SOLAR BAY – TARARUA
Glint/Glare Assessment

MANGAMAIRE ROAD, TARARUA

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Document Version

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Approval

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Related Documents

Document Type	Document Title (Number & Title)
ForgeSolar Report	APPENDIX I - Tararua SAT Existing V20230811
ForgeSolar Report	APPENDIX II - Tararua SAT Potential V20230811
Architects Document	APPENDIX III - Tararua Receptor Locations
Architects Document	APPENDIX IV - Tararua Planting Mitigation

Stakeholder Consultation

Name	Position

1. Executive Summary

Vector PowerSmart (**VPS**) was engaged by Solar Bay (**SB**) to prepare a Glint and Glare Assessment at Tararua, Mangamaire Road, Tararua.

Conclusions:

- Two ForgeSolar Glint and Glare reports were produced, the first for existing receptors and a second for potential receptors.
- Both the eastern and western arrays are expected to produce yellow glare on several of the existing and potential OPs with minimal green glare.
- As yellow glare is present, further consultation may need to be undertaken to determine if extra mitigation is required.
- No red glint and/or glare is predicted in any of the scenarios.
- If a stow alarm occurs due to an isolated event such extreme weather or failure of equipment, the mounting system may stow into a manufacturer determined angle and orientation to protect the array.

2. GlareGauge Glint and Glare Assessment Report

2.1. Glint and Glare from PV Modules

Light reflects off all surfaces with the potential of causing glint (a momentary flash of bright light) and glare (a continuous source of bright light) and can possibly occur when reflected of a surface. Both phenomena can cause a brief loss of vision and a potential for after imaging. After image is define as an impression of a vivid image retained by the eye after viewing of the light source has ceased. Glint is usually experienced from moving reflectors whereas glare may occur when the reflector is slow or stationary.

As PV modules are constructed from light-absorbing material to absorb as much solar irradiation as possible to increase their efficiency and often include an anti-reflective coating therefore reflectivity is low compared to many other common materials such as vegetation and equal to water. This can be seen in Figure 1 below:

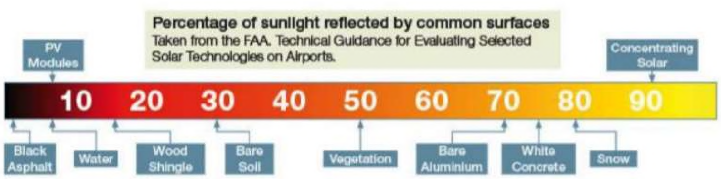

Figure 1: Chart indicating reflectivity of common surfaces. https://www.forgesolar.com/help/

The position of the PV modules relative to the sun has the largest effect on the module's reflectivity. As shown in Figure 2 below, the larger the angle of incidence the higher the percentage of light is reflected.

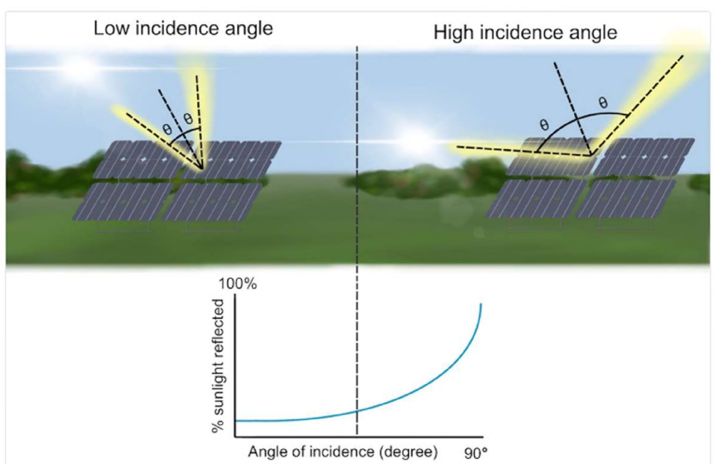

Figure 2: Angle of incidence effect on PV module reflectivity. https://www.forgesolar.com/help/

Single axis tracking systems tend to have a smaller angle of incidence as they follow the sun therefore reflecting less light than fixed-tilt systems that are stationary. As fixed-tilt systems are stationary the angle of incidence varies throughout the day (higher reflectivity generally occurs during sunrise and sunset) and will often reflect more light than single axis tracking systems.

2.2. GlareGauge Glint and Glare Assessment Tool

As it is possible for PV modules to create glint and glare, a comprehensive analysis was undertaken by Vector PowerSmart (VPS). There is currently no guidance from New Zealand's Civil Aviation Authority (CAA) or any other local organisations around assessment methods for glint and glare caused by solar farms however the American Federal Aviation Administration (FAA) previously recommended the Solar Glaze Hazard Analysis Tool (SGHAT). This tool has since been developed into GlareGauge by ForgeSolar.

The GlareGauge tool identifies possible glare from PV arrays and classifies them regarding their ocular impact. It should be noted that this software doesn't consider view shedding, (the blocking of the glare source from buildings, terrain, or vegetation, therefore representing a worst-case scenario unless stated otherwise).

The ocular impact of solar glare is quantified into three categories showing effect of after image:

- Green - low potential to cause after-image.
- Yellow - potential to cause temporary after-image.
- Red - potential to cause retinal burn.

If any glare occurs in the model, it is classified into the three colour-coded categories as seen in Figure 3 below:

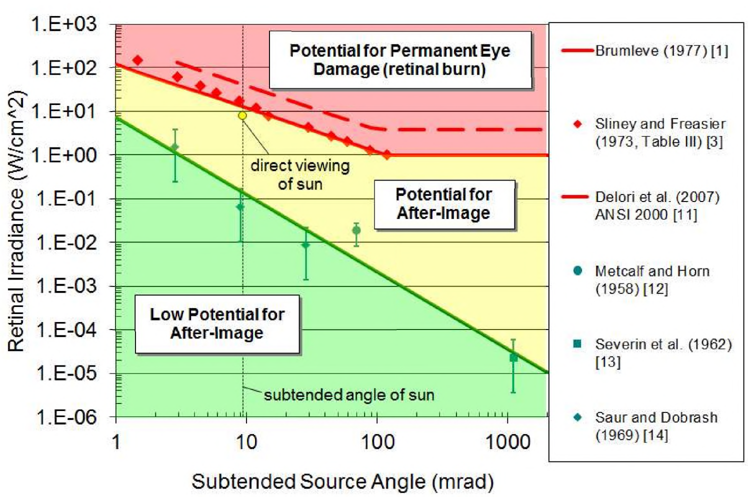

Figure 3: Sample glare hazard plot showing after image potential. https://www.forgesolar.com/help/#ref-ho-2011-method.

Essentially if the simulation predicts glare, the ocular impact of the glare is plotted onto the graph shown in Figure 3 to determine the category it belongs to.

The subtended source angle represents the size of the object producing glare (in this case the PV array) viewed by an observer, while the retinal irradiance determines the amount of energy impacting the retina of the observer. Larger source angles (closer to the array) can result in glare of high intensity, even if the retinal irradiance is low. The further away the observer is to the array, the smaller the subtended angle will be thus decreasing the glare intensity.

It is important to note that the GlareGauge simulation uses "Clear Sky" model for simulation which is the worst-case scenario i.e., does not include clouds or other atmospheric conditions which would reduce glint and glare.

2.2.1. Impact Significant Definition

Table 1 below presents the recommended definition of 'impact significance' and the requirement for mitigation.

Impact Significance	Definition	Mitigation Requirement
No Impact	The assessed receptor will not experience any solar reflection due to lack of visibility.	No mitigation is necessary.
Low/Green	The assessed receptor may have a small visual impact from solar reflection, but it is considered insignificant.	No mitigation is necessary.
Moderate/Yellow	The assessed receptor may experience solar reflection, which is visible and considered to have a moderate impact.	Further analysis and consultation should be conducted to determine if mitigation measures are required.
High/Red	The assessed receptor will experience a significant impact from solar reflection.	Mitigation measures and consultation are strongly recommended. If the proposed development is to proceed it is highly likely mitigation will be necessary.

Table 1: Impact Significant Definition

2.3. FAA Glare Requirements

In 2013 the FAA released the "Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports"[1] which endorsed and required a SGHAT tool (now GlareGauge) analysis of the ocular impact of a proposed solar energy system on federally obligated airport. The FAA adopted the Glare Hazard Plot shown in Figure 3, and required the following standards to be met:

1. No potential for glint or glare in the existing or planned Airport Traffic Control Tower (ATCT) cab, and
2. No potential for glare or ''low potential for after-image'' (shown in green in Figure 3) along the final approach path for any existing landing threshold or future landing thresholds.

To summarize, the FAA allows the construction of a PV array that may produce green glare that can impact the pilots or other airport personal unless there is an impact on the ATCT. The FAA will not allow a PV array that produces "potential for after-image" (shown in yellow in Figure 3).

As there is no guidance from the CAA or Waka Kotahi, it is assumed the FAA guidance applies to Glint and Glare analysis in New Zealand. Therefore, predicted green glare should not require mitigation whereas yellow glare potentially would.

Note: the 2013 "Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports" was replaced in 2021 by the "Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally Obligated Airports"[2] which no longer recommends or requires a SGHAT tool (GlareGauge) analysis. Stating "The tool is no longer available to all users at no cost. There are several glint and glare analysis tools available to airport sponsors on the open market." Instead, the FAA requires the sponsor to confirm they have completed a glint and glare analysis and determined there is no impact on an ATCT.

[1] Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports: https://www.federalregister.gov/documents/2013/10/23/2013-24729/interim-policy-faa-review-of-solar-energy-system-projects-on-federally-obligated-airports

[2] Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports: https://www.federalregister.gov/documents/2021/05/11/2021-09862/federal-aviation-administration-policy-review-of-solar-energy-system-projects-on-federally-obligated

2.4. Sample Graph Cluster

Figure 4 below is a sample graph cluster, these graphs are the visual representation of the predicted glare effecting a receptor caused by the Solar Farm. Each OP or Route will have a graph cluster for each array that produces glare:

Note: Figure 4 only shows yellow glare. If red or green glare is present, it would also be represented on this example.

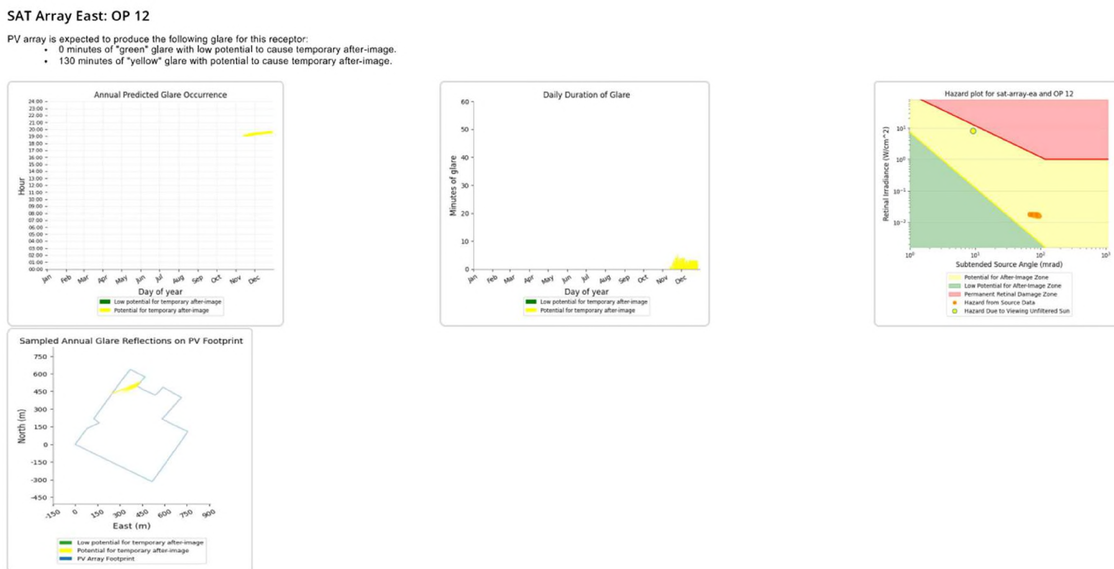

Figure 4: Sample Graph Cluster

Annual Predicted Glare Occurrence: This graph shows the time of day that glare occurs throughout the year. In this example, yellow is predicted between 7pm and 8pm during late September through to mid-March.

Daily Duration of Glare: This graph shows the duration of predicted glare in minutes throughout the year of which the longest period is approximately 5 minutes.

Hazard Plot for sat-array-ea and OP 12: Utilizes the same graph shown in Figure 3. As shown on the hazard plot in Figure 4, the orange plot points represent the intensity of the glare by the zone the plot appears in. In this case the glare is predicted to be yellow.

Sampled Annual Glare Reflections on PV Footprint: The blue outline shows the Solar Farm footprint. The area of the PV footprint that produces the received glare is represented by the colour spread across the footprint (either yellow or green glare). This example shows yellow glare is produced on the northern area across the array.

2.5. ForgeSolar Report

VPS used the ForgeSolar software tool to evaluate the potential for and duration of glare for receptors surrounding the proposed solar arrays. The receptors and obstructions were identified by Rough Milne Mitchell Landscape Architects, the receptors were further classified as the following:

- Existing: these are receptors mainly consisting of existing residences surrounding the arrays that could be affected if the arrays were operational at the present time, this also includes the two route receptors Mangamaire Road and Tutaekara Road.
- Potential: areas that are not currently inhabited but have the potential to be developed and settled in the future.

Two ForgeSolar reports were generated, the first for existing receptors and the second for potential. These reports can be found attached as Appendices I and II. The obstructions and PV array footprint is the same in both reports, the only variables are the OPs and route receptors.

Figure 5 below shows the site configuration Appendix I, existing receptors showing following information:

- SAT Array East and SAT Array West
- Existing Observation Points (OP) 1 to 20 located around both arrays.
- Route receptors Mangamaire Road and Tutaekara Road
- Various Obstructions located around both arrays, these obstructions include existing planting and proposed shelterbelts found in Appendix III and IV.

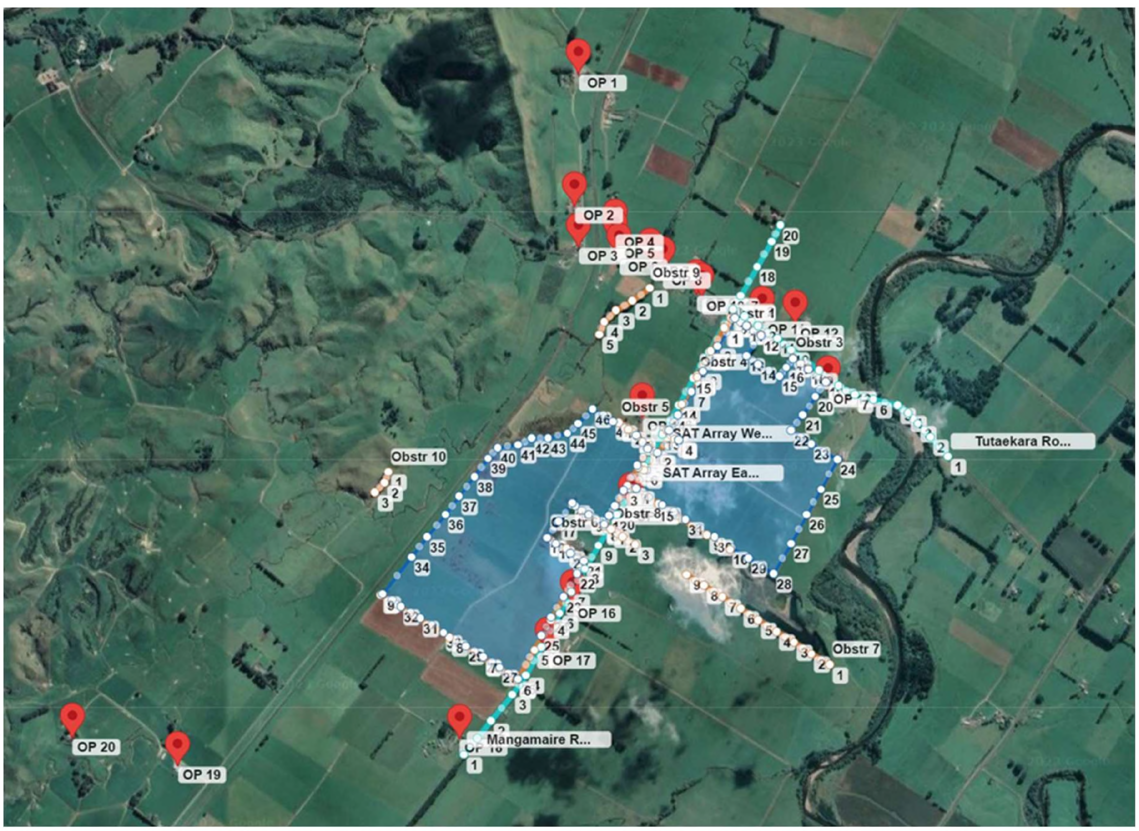

Figure 5: Site Configuration of Tararua Solar Farm with Existing Receptors

Figure 6 below shows the site configuration Appendix II, potential receptors showing following information:

- SAT Array East and SAT Array West
- Potential Observation Points (OP) 1 to 26 located around both arrays.
- Various Obstructions located around both arrays, these obstructions include existing planting and proposed shelterbelts found in Appendix III and IV.

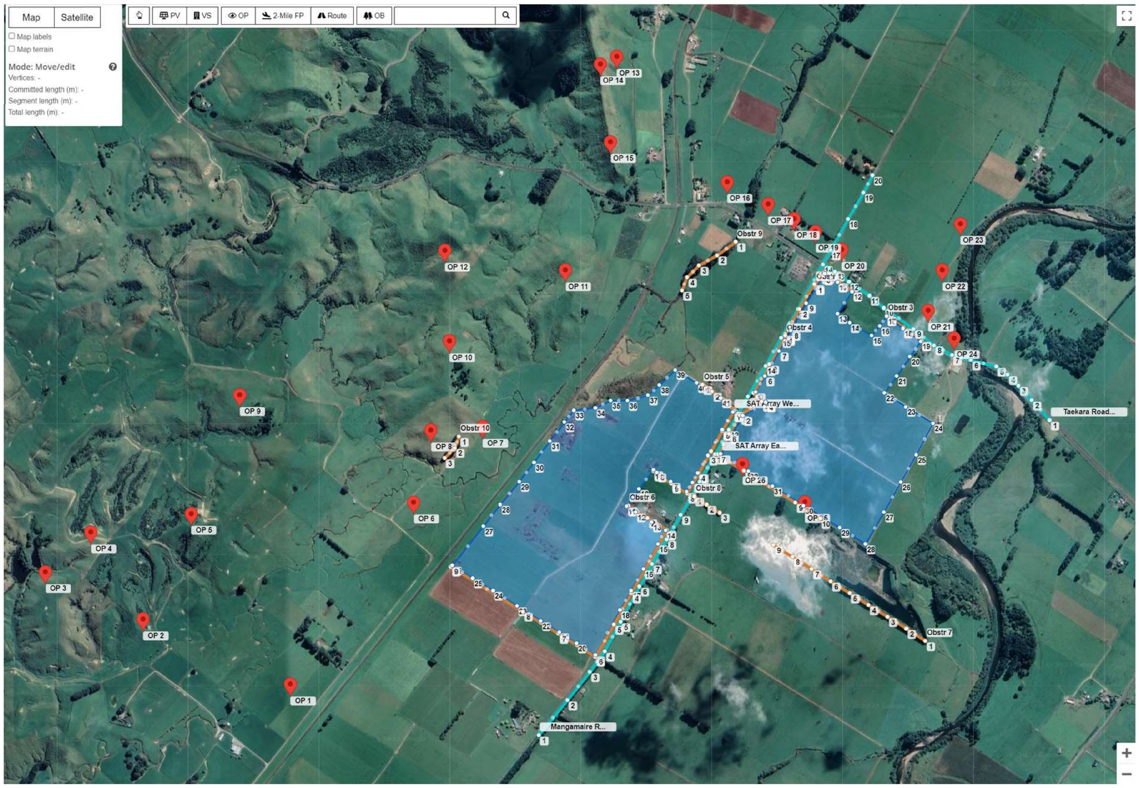

Figure 6: Site Configuration of Tararua Solar Farm with Potential Receptors

Note: OP1 for Appendix I existing receptors does not correspond to OP1 for Appendix II potential receptors, the same is true to all OPs. All OPs in Appendix I are separate to OPs in Appendix II.

3. Reported Glare

Full results are available in attached Appendices I and II.

Note: Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour. This software does not include viewshed analysis (therefore not accounting for terrain, buildings or vegetation blocking the glare source) thus representing a worst-case scenario.

3.1. Single Axis Tracker Existing Receptors Results

Table 2 below reports the predicted glare for **SAT Array East** based on the observations in Appendix I, existing receptors. Yellow glint/glare is reported at several of the OP's, no glare is predicted for the Route Receptors as shown in table 3:

OP	Time (Hours)	Duration (Month of year)	Max. Minutes of Glare per day	Glare		Total Minutes Annually
				Green	Yellow	
OP1	No Glare found					
OP2	No Glare found					
OP3	5am-5.30am	Mid-November to mid-December & early January	13	0	267	267
OP4	No Glare found					
OP5	No Glare found					
OP6	5am-5.30am	Late November to early January	10	0	271	271
OP7	No Glare found					
OP8	No Glare found					
OP9	No Glare found					
OP10	No Glare found					
O11	No Glare found					
OP12	7pm-8pm	Mid-November to late December	6	0	130	130
OP13	7pm-8pm	Mid-November to late December	4	0	111	111
OP14	No Glare found					
OP15	5am-7am	Early February to mid-March, late August to mid-October, early November to mid-	11	0	398	398

		December & early January				
OP16	No Glare found					
OP17	No Glare found					
OP18	No Glare found					
OP19	No Glare found					
OP20	No Glare found					

Table 2: Total annual glare predicted per existing receptor caused by SAT Array East.

Route Receptors	**Time (Hours)**	**Duration (Month of year)**	**Max. Minutes of Glare per day**	**Glare**		**Total Minutes Annually**
				Green	**Yellow**	
Route: Mangamaire Road	No Glare found					
Route: Tutaekara Road	No Glare found					

Table 3: Total annual glare predicted per existing Road Receptor caused by SAT Array East.

Table 4 below reports the predicted glare for **SAT Array West** based on the observations in Appendix I, existing receptors. No glint/glare is reported at all OP's, no glare is predicted for the Route Receptors as shown in table 5:

OP	Time (Hours)	Duration (Month of year)	Max. Minutes of Glare per day	Glare		Total Minutes Annually
				Green	Yellow	
OP1	No Glare found					
OP2	No Glare found					
OP3	No Glare found					
OP4	No Glare found					
OP5	No Glare found					
OP6	No Glare found					
OP7	No Glare found					
OP8	No Glare found					
OP9	No Glare found					
OP10	No Glare found					
O11	No Glare found					
OP12	No Glare found					
OP13	No Glare found					
OP14	No Glare found					
OP15	No Glare found					
OP16	No Glare found					
OP17	No Glare found					
OP18	No Glare found					
OP19	No Glare found					
OP20	No Glare found					

Table 4: Total annual glare predicted per existing receptor caused by SAT Array West.

Route Receptors	Time (Hours)	Duration (Month of year)	Max. Minutes of Glare per day	Glare		Total Minutes Annually
				Green	Yellow	
Route: Mangamaire Road	No Glare found					
Route: Tutaekara Road	No Glare found					

Table 5: Total annual glare predicted per existing Road Receptor caused by SAT Array West.

3.2. Single Axis Tracker Potential Receptors Results

Table 6 below reports the predicted glare for **SAT Array East** based on the observations in Appendix II, potential receptors. Green and yellow glint/glare is reported at several of the OP's.

OP	Time (Hours)	Duration (Month of year)	Max. Minutes of Glare per day	Glare		Total Minutes Annually
				Green	Yellow	
OP1	No Glare found					
OP2	No Glare found					
OP3	6.30am-7.30am	Late April & mid-August to mid-September	3	37	40	77
OP4	6.30am-7.30am	April, late August & late September	10	4	152	156
OP5	6am-7.30am	April & September	10	0	257	257
OP6	No Glare found					
OP7	No Glare found					
OP8	5.30am-7.30am	Late February to early March, April, late August & late September to late October	9	0	167	167
OP9	5.30am-7am	Late February to early March, early April & October	7	0	77	77
OP10	5am-7am	Sporadic from mid-September to early April	19	0	826	826
OP11	5am-7am	Sporadic from mid-September to late March	22	0	753	753
OP12	5am-7am	Sporadic from October to mid-March	22	0	706	706
OP13	No Glare found					
OP14	No Glare found					
OP15	5am-6am	Late November & late December to early January	10	0	174	174
OP16	No Glare found					

OP17	No Glare found					
OP18	No Glare found					
OP19	No Glare found					
OP20	No Glare found					
OP21	No Glare found					
OP22	7pm-8pm	Early & late November, January to early February	4	0	63	63
OP23	7pm-8pm	Early December to late January	5	0	170	170
OP24	No Glare found					
OP25	5am-6am	Early January	5	0	19	19
OP26	No Glare found					

Table 6: Total annual glare predicted per potential receptor caused by SAT Array East.

Table 7 below reports the predicted glare for **SAT Array West** based on the observations in Appendix II, potential receptors. Yellow glint/glare is reported at several of the OP's.

OP	Time (Hours)	Duration (Month of year)	Max. Minutes of Glare per day	Glare		Total Minutes Annually
				Green	Yellow	
OP1	No Glare found					
OP2	No Glare found					
OP3	6am-7am	Early March & mid-September to early October	4	0	80	80
OP4	6am-7am	March & September to mid-October	12	0	375	375
OP5	5.30am-7.30am	Sporadic late January to mid-March & late August to early November	21	0	1212	1212
OP6	No Glare found					
OP7	No Glare found					
OP8	5am-7am	Sporadic late August to mid-April	17	0	1669	1669
OP9	5am-7am	Sporadic early October to late March	25	0	1512	1512
OP10	5am-7am	Sporadic October to mid-March	43	0	3660	3660
OP11	No Glare found					
OP12	5am-6am	Sporadic mid-November to late January	47	0	1034	1034
OP13	No Glare found					
OP14	No Glare found					
OP15	No Glare found					
OP16	No Glare found					
OP17	No Glare found					
OP18	No Glare found					

OP19	No Glare found
OP20	No Glare found
OP21	No Glare found
OP22	No Glare found
OP23	No Glare found
OP24	No Glare found
OP25	No Glare found
OP26	No Glare found

Table 7: Total annual glare predicted per potential receptor caused by SAT Array West.

3.3. Stow Alarm

At times during situations such as isolated extreme weather events or failure of certain equipment a stow alarm will cause the mounting system to stow at a predetermined orientation and angle (often 0°) to protect the array. Due to such an event, there may be additional glare produced outside of the ForgeSolar predictions.

It is important to note that the Glint and Glare simulation uses "Clear Sky" model for simulation which is the worst-case scenario i.e., does not include clouds or other atmospheric conditions which would reduce glint and glare. The fact that typically high wind >= 55km/hour events are predominant with clouds/storms rather than cloudless, with isolated events where high wind prevail in a cloudless scenario, the actual glare at the receptors should be less than the simulation suggests.

Stow alarm conditions are determined by the mounting system manufacturer.

4. Conclusions and Observations

To conclude, both east and west arrays are predicted to produce glare for several of the existing and potential receptors. Glare is not predicted to effect either Mangamaire Road or Tutaekara Road. These results are based on analysis with the inclusion of existing and proposed shelterbelts.

No red glare was predicted in any of the scenarios.

Due to the absence of New Zealand guidance documentation (CAA or Waka Kotahi) or prior examples of acceptance criteria relating to glint and glare, the American FAA guidelines have been applied. Based on those guidelines, some mitigation may be required based on the presence of yellow glint and/or glare, more consultation may be required. Examples of further mitigation could include screening via additional shelterbelts.

If a stow alarm occurs due to an isolated event such extreme weather or failure of equipment, the mounting system may stow into a manufacturer determined angle and orientation to protect the array. This rare event could produce unforeseen glint or glare depending on stow angle and orientation.

Simulation uses “Clear Sky” weather data where glint and glare are not reduced due to atmospheric conditions or clouds obstructing the sun, essentially providing a worst-case scenario.

Appendices

APPENDIX I - Tararua SAT Existing V20230811

APPENDIX II - Tararua SAT Potential V20230811

APPENDIX III - Tararua Receptor Locations

APPENDIX IV - Tararua Planting Mitigation