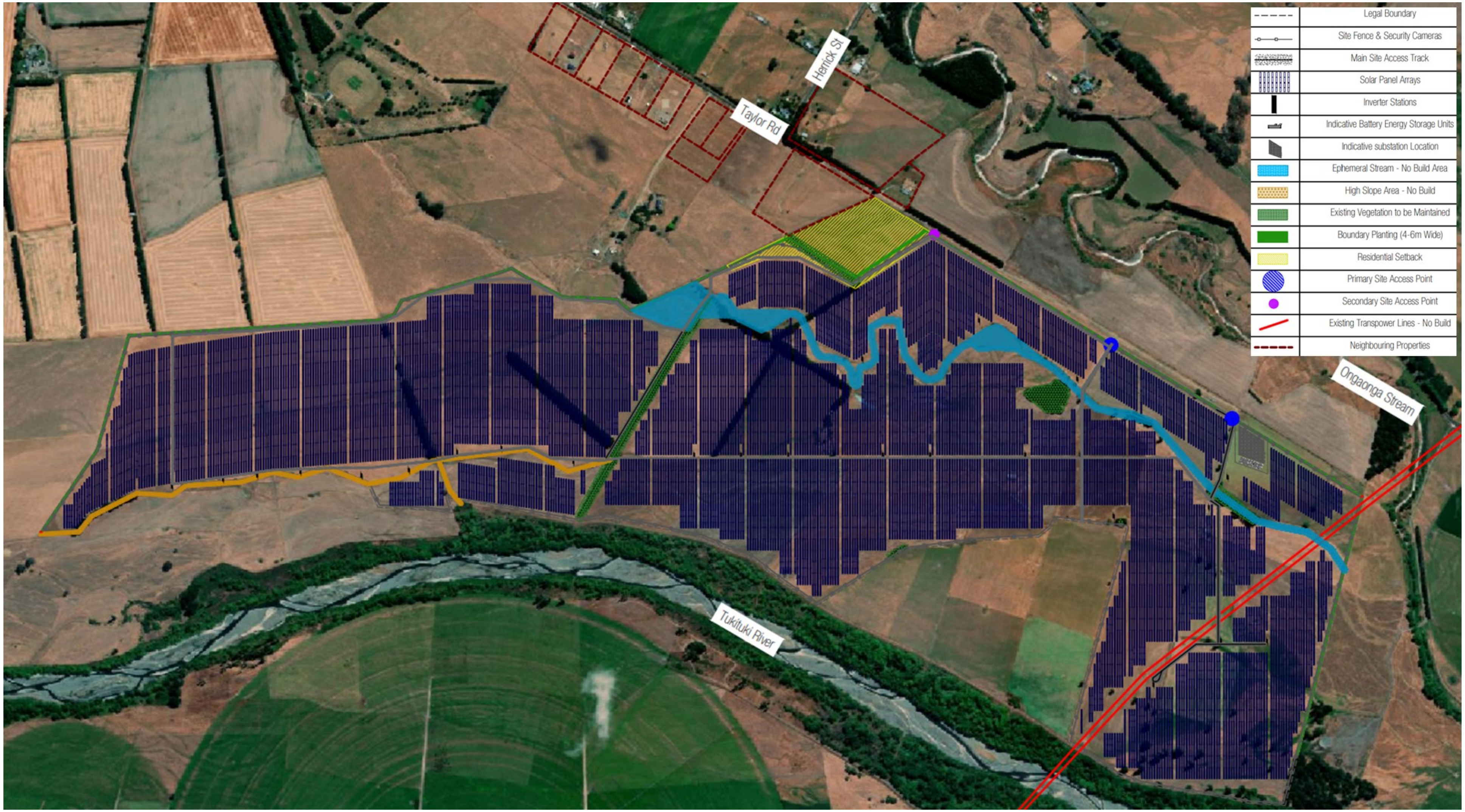

Figure 6: Ongaonga Solar Farm Preliminary PV layout

2.2 Solar Farm Details

Table 2 summarises the details of the proposed solar farm.

Table 2: Solar farm information

Parameter	Description
Solar farm name	Ongaonga Solar Farm
Capacity	126 MWp
Mounting system	Single-axis tracking

Helios is proposing to construct a solar farm with a capacity of 126 MWp on a 240 ha site. There will be approximately 204,400 solar modules installed in single-axis tracking tables running north to south. Panels are arranged in a portrait configuration, with tracker rows ranging from 52-104 modules in length. The solar farm will include 26 medium voltage (MV) inverters, each with a capacity of 4.2 MVA.

3 ANALYSIS

3.1 Overview

The Solar Glare Hazard Analysis Tool (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 was required by the United States FAA for glare hazard analysis near airports until 2021 and is also recognised by the Australian Government Civil Aviation Safety Authority (CASA).

The GlareGauge software uses SGHAT to provide an indication of the type of glare expected at each potential receptor. It runs with a simulation timestep of one minute. Glint lasting for less than one minute is unlikely to occur from the sun on PV modules due to their slow movement.

3.2 Assumptions

The visual impact of solar farms 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. Our model includes selected obstructions[2] as described in Section 3.3.2.

Atmospheric conditions such as cloud cover influence light reflection and the resulting impact on visual receptors. GlareGauge does not model varying atmospheric conditions; instead, the model assumes clear sky conditions, with a peak direct normal irradiance (DNI) of 1,000 W/m^2 which varies throughout the day.

Table 3 details the parameters used in the SGHAT model. GlareGauge default settings were adopted for the analysis time interval, direct normal irradiance, observer eye characteristics and slope error. The height of the observation points for road users was assumed to be 1.5 m. The height for a person standing was assumed to be 1.65 m.

Table 3: SGHAT specification inputs

Parameters	Input
Time zone	UTC+13:00
Module surface material	Smooth glass with ARC (anti-reflective coating)
Module tracking	Single Axis Tracking with backtracking
Maximum tilt angle	±60˚

[2] In the GlareGauge model, obstructions are opaque barriers that block the transmission of incident and reflected light

Parameters	Input
Module axis orientation	0°
Height of modules above ground	1.7 m (height from the ground to the table centre)

3.3 Model construction

3.3.1 Study area

This assessment considers potential visual receptors (e.g., residences and road users) within 2 km of the site. There is no formal guidance on the maximum distance for glint and glare assessments; however, the significance of a reflection decreases with distance for two main reasons:

3. The solar farm appears smaller (smaller subtended angle), and glare has less impact
4. Visual obstructions (e.g., terrain, vegetation) may block the view of the solar farm

Glint and glare impacts beyond 2 km are highly unlikely. This choice of distance is conservative and is based on existing studies and assessment experience.

3.3.2 Model components

The model (see Figure 7) was constructed as follows:

- The array was divided into eight separate PV objects based on the general arrangement (see Figure 8).
- Receptors were placed at 39 observation points and 10 road routes (see Figure 9 and Figure 10).
- Nine observation points and three road routes were excluded (see Figure 11, and Appendix A).
- Obstructions included lines of existing trees and proposed vegetation screens.[3] All obstructions included in the model are displayed in Figure 8. Obstruction heights varied based on the maturity of the vegetation and details on proposed vegetations screens.[3]

In some instances, a single OP is used in the model to denote a few buildings located close together, as the received glare is generally not very sensitive to precise locations (assuming that line of sight is not impacted by obstructions). We also usually exclude buildings in towns that are not on the edge facing the solar farm, as their line of sight is obstructed by surrounding buildings.

[3] 4894 Ongaonga Solar Planting LR, provided to ITP by Helios

3.4 Simulations

ITP conducted simulations of the glare impact in the first and fifth years of solar farm operation. This assesses how glare impact may change with the growth of the proposed vegetation screens. Obstruction heights were calculated as a weighted average based on the indicative mix of plant species' comprising the screens, in each of the years simulated.[3]

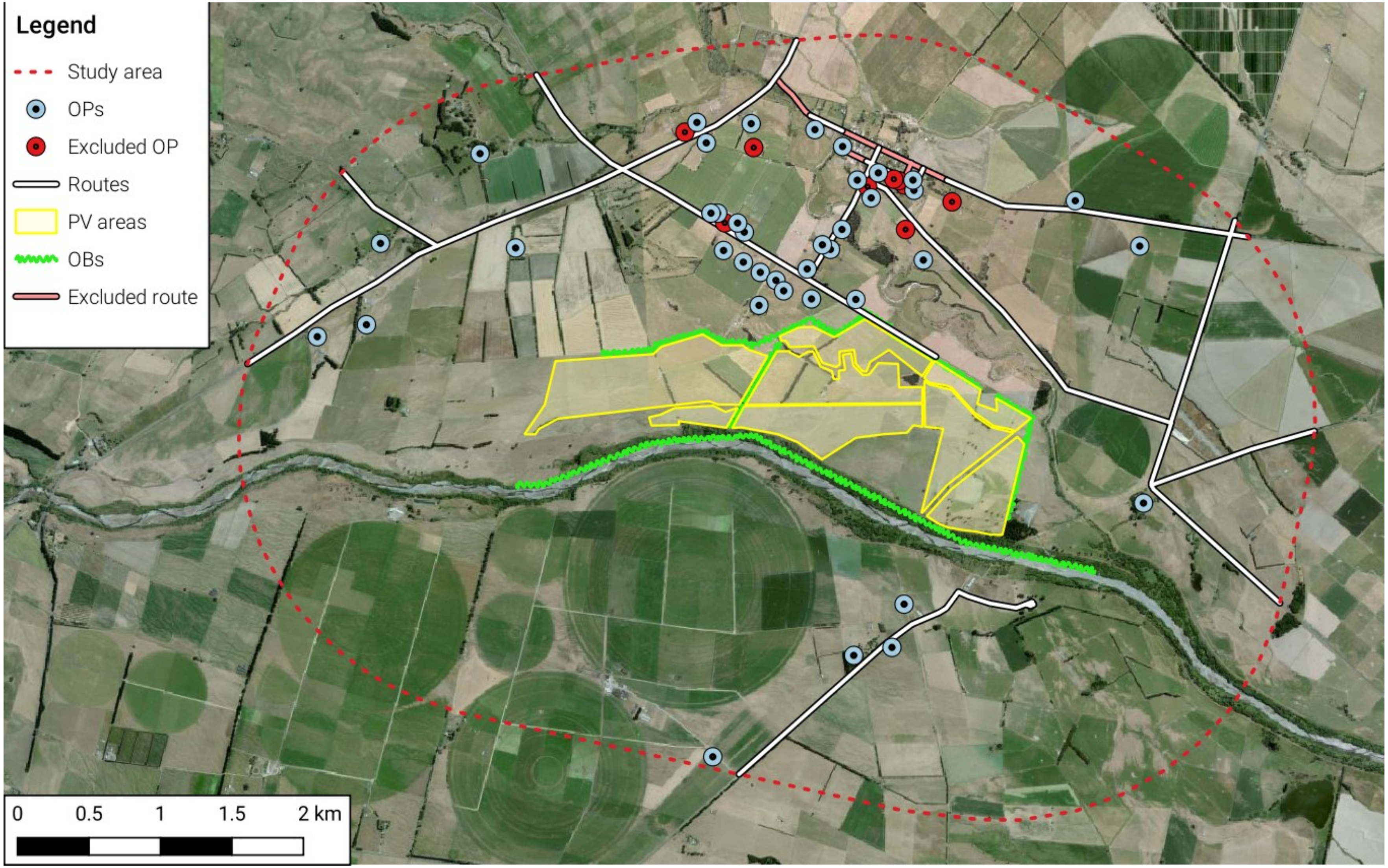

Figure 7: Model showing study area, arrays, receptors, and obstructions.

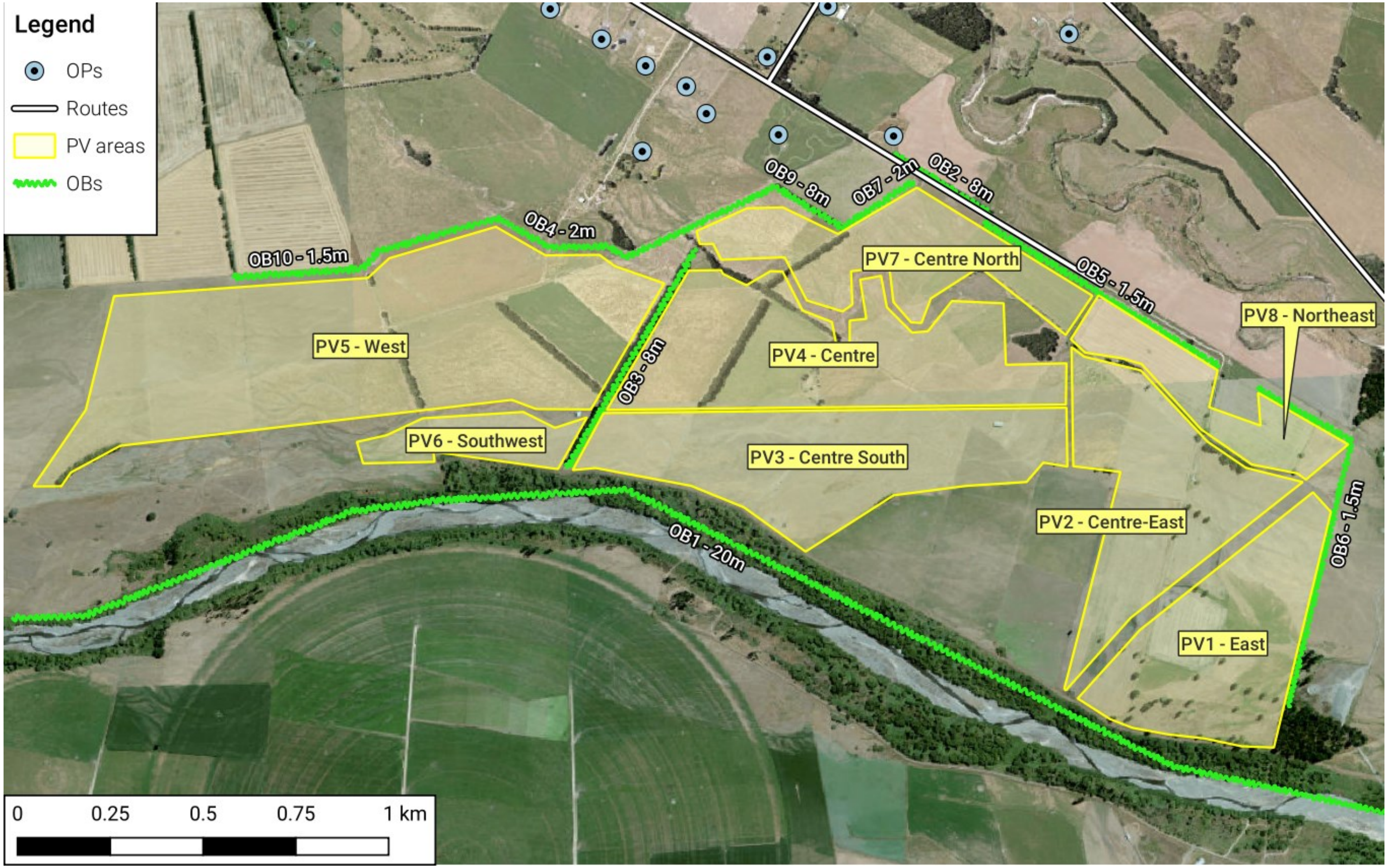

Figure 8: PV array sections and obstructions

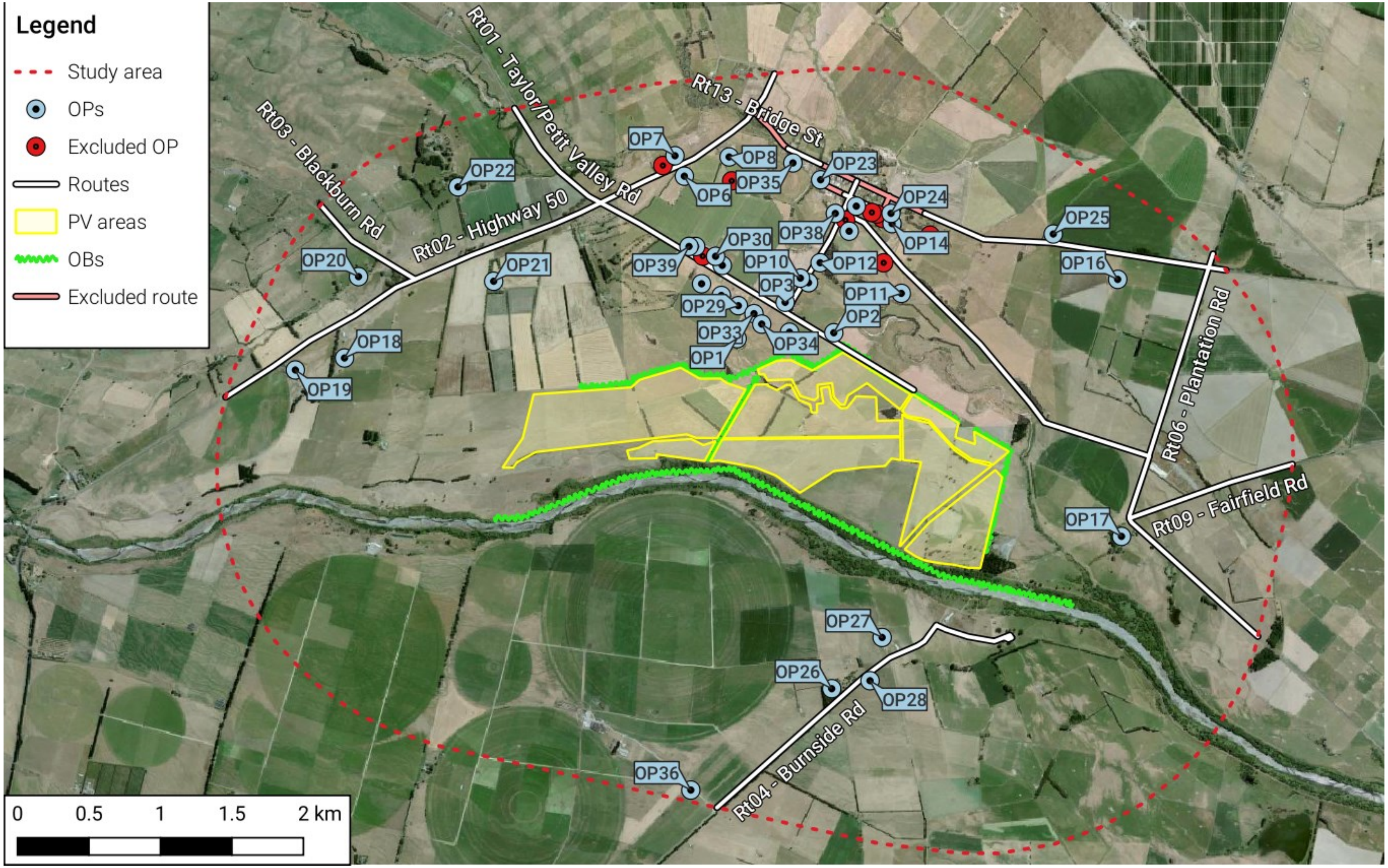

Figure 9: Potential receptors

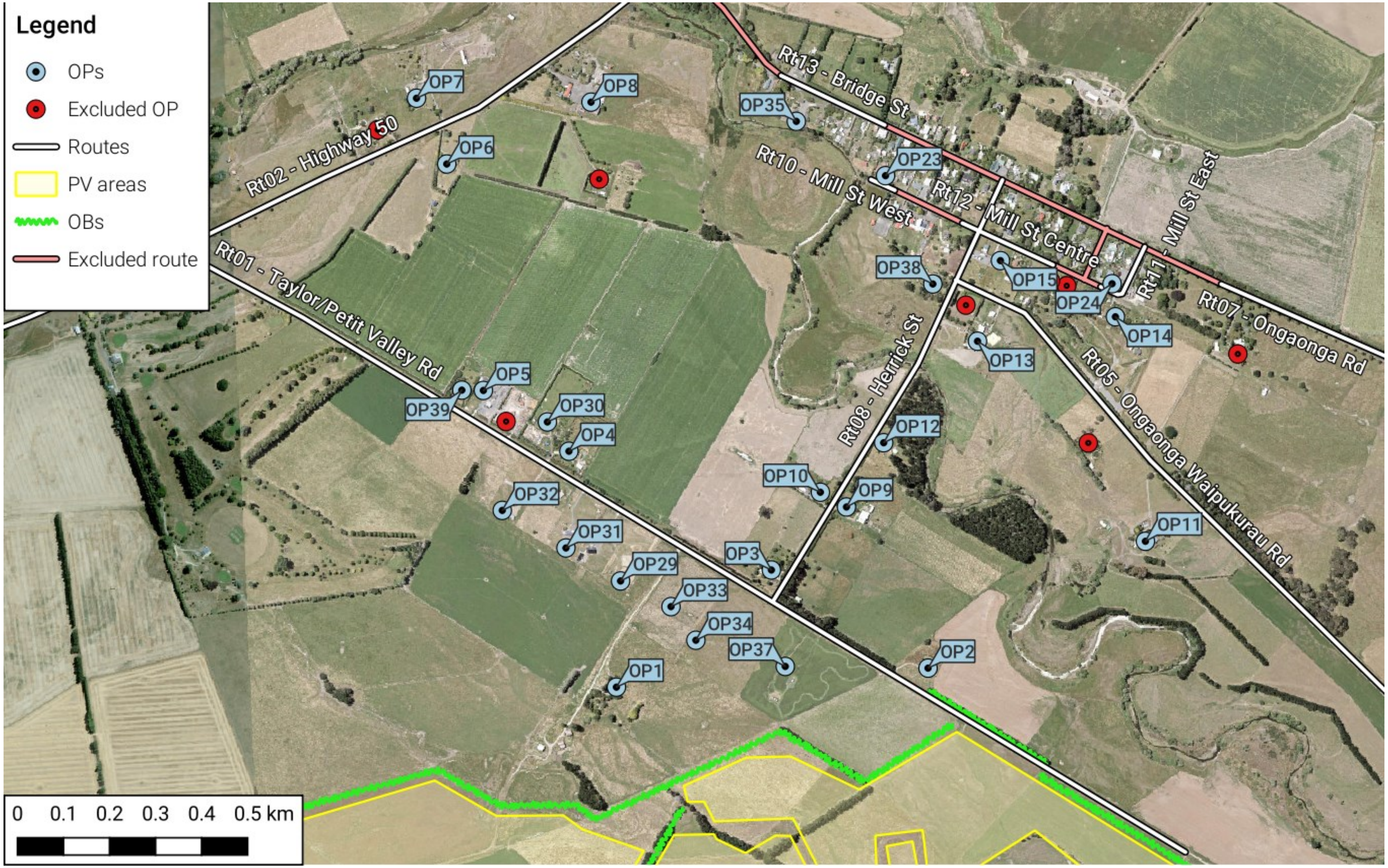

Figure 10: Receptors due north of Ongaonga Solar Farm

Figure 11: Excluded receptors.*Excluded receptors are detailed in Appendix A.*

3.5 Results

Our results are presented below for two scenarios:

1. **Year 1:** With vegetation screens planted.
2. **Year 5:** With vegetation screens after five years of growth.

3.5.1 Year 1 Results

The results of the GlareGauge analysis for year 1 (Appendix B) are summarised in Table 4. Over the period of a year, the analysis identified 1,499 minutes (~25 hours) of cumulative green glare, and 215 minutes (~3.5 hours) of cumulative yellow glare spread across five routes and two observation points.

The glare received each day varied across the year. For observation points where some glare occurred, the impact is described qualitatively. No observation points or routes received more than 9 minutes of glare in any single day. The time of day at which glare was observed varied between observation points and across the year. In general, most glare occurred in the early mornings or late evenings, when the array is backtracking.

Table 4: Glare potential at each receptor in year 1.

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP1	126 Taylor Road, Ongaonga	0	0	None
OP2	179 Taylor Road, Ongaonga	0	0	None
OP3	98 Herrick Street, Ongaonga	0	0	None
OP4	93 Taylor Road, Ongaonga	0	0	None
OP5	73 Taylor Road, Ongaonga	0	0	None
OP6	1567 Highway 50, Ongaonga	0	0	None
OP7	1564 Highway 50, Ongaonga	0	0	None
OP8	1539 Highway 50, Ongaonga	0	0	None
OP9	79 Herrick Street, Ongaonga	0	0	None
OP10	80 Herrick Street, Ongaonga	0	0	None
OP11	865 Ongaonga Waipukurau Road, Ongaonga	0	0	None
OP12	61 Herrick Street, Ongaonga	0	0	None
OP13	913 Ongaonga Waipukurau Road, Ongaonga	0	0	None
OP14	13 Mill Street, Ongaonga	0	0	None
OP15	33-41 Mill Street, Ongaonga	0	0	None
OP16	1343 Ongaonga Road, Ongaonga	0	0	None

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP17	593 Ongaonga Waipukurau Road, Ongaonga	405	0	Up to 9 minutes of green glare between 4:30 pm and 5:30 pm, from 9 May to 3 July and from 11 July to 3 August.
OP18	1815 Highway 50, Ongaonga	0	0	None
OP19	1881 Highway 50, Ongaonga	0	0	None
OP20	21 Blackburn Road, Ongaonga	0	0	None
OP21	1713 Highway 50, Ongaonga	0	0	None
OP22	1730 Highway 50, Ongaonga	0	0	None
OP23	62-68 Mill Street, Ongaonga	0	0	None
OP24	14-16 Mill Street, Ongaonga	0	0	None
OP25	1396 Ongaonga Road, Ongaonga	0	0	None
OP26	1017 Burnside Road, Ashley Clinton, Takapau	0	0	None
OP27	1063 Burnside Road, Ashley Clinton, Takapau	0	0	None
OP28	1046 Burnside Road, Ashley Clinton, Takapau	0	0	None
OP29	112 Taylor Road, Ongaonga	0	0	None
OP30	91 Taylor Road, Ongaonga	0	0	None
OP31	100 Taylor Road, Ongaonga	0	0	None
OP32	92 Taylor Road, Ongaonga	0	0	None

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP33	128 Taylor Road, Ongaonga	0	0	None
OP34	138 Taylor Rd, Ongaonga	0	0	None
OP35	83 Bridge Street, Ongaonga	0	0	None
OP36	958 Ashcott Road, Ashley Clinton, Takapau	0	0	None
OP37	162 Taylor Road, Ongaonga	21	0	Up to 2 minutes of green glare between 4:45 am and 5:15 am, from 5 December to 29 December.
OP38	22 Herrick Street, Ongaonga	0	0	None
OP39	69 Taylor Rd, Ongaonga	0	0	None
RT01	Taylor Road	37	200	Up to 5 minutes of yellow glare between 6:00 pm and 7:30 pm, from 1 February to 12 March and from 1 October to 8 November.
RT02	Highway 50	0	0	None
RT03	Blackburn Rd	0	0	None
RT04	Burnside Rd	482	0	Up to 9 minutes of green glare between 4:15 pm and 5:00 pm, from 20 May to 24 July.
RT05	Ongaonga Waipukurau Rd	206	1	Up to 1 minute of yellow glare between 6:30 pm and 6:45 pm, on 13 March.
RT06	Plantation Rd	0	0	None
RT07	Ongaonga Rd	51	0	Up to 1 minute of green glare between 6:45 pm and 7:45 pm, from 4 November to 15 December and from 27 December to 27 January.
RT08	Herrick St	0	0	None
RT09	Fairfield Rd	297	14	Up to 1 minute of yellow glare between 4:45 pm and 6:00 pm, from 7 April to 1 May, from 9 May to 16 May, from 1 August to 13 August, on 21 August, and on 8 September.

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
RT10	Mill St West	0	0	None
RT11	Mill St East	0	0	None
RT12	Mill St Centre	0	0	None
RT13	Bridge St	0	0	None
Total		**1,499**	**215**	

The yellow glare received by Taylor Road was limited to the section immediately before it turns into a paper road,[4] as illustrated by Figure 12. The yellow glare is reflected from the PV array adjacent to this section of the road, displayed in Figure 13. We expect very low traffic volume along this section of road. Combined with the short daily duration, we consider this glare to be low impact.

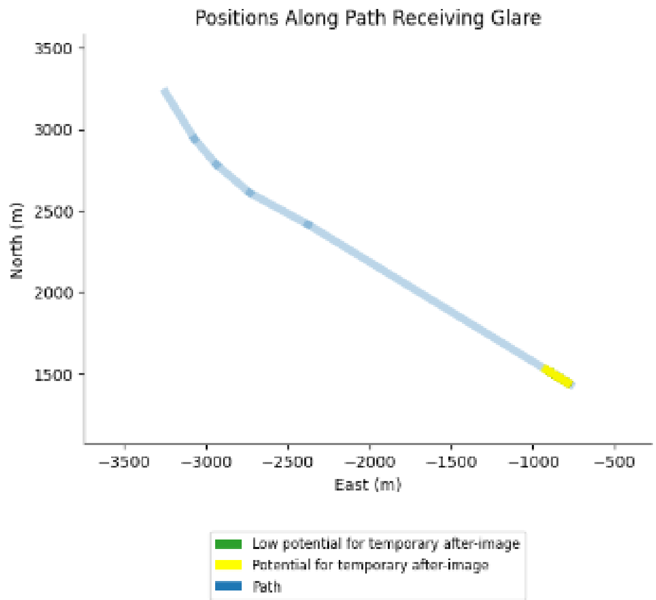

Figure 12: Location of glare impact on Taylor Road

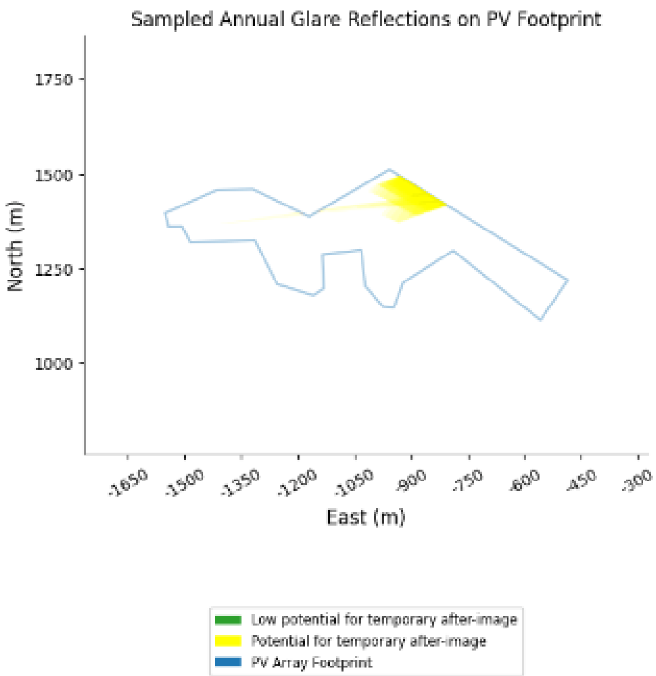

Figure 13: Glare reflections on PV footprint

[4] A legal road that is not formed or is only partly formed.

Fairfield Rd experienced some yellow glare, spread across various points along the road, as displayed in Figure 14. Ongaonga Waipukurau experienced 1 minute of yellow glare. Figure 15 displays the sections of Ongaonga Waipukurau Rd subject to some glare. We consider the glare experienced by these receptors to be low impact, as it occurs infrequently, and for short periods of time.

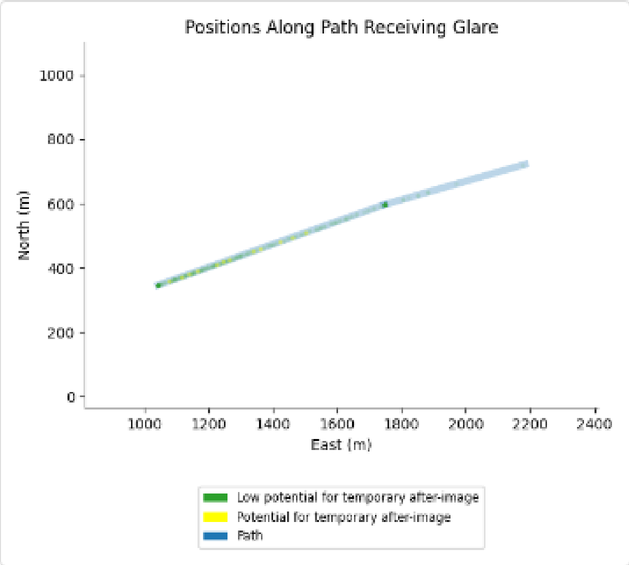

Figure 14: Location of glare impact on Fairfield Rd

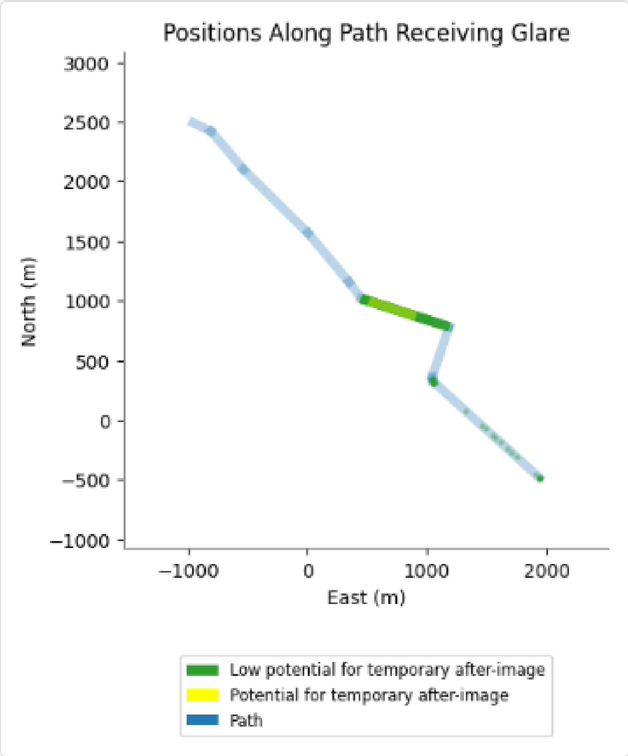

Figure 15: Location of glare impact on Ongaonga Waipukurau Rd

3.5.2 Year 5 Results

The results of the GlareGauge analysis for year 5 (Appendix B) are summarised in Table 5 for receptors that were subject to some glare in year 1. Over the period of one year, the analysis identified 1,095 minutes (~18 hours) of green glare and 205 minutes (~3 hours) of yellow glare. This shows a 27% reduction in green glare, and a 5% reduction in yellow glare when compared to the first year of operation.

Table 5: Glare potential in year 5.

Receptor	Location	Green (min/yr)	Yellow (min/yr)	Daily glare potential
OP17	593 Ongaonga Waipukurau Road, Ongaonga	169	0	Up to 3 minutes of green glare between 4:30 pm and 5:30 pm, from 9 May to 3 July and from 18 July to 3 August.
OP37	162 Taylor Road, Ongaonga	0	0	None
RT01	Taylor Road	36	195	Up to 5 minutes of yellow glare between 6:00 pm and 7:30 pm, from 1 February to 11 March and from 1 October to 8 November.
RT04	Burnside Rd	484	0	Up to 10 minutes of green glare between 4:15 pm and 5:00 pm, from 20 May to 24 July.
RT05	Ongaonga Waipukurau Rd	114	3	Up to 1 minute of yellow glare between 5:15 pm and 5:45 pm, on 17 April, 26 April, and 15 August.
RT07	Ongaonga Rd	59	0	Up to 2 minutes of green glare between 6:45 pm and 7:45 pm, from 4 November to 15 December and from 26 December to 28 January.
RT09	Fairfield Rd	233	7	Up to 1 minute of yellow glare between 5:00 pm and 5:45 pm, on 18 April, from 28 April to 1 May, and from 10 August to 21 August.
Total		**1,095**	**205**	

4 SUMMARY

The results of the GlareGauge analysis for year 1 indicated two observation points and five road routes received green glare, while three road routes received yellow glare (Taylor Road, Ongaonga Waipukurau Road, and Fairfield Road). Yellow glare has the potential to cause after-image to observers, while green glare has low potential to cause after-image. In year 5, the growth of the vegetation screens reduced the glare impact for all receptors.

Taylor Road received the most glare, with up to 5 minutes of yellow glare in a single day. The yellow glare received by Taylor Road was limited to the section immediately before it turns into a paper road. We expect very low traffic volume along this section of road. Combined with the short daily duration, we consider this glare to be low impact, and further mitigation is not required.

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/

Thompson, R., Ave, I., Anne, D., Jan, M., David, S. and Robert, C., 2013. Interim policy, FAA review of solar energy system projects on federally obligated airports.

Barrett, S., Devita, P., Ho, C. and Miller, B., 2014. Energy technologies' compatibility with airports and airspace: Guidance for aviation and energy planners. Journal of Airport Management, 8(4), pp.318-326.

APPENDIX A. EXCLUDED RECEPTORS

Table 6: Excluded receptors

Receptor	Location	Justification
Exc 01	1578 Highway 50, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 02	881 Ongaonga-Waipukurau Rd, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 03	1557 Highway 50, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 04	17 Mill St, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 05	21 Mill St, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 06	23 Mill St, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 07	1483 Ongaonga Rd, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc 08	Between 73 and 91 Taylor Rd	Is a firewood business and not a dwelling
Exc 09	27 Herrick St, Ongaonga	View of solar farm obscured by surrounding vegetation
Exc Route 1	Sections of Mill St	View of solar farm obscured by surrounding vegetation and buildings
Exc Route 2	Sections of Ongaonga Rd	View of solar farm obscured by vegetation to the south
Exc Route 3	Sections of Bridge St	View of solar farm obscured by surrounding vegetation and buildings

APPENDIX B. FORGESOLAR GLARE ANALYSIS

We have attached the following analysis reports exported from ForgeSolar:

- **ForgeSolar – Year 1:** results described in 3.5.1 with vegetation screen height at the time of planting.
- **ForgeSolar – Year 5:** results described in 3.5.2 with vegetation screen height after 5 years of growth.

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