WHEATCREST SOLAR PROJECT

Glint and Glare Assessment for the Wheatcrest Solar Project

BluEarth Renewables Inc.

Document No.: 10093992-HOU-R-03
Issue: C
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Date: 23 April 2021

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Project Name:	Wheatcrest Solar Project	DNV Energy Systems Canada Inc.
Report Title:	Glint and Glare Assessment for the Wheatcrest Solar Project	Bow Valley Square 4
		250 – 6 Avenue SW
Customer:	BluEarth Renewables Inc.	Calgary, AB T2P 3H7
	400, 214 – 11 Avenue S.W.	
	Calgary, AB T2R 0K1	
Contact Person:	Isabelle Deguise	
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Task and Objective:

This report presents a glint and glare assessment conducted for the Wheatcrest Solar Project located within the Municipal District of Taber, Alberta.

Prepared By:	Verified By:	Approved By:
Chelsea Scheske, B.Eng. Project Analyst	Gabriel Constantin Team Leader	Aren Nercessian Project Siting Engineer

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Issue	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	23 October 2020	Draft	C. Scheske	A. Rieseberg	J. Newmiller
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C	23 April 2021	Update to solar technology	C. Scheske	G. Constantin	A. Nercessian

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List of Abbreviations

Abbreviation	Meaning
ARC	Anti-Reflective Coating
AUC	Alberta Utilities Commission
ASL	Above Sea Level
BMP	Best Management Practice
DNV	DNV Energy Systems Canada Inc.
km	Kilometre
m	Metre
MD	Municipal District
MST	Mountain Standard Time
OPR	Observation Point Receptor
PV	Photovoltaic
RPR	Route Path Receptor

EXECUTIVE SUMMARY

BluEarth Renewables Inc. ("BluEarth" or the "Proponent") retained DNV Energy Systems Canada Inc. ("DNV") to perform an independent glint and glare assessment for the proposed Wheatcrest Solar Project (the "Project") which is located within the Municipal District of Taber, approximately 13 kilometres north of the Hamlet of Enchant.

DNV used Forge Solar's GlareGauge solar glare analysis tool to predict glare occurrence at identified observation point receptors and route path receptors within the vicinity of the Project and evaluated the associated ocular impacts on nearby dwellings, roads, and aviation activity. The following receptors were considered in the assessment:

- Two dwellings;
- Five local roads; and
- Seven intersections.

If found, glare predicted to occur at receptors was categorized into an ocular hazard colour code (green, yellow, or red) based on the intensity and angle of incoming light.

The results of this assessment show that glare from the Project is not expected to impact any of the receptors included in the current analysis. DNV is of the opinion that no mitigative actions are warranted for the Project to address glare at the receptor locations that were analyzed. Reassessment is recommended if Project parameters change.

1 INTRODUCTION

BluEarth Renewables Inc. (“BluEarth” or the “Proponent”) retained DNV Energy Systems Canada Inc. (“DNV”) to perform an independent glint and glare assessment for the proposed Wheatcrest Solar Project (the “Project”) in order to identify the potential glint and glare impacts to dwellings, roads, and aviation activity located within the vicinity of the Project.

1.1 Objective and Regulatory Context

The objective of this glint and glare assessment is to fulfill the requirements stipulated by the Alberta Utilities Commission (AUC) within *Bulletin 2019-09 – Interim Information Requirements for Solar and Wind Energy Plant Requirements (“AUC Bulletin 2019-09”)* [1]. This bulletin states that applicants for new solar energy projects must include a solar glare assessment as part of the *AUC Rule 007: Applications for Power Plants, Substations, Transmission Lines, Industrial System Designations and Hydro Development (“AUC Rule 007”)* submission [2].

As per *AUC Bulletin 2019-09,* the solar assessment is required to include the following components:

- A description of the time, location, duration and intensity of solar glare predicted to be caused by the Project;
- A description of the potential impact on dwellings and transportation routes surrounding the Project and any potential mitigation measures that are proposed; and
- A description of the software and tools used to complete the assessment, including any assumptions made.

In addition to the *AUC Bulletin 2019-09* requirements, NAV CANADA also requires that a glint and glare study be submitted for solar projects as part of the Land Use Proposal submission. This was completed by BluEarth for the Project in November 2020.

At the time of writing this report, there are no other existing glint and glare requirements applicable to the Project.

2 PROJECT DESCRIPTION

The Project is located within the Municipal District (MD) of Taber, approximately 13 kilometres (km) north of the Hamlet of Enchant. The Project is situated on two adjoining quarter sections (SE-22-15-18-W4M and SW-22-15-18-W4M), encompassing 129.41 hectares (ha) of cultivated agricultural land (the “Project Area”). Elevation throughout the Project Area is relatively consistent with minimal variability, ranging from 802 m to 815 m Above Sea Level (ASL). Surrounding land use primarily consists of cultivated agricultural land and includes a small number of developed areas associated with residential properties and farming land uses. There are no airports or aerodromes located within four km of the Project area.

The Project will have a capacity of 60 MW_{AC} and will consist of approximately 136,586 solar photovoltaic (PV) panels mounted on single-axis trackers. Other Project components include internal access roads, underground collection lines, electrical inverters, a transformer substation, and a perimeter fence.

A map of the Project layout, including the dwellings and road features considered as part of this assessment, is included below (Figure 2-1).

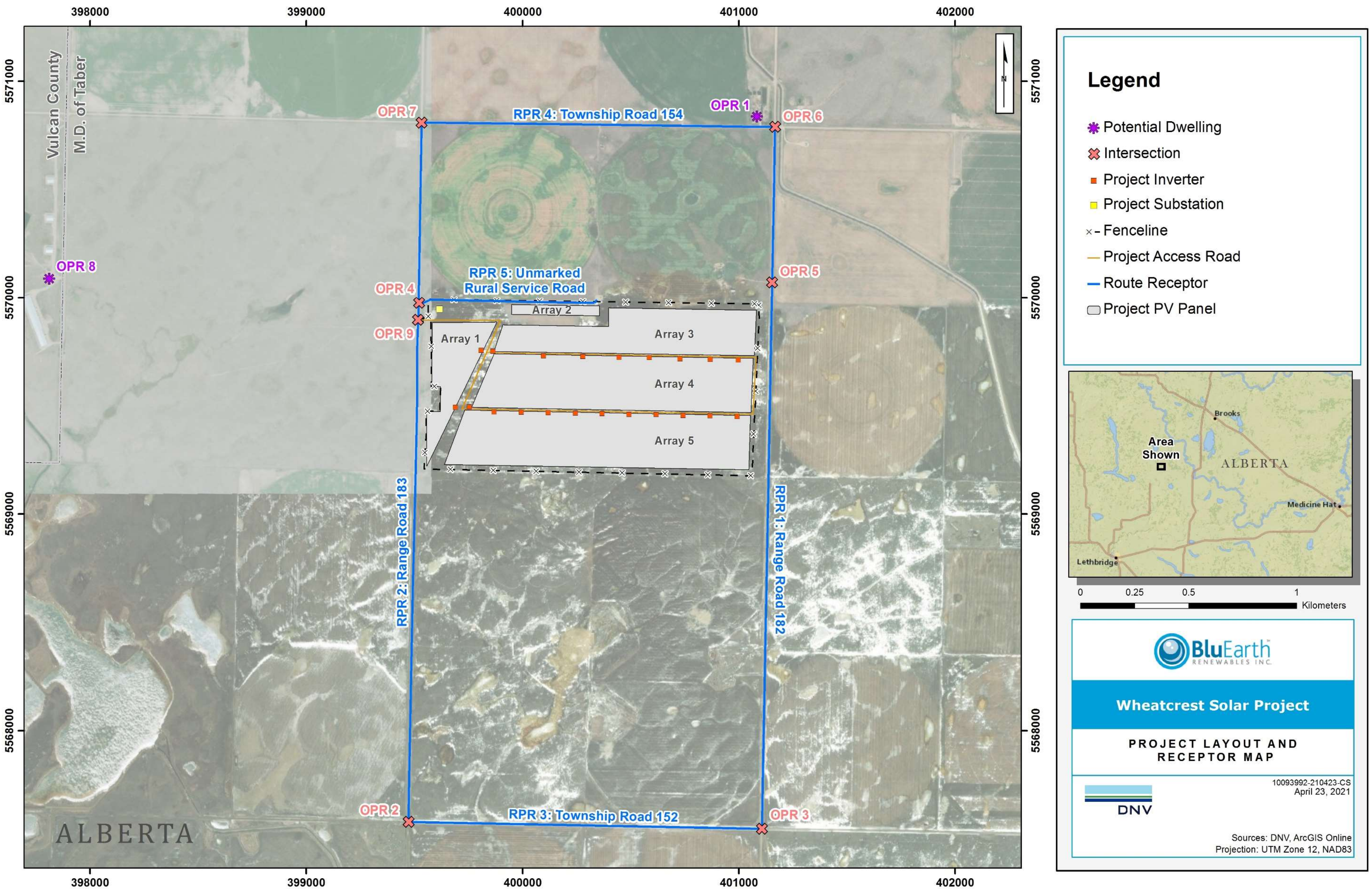


Figure 2-1 Project Layout and Receptor Map

3 METHODOLOGY

3.1 Overview

3.1.1 Definitions

For the purposes of this assessment, DNV has relied on the following definitions used by the United States (US) Federal Aviation Administration's (FAA) *Technical Guidance for Evaluating Selected Solar Technologies on Airports* for glint, glare, and reflectivity:

- **Glint:** A momentary flash of bright light reflected from a surface; and
- **Glare:** Continuous source of bright light reflected from a surface [3].

Glint is typically received by moving receptors (e.g. cars, airplanes) while glare is typically received by static receptors (e.g. dwellings). However, as industry-standard glare analysis tools, including the one used within this assessment (see Section 3.3), evaluate occurrence of glare on a minute-by-minute basis, ocular hazards are generally presented within glint and glare assessments using the collective term glare.

3.1.2 Reflectivity

The amount of glint or glare that is reflected off a solar panel depends on wide variety of factors including the:

- Amount of sunlight that hits the panel surface;
- Overall reflectivity of the panel surface;
- Geographic location of the solar farm;
- Time of year;
- Cloud cover; and
- Orientation of the solar panel relative to the sun.

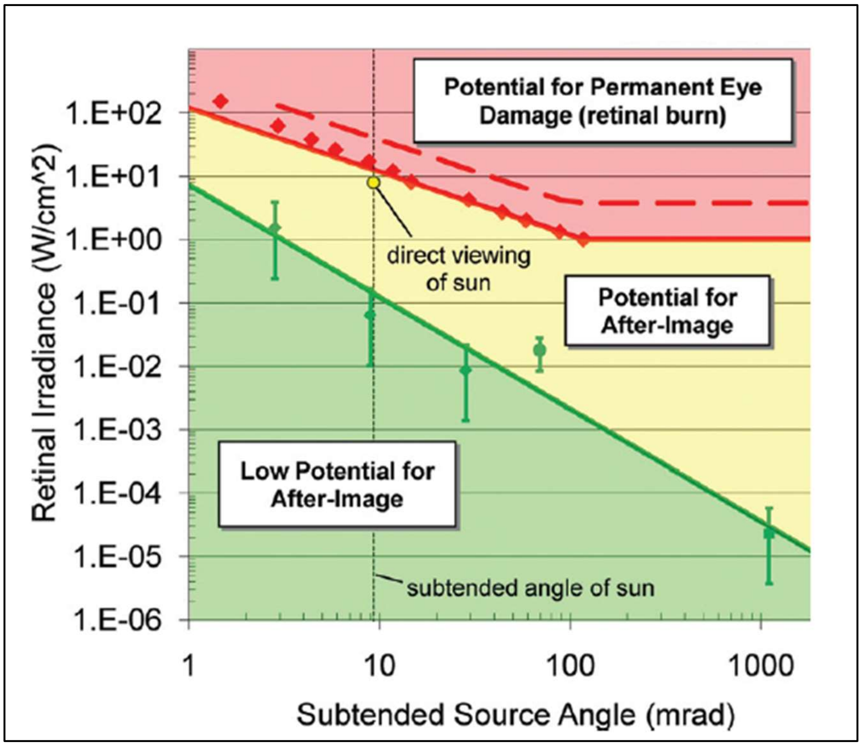
Solar PV panels are constructed of dark, light-absorbing material that is designed to maximize sunlight absorption and minimize reflection in order to ensure maximum electricity production. The majority of solar PV panel glass covers are also treated with an anti-reflective coating (ARC) that further reduces the amount of sunlight that is reflected.

3.1.3 Ocular Impacts

The standard practice for predicting potential ocular impacts is to calculate retinal irradiance and subtended angle (size/distance) of the glare source and based on the results, categorize the predicted ocular impact into one of the following three ocular hazard colour codes:

- **Green:** Glare with low potential to cause temporary after-image (i.e. lingering image in a viewer's eye associated with a flash of light) to a viewer prior to a typical blink response time;
- **Yellow:** Glare with potential to cause temporary after-image to a viewer prior to a typical blink response time; and
- **Red:** Glare with potential to cause retinal damage to a viewer prior to a typical blink response time.

These widely accepted ocular hazard colour codes were originally established in 2011 by Ho et al. [4] through a study that assessed the potential impacts of retinal irradiance as a function of subtended source angle. The ocular hazard plot contained within this study, included as Figure 3-1, was adopted by the FAA as part of their *Interim Policy – FAA Review of Solar Energy Projects on Federally Obligated Polices* as the standard for measuring the ocular impact of solar facilities [7].



Image, Ho et al. [4]

Figure 3-1 Ocular Hazard Plot

3.2 Identification of Receptors

DNV used best practices and AUC guidelines to develop the following conservative approach to identifying Observation Point Receptors (OPRs) for the Project:

- Dwellings with potential to receive glare that are inhabited and located within 2,000 metres (m) of the Project Area;
- Routes and road intersections including driveways with potential to receive glare that are located within 1,500 m of the Project Area; and
- Aerodromes and associated flight paths with potential to receive glare that are located within 4,000 m of the Project Area.

To ensure a comprehensive analysis of potential glare for the Project, DNV included both routes and route intersections as part of the glare assessment. Routes are denoted as Route Point Receptors (RPRs) and intersections or residences are denoted as OPRs. No aerodromes or flight paths were found within 4 km of the Project.

A summary of the receptors identified for the Project are presented in Table 3-1.

Table 3-1 Project Observation Point Receptors and Route Point Receptors

Receptor ID	Receptor Type	Details
OPR 1	Dwelling	Potential Residence
OPR 2	Intersection	Township Road 152 & Range Road 183
OPR 3	Intersection	Township Road 152 & Range Road 182
OPR 4	Intersection	Range Road 183 & Unmarked Rural Access Road
OPR 5	Intersection	Range Road 183 & Driveway
OPR 6	Intersection	Township Road 154 & Range Road 182
OPR 7	Intersection	Township Road 154 & Range Road 183
OPR 8	Dwelling	Potential Residence
OPR 9	Intersection	Range Road 183 & Project Access Road
RPR 1	Route	Range Road 182
RPR 2	Route	Range Road 183
RPR 3	Route	Township Road 152
RPR 4	Route	Township Road 154
RPR 5	Route	Unmarked Rural Service Road

No aerodromes or flight paths were found within 4 km of the Project.

3.2.1 Dwellings

Two dwellings with potential to receive glare were identified within 2,000 m of the Project Area. One dwelling northeast of the Project Area was identified by DNV but excluded from analysis as the receptor appears to be abandoned. The observation height at dwellings was assumed to be 4.5 m to align with the assumed height for two-storey dwellings stipulated within AUC's *Rule 012: Noise Control* [8]. A two-storey dwelling height was selected as it represents the more conservative option in terms of glare impact in the current scenario.

3.2.2 Route Paths and Intersections

Seven intersections and five route paths with potential to receive glare were identified within 1,500 m of the Project Area. To accurately capture glare received by various road users, three vehicle observation heights were used:

- Cars: 1.1 m;
- SUVs/Trucks: 1.8 m; and
- Semis/Tractors: 2.3 m [9].

3.2.3 Flight Paths and Aerodromes

No flight paths or aerodromes were identified within 4,000 m of the Project Area. The closest airport, Vauxhall Airport, is located more than 30 km from the Project Area [10]. As a result, assessment of potential Project impacts to flight paths and aerodromes was determined to not be necessary for the Project and these features were excluded from further analysis.

3.3 Modelling Tool

DNV used GlareGauge, a product of ForgeSolar, which is a comprehensive solar glare analysis tool that relies on Solar Glare Hazard Analysis Tool (SGHAT) technology developed by Sandia National Laboratories, to predict the potential for glare at OPRs and RPRs identified within the vicinity of the Project [11]. Assumptions and limitations associated with GlareGauge are described within 3.3.2.

3.3.1 Model Inputs

Table 3-2 outlines the Project-specific parameters that DNV used as inputs for the model to complete the analysis, along with the default GlareGauge parameters.

Table 3-2 Model Inputs Used for the Project

Parameter		Value	Input Type
Axis Tracking		Single Axis tracking	Project-Specific
Panel Material		Lightly Textured Glass with Anti-Reflective Coating (ARC)	Project-Specific
Tilt of Tracking Axis		0 degrees	Project-Specific
Ground Clearance		1.5 m	Project-Specific
Orientation (Azimuth)		180 degrees (South)	Project-Specific
Module Offset Angle		0 degrees	Project-Specific
Max Tracking Angle		60 degrees	Project-Specific
Resting Angle		15 degrees	Project-Specific
Observation Heights	Dwelling	4.5 m	General
	Car	1.1 m	General
	SUV	1.8 m	General
	Semi/Tractor	2.3 m	General
View Angle of Route Viewers		50 degrees left and right	Default Value
Analysis Time Interval		One Minute	Default Value
Reflectivity		Varies with sun position	Default Value

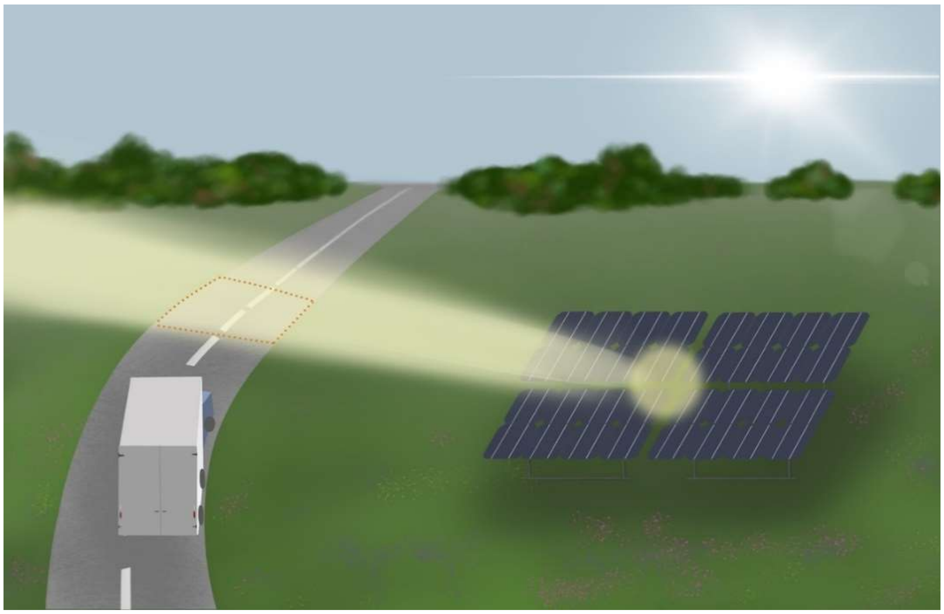
Parameter	Value	Input Type
Ocular Transmission Coefficient	0.5	Default Value
Pupil Diameter	0.002 m	Default Value
Eye Focal Length	0.017 m	Default Value
Sun Subtended Angle	9.3 milliradians	Default Value
Slope Error	Correlates with panel material	Default Value

3.3.2 Model Assumptions and Limitations

Assumptions and limitations with the GlareGauge model are listed below:

- Times of day presented within the results (see Section 4) are denoted in Mountain Standard Time (MST). One hour should be added for daylight savings;
- GlareGauge requires a simplified version of a solar project as an input. Detailed geometry of the PV panels such as gaps between the modules is not represented within the algorithm and as a result, actual glare results may be impacted. Despite this limitation, GlareGauge has been shown to accurately predict the occurrence and intensity of glare at multiple sites [11];
- Calculation of glare at route path receptors (i.e. the RPRs) uses the PV panel array centroid, rather than the actual glare spot location, due to algorithm limitations;
- Limitations inherent in the GlareGauge software mean that it is only possible to model a single backtracking resting angle (rather than a more realistic backtracking algorithm, such as one that would be implemented in a typical tracker controller). Modelling a more realistic backtracking algorithm may impact the glare durations predicted in this assessment;
- The algorithm used within GlareGauge assumes that the PV panel array is aligned with a plane defined by the heights and coordinates obtained from Google Maps;
- Potential screening from man-made or natural obstacles between the OPRs, RPRs, and the Project that may obstruct observed glare, such as vegetation or other physical obstructions are not accounted for within the model;
- The algorithm used within GlareGauge assumes that specified PV panel arrays are aligned with a plane fitted to the array co-ordinates and vertex elevations. The vertex elevations are obtained by GlareGauge from Google Elevation services [11], however the accuracy and resolution of the elevation data from this source are not specified. As the glare duration and intensity can be greatly impacted by the elevation in certain situations, the accuracy of elevation data has a significant impact on the uncertainty associated with the glare predictions. Further, variations or undulations of the terrain within the area of each PV panel array (whether or not they are accurately represented by the elevation data set) are effectively neglected;
- The ocular hazard colours predicted are based on number of environmental, optical and human factors for which the model assumes a range of values. These factors will vary on a site and viewer-specific basis;

- The results of RPRs are based on a generic multi-line representation which simulates observers travelling along continuous paths. GlareGauge presents the results for RPRs in one-minute intervals. However, for the purposes of this study, these results should be interpreted from the point of view of the vehicle users, who will be traveling through the continuous glare zone relatively quickly, resulting in momentary glint rather than continuous glare being observed at these locations (see Figure 3-2).



Image, ForgeSolar [11]

Figure 3-2 Illustration of Reflected Glare Impacting a Route

3.4 General Assumptions

General assumptions made by DNV in completing the glare analysis are listed below:

- At the time of writing, the module under consideration for the project is the BiHiKu7 CS7L-575MB-AG, a Bifacial High Power Dual Cell PERC Module on a Single-Axis tracker [5]. The manufacturer has verified that the panel material can be considered to be lightly textured glass with ARC [6]. The analysis was run using parameters concurrent with this panel model;
- OPRs and RPRs were identified via aerial imagery and the receptors, access routes, and intersections included within this analysis were not field verified;
- Dwellings were assumed to be two-storey, with observation heights of 4.5 m [8]; and
- Observation heights for vehicles using the route receptors were assumed to be 1.1 m, 1.8 m and 2.3 m for Cars, SUVs/Trucks, and Semis/Tractors, respectively [9].

4 RESULTS AND ANALYSIS

4.1 Summary

The results of the analysis show that no glare is predicted to occur at any of the 14 receptors. These results are presented in Table 4-1. For reference purposes, the output of the Forge Solar GlareGauge software is provided in Appendix A.

Table 4-1 Summary of Potential Glare Impacts for the Project

Receptor ID	Receptor Type	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)
OPR 1	Dwelling	0	0	0
OPR 2	Intersection	0	0	0
OPR 3	Intersection	0	0	0
OPR 4	Intersection	0	0	0
OPR 5	Intersection	0	0	0
OPR 6	Intersection	0	0	0
OPR 7	Intersection	0	0	0
OPR 8	Dwelling	0	0	0
OPR 9	Intersection	0	0	0
RPR 1	Route	0	0	0
RPR 2	Route	0	0	0
RPR 3	Route	0	0	0
RPR 4	Route	0	0	0
RPR 5	Route	0	0	0

These results suggest that the Project, in its current configuration, will not produce glare that impacts any of the 14 identified receptors.

4.2 Impacts on Dwelling OPRs

No glare is predicted to occur at any of the Dwelling OPRs.

4.3 Impacts on Roads and Intersections

4.3.1 RPRs

No glare is predicted for any of the RPRs at car height (1.1 m), SUV/truck height (1.8 m), nor semi/tractor height (2.3 m).

4.3.2 Intersection OPRs

No glare is predicted for any of the Intersection OPRs at car height (1.1 m), SUV/truck height (1.8 m), nor semi/tractor height (2.3 m).

4.4 Impacts on Aerodromes and Flight Paths

As described within Section 3.2.3, impacts to flight paths and aerodromes were excluded from the glare analysis as no flight paths or aerodromes were identified within 4,000 m of the Project Area.

5 DISCUSSION

The results of this assessment show that no glare emanating from the Project is expected to impact the analyzed receptors at the heights assumed in the current analysis. These results assume that the parameters provided to DNV will be the operating parameters of the Project. If these parameters change, or additional receptors are identified, a reanalysis will be required.

To provide additional context, DNV investigated the impact of alternative resting angles and vehicle receptor heights on the results.

5.1 Effect of Resting Angle

Resting angle is a key determinant of Project glare within the GlareGauge software analysis, especially near sunrise and sunset. GlareGauge simulations were run for different resting angles, including:

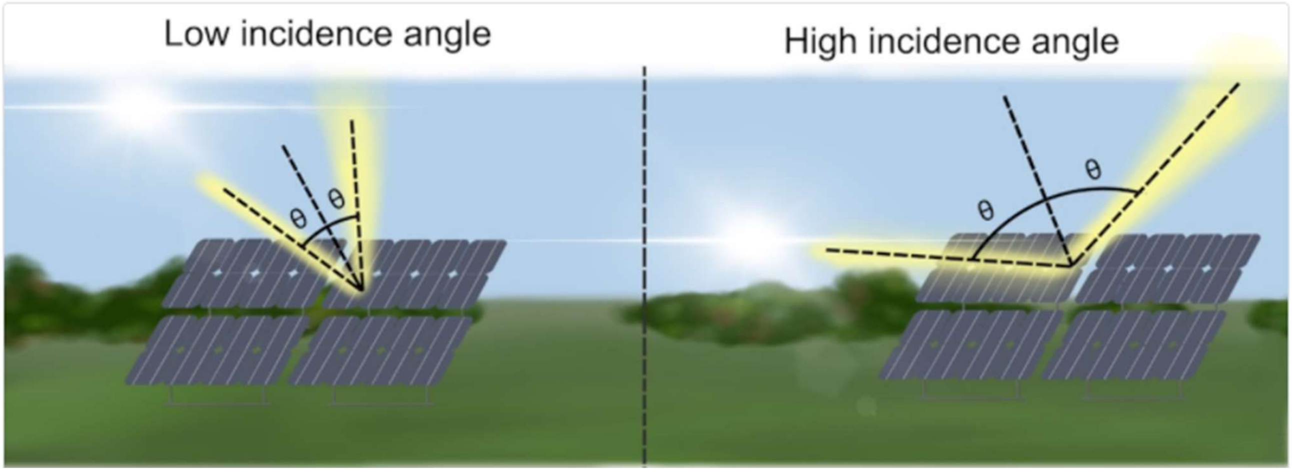
- 0 degrees
- 5 degrees
- 6 degrees
- 7 degrees
- 10 degrees

No glare was predicted for receptors with a resting angle greater than 7 degrees. With a resting angle of 0 degrees, green and yellow glare was predicted for 11 out of 14 receptors. With a resting angle of 5 and 6 degrees, yellow glare was predicted for only 1 out of 14 receptors, and green glare was predicted to impact none. The aggregate annual minutes of predicted glare impacting analyzed receptors in each of these resting angle scenarios are summarized in Table 5-1:

Table 5-1 Effect of Resting Angle on Predicted Glare

Resting Angle	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)
0 degrees	1,061	34,392	0
5 degrees	0	1,649	0
6 degrees	0	771	0
7 degrees	0	0	0
10 degrees	0	0	0

As the position of the panels relative to the sun is a key determinant of glare, it is expected that ground-based receptors would receive more glare in scenarios with resting angles of lower magnitude. Solar glare occurs when the incidence angle of the sun's rays with respect to a reflective surface causes the reflected light to intersect a receptor [11]. Figure 5-1 shows the impact of incidence angle on glare. A higher incidence angle occurs when the sun is near the horizon and the panel is flat. The resulting glare is emitted closer to the ground, compared to scenarios where the incidence angle is smaller, i.e., when the sun is higher in the sky, or when the panel is angled upwards. As such, a resting angle of zero causes more glare at ground-based receptors proximate to the Project near sunrise and sunset.



Image, ForgeSolar [11]

Figure 5-1 Illustration of Incidence Angle Effects on Reflection

These results suggest that, should the resting angle be changed, care should be taken to optimize it such that glare is not experienced at surrounding receptors.

According to the analysis results, restricting the resting angle to a minimum of 7 degrees could maintain the zero-glare condition for all receptors considered in the analysis, assuming all else remains constant. If other parameters are changed, the resting angle best suited to eliminate glare may also need to be reassessed. DNV notes that such a restriction may reduce Project energy production and that energy optimisation strategies may need to be considered.

5.2 Vehicle Height Considerations

DNV ran several analyses where the heights of the surrounding route receptors were varied to determine the minimum theoretical vehicle height at which glare would occur on routes proximate to the Project. The resting angle was maintained at a constant 15 degrees. Glare prediction was calculated for the following vehicle heights:

- 3 m
- 4 m
- 4.25 m
- 4.5 m

The results are presented in Table 5-2.

Table 5-2 Predicted Glare by Passenger Eye-Height

Passenger Eye Height	Green Glare (min/year)	Yellow Glare (min/year)	Red Glare (min/year)
3 m	0	0	0
4 m	0	0	0
4.25 m	0	0	0
4.5 m	0	61	0

The height of the receptor is one factor that determines whether a receptor will be intersected by the glare produced by a given solar incidence angle. In the context of the current Project, the potential for glare increased at greater route receptor heights. Glare was predicted for one route receptor at a height of 4.5 m. No glare was predicted for any route receptors when heights ≤4.25 m were analyzed. These results suggest that road users with eye-heights ≤4.25 m above grade would not be impacted by glare. Vehicles designed such that driver eye-heights are greater than 4.25 m are uncommon and unlikely to be operating on Project adjacent roads. Given the average eye-height of vehicular users for standard passenger and agricultural vehicles [9], DNV concludes that common vehicle users are unlikely to experience glare at this site under the current analysis conditions. Should Project parameters change, reanalysis is recommended.

6 CONCLUSION

Based on the results of this analysis, which predict no glare impact on any of the 14 analyzed receptors, DNV does not expect any mitigative actions to be necessary for the Project in its current configuration. DNV notes that analysis results are sensitive to elevation changes and recommends that consideration is given to updating the results of this assessment if higher-resolution elevation data that includes the impact of any civil works planned during construction, becomes available. In addition, should any Project parameters change during construction or operation, reanalysis is recommended.

7 REFERENCES

[1] Alberta Utilities Commission, Bulletin 2019-09 – Interim Information Requirements for Solar and Wind Energy Plant Requirements, 3 July 2019.

[2] Alberta Utilities Commission, Rule 007: Applications for Power Plants, Substations, Transmission Lines, Industrial System Designations and Hydro Developments, 1 August 2019.

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[4] 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, ASME J. Sol. Energy Eng., 133, 2011.

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[8] Alberta Utilities Commission, Rule 012: Noise Control, 2 March 2020.

[9] Alberta Transportation, Highway Geometric Design Guide – Chapter B, Alignment Elements, September 2020.

[10] NAV CANADA, NOTAM Series Aerodromes, 2015. Accessible from https://www.navcanada.ca/en/aeronautical-information/aip-canada.aspx

[11] ForgeSolar, Guidance and Information on Using ForgeSolar Analysis Tools, Undated, https://www.forgesolar.com/help/#glare.

APPENDIX A – GLAREGAUGE RESULTS

ForgeSolar

Wheatcrest Solar - April 2021 Updates

WC - April 2021 Updates - 2pt3m Assessment

Client: BluEarth

Created April 14, 2021
Updated April 14, 2021
Time-step 1 minute
Timezone offset UTC-7
Site ID 52455.9408

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:

- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

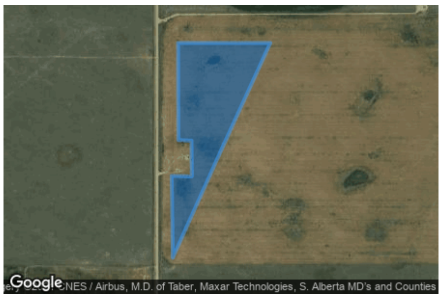
Summary of Results No glare predicted!

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
Array1	SA tracking	SA tracking	0	0	-
Array2	SA tracking	SA tracking	0	0	-
Array3	SA tracking	SA tracking	0	0	-
Array4	SA tracking	SA tracking	0	0	-
Array5	SA tracking	SA tracking	0	0	-

PV Array(s)

Total PV footprint area: 974,495 m^2

Name: Array1
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 15.0 deg
Footprint area: 92,799 m^2
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad



Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	50.266580	-112.409423	802.00	1.50	803.50
2	50.268910	-112.409472	804.00	1.50	805.50
3	50.268897	-112.408576	804.57	1.50	806.07
4	50.269914	-112.408590	806.00	1.50	807.50
5	50.269928	-112.409173	806.00	1.50	807.50
6	50.272695	-112.409187	807.00	1.50	808.50
7	50.272695	-112.405090	808.89	1.50	810.39
8	50.269665	-112.407256	805.00	1.50	806.50

Name: Array2
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 15.0 deg
Footprint area: 18,787 m^2
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	50.272966	-112.404046	809.00	1.50	810.50
2	50.273387	-112.404073	809.00	1.50	810.50
3	50.273387	-112.398349	810.00	1.50	811.50
4	50.272980	-112.398322	809.00	1.50	810.50

Name: Array3
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 15.0 deg
Footprint area: 210,454 m^2
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	50.271393	-112.405294	808.00	1.50	809.50
2	50.271969	-112.404951	809.00	1.50	810.50
3	50.272532	-112.404629	809.00	1.50	810.50
4	50.272586	-112.397779	809.00	1.50	810.50
5	50.273346	-112.397770	810.00	1.50	811.50
6	50.273337	-112.392939	811.00	1.50	812.50
7	50.273355	-112.388108	812.00	1.50	813.50
8	50.272374	-112.388167	813.00	1.50	814.50
9	50.271420	-112.388184	814.30	1.50	815.80
10	50.271427	-112.396777	809.00	1.50	810.50

Name: Array4
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 15.0 deg
Footprint area: 310,523 m^2
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

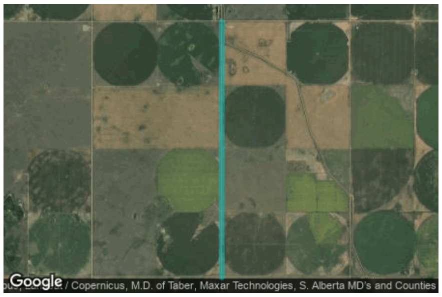
Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	50.269076	-112.406777	806.00	1.50	807.50
2	50.270234	-112.405971	807.00	1.50	808.50
3	50.271365	-112.405145	808.60	1.50	810.10
4	50.271358	-112.396699	809.00	1.50	810.50
5	50.271365	-112.388253	814.00	1.50	815.50
6	50.270234	-112.388306	814.00	1.50	815.50
7	50.269076	-112.388359	814.00	1.50	815.50
8	50.269076	-112.397546	808.00	1.50	809.50

Name: Array5
Axis tracking: Single-axis rotation
Tracking axis orientation: 180.0 deg
Tracking axis tilt: 0.0 deg
Tracking axis panel offset: 0.0 deg
Maximum tracking angle: 60.0 deg
Resting angle: 15.0 deg
Footprint area: 341,932 m^2
Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	50.266660	-112.408514	803.00	1.50	804.50
2	50.267863	-112.407741	804.00	1.50	805.50
3	50.269012	-112.407010	805.71	1.50	807.21
4	50.268983	-112.388359	814.00	1.50	815.50
5	50.267841	-112.388377	814.00	1.50	815.50
6	50.266673	-112.388439	811.95	1.50	813.45
7	50.266666	-112.398412	806.00	1.50	807.50

Route Receptor(s)

Name: Range Rd 182 - 2p3m
Route type Two-way
View angle: 50.0 deg



Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	50.251804	-112.387152	804.38	2.30	806.68
2	50.255528	-112.387175	805.22	2.30	807.52
3	50.259289	-112.387183	805.00	2.30	807.30
4	50.262813	-112.387184	804.00	2.30	806.30
5	50.266368	-112.387159	811.83	2.30	814.13
6	50.271073	-112.387174	815.00	2.30	817.30
7	50.275879	-112.387160	810.00	2.30	812.30
8	50.280927	-112.387167	810.00	2.30	812.30

Name: Range Rd 183 - 2p3m
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	50.251813	-112.410100	794.00	2.30	796.30
2	50.255445	-112.410089	794.76	2.30	797.06
3	50.259138	-112.410115	794.90	2.30	797.20
4	50.262782	-112.410095	797.00	2.30	799.30
5	50.266347	-112.410091	801.00	2.30	803.30
6	50.276067	-112.410084	807.00	2.30	809.30
7	50.280867	-112.410093	807.00	2.30	809.30

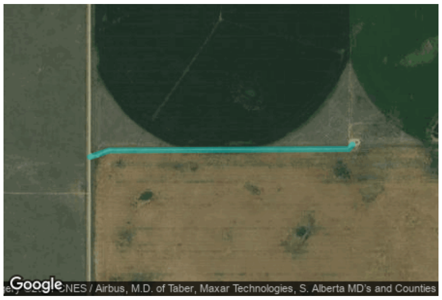
Name: TWP Rd 152 - 2p3m
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	50.251815	-112.410106	794.00	2.30	796.30
2	50.251813	-112.404330	793.00	2.30	795.30
3	50.251814	-112.398603	794.00	2.30	796.30
4	50.251821	-112.392889	797.00	2.30	799.30
5	50.251800	-112.387164	804.32	2.30	806.62

Name: TWP Rd 154 - 2p3m
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	50.280864	-112.410091	807.00	2.30	809.30
2	50.280878	-112.404209	808.00	2.30	810.30
3	50.280892	-112.398498	810.00	2.30	812.30
4	50.280906	-112.392829	810.00	2.30	812.30
5	50.280920	-112.387161	810.00	2.30	812.30

Name: Un-named Rural Service Road - 2p3m
Route type Two-way
View angle: 50.0 deg



Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	50.273305	-112.410093	806.00	2.30	808.30
2	50.273488	-112.409232	807.00	2.30	809.30
3	50.273529	-112.398610	810.00	2.30	812.30
4	50.273653	-112.398439	810.00	2.30	812.30

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
OP 1	50.281393	-112.388360	810.00	4.50	814.50
OP 2	50.251803	-112.410154	794.00	2.30	796.30
OP 3	50.251804	-112.387171	804.30	2.30	806.60
OP 4	50.273315	-112.410103	806.00	2.30	808.30
OP 5	50.274488	-112.387174	811.00	2.30	813.30
OP 6	50.280924	-112.387173	810.00	2.30	812.30
OP 7	50.280887	-112.410102	807.00	2.30	809.30
OP 8	50.274105	-112.434069	800.00	4.50	804.50
OP 9	50.272684	-112.410092	806.00	2.30	808.30

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
Array1	SA tracking	SA tracking	0	0	-	-
Array2	SA tracking	SA tracking	0	0	-	-
Array3	SA tracking	SA tracking	0	0	-	-
Array4	SA tracking	SA tracking	0	0	-	-
Array5	SA tracking	SA tracking	0	0	-	-

PV & Receptor Analysis Results

Results for each PV array and receptor

Array1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 2p3m	0	0
Route: Range Rd 183 - 2p3m	0	0
Route: TWP Rd 152 - 2p3m	0	0
Route: TWP Rd 154 - 2p3m	0	0
Route: Un-named Rural Service Road - 2p3m	0	0

No glare found

Array2 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 2p3m	0	0
Route: Range Rd 183 - 2p3m	0	0
Route: TWP Rd 152 - 2p3m	0	0
Route: TWP Rd 154 - 2p3m	0	0
Route: Un-named Rural Service Road - 2p3m	0	0

No glare found

Array3 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 2p3m	0	0
Route: Range Rd 183 - 2p3m	0	0
Route: TWP Rd 152 - 2p3m	0	0
Route: TWP Rd 154 - 2p3m	0	0
Route: Un-named Rural Service Road - 2p3m	0	0

No glare found

Array4 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 2p3m	0	0
Route: Range Rd 183 - 2p3m	0	0
Route: TWP Rd 152 - 2p3m	0	0
Route: TWP Rd 154 - 2p3m	0	0
Route: Un-named Rural Service Road - 2p3m	0	0

No glare found

Array5 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 2p3m	0	0
Route: Range Rd 183 - 2p3m	0	0
Route: TWP Rd 152 - 2p3m	0	0
Route: TWP Rd 154 - 2p3m	0	0
Route: Un-named Rural Service Road - 2p3m	0	0

No glare found

ForgeSolar

Wheatcrest Solar - April 2021 Updates

WC - April 2021 Updates - 1pt8m Assessment

Client: BluEarth

Created April 14, 2021
Updated April 14, 2021
Time-step 1 minute
Timezone offset UTC-7
Site ID 52454.9408

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:

- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh
Array1	SA tracking	SA tracking	0	0	-
Array2	SA tracking	SA tracking	0	0	-
Array3	SA tracking	SA tracking	0	0	-
Array4	SA tracking	SA tracking	0	0	-
Array5	SA tracking	SA tracking	0	0	-

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
Array1	SA tracking	SA tracking	0	0	-	-
Array2	SA tracking	SA tracking	0	0	-	-
Array3	SA tracking	SA tracking	0	0	-	-
Array4	SA tracking	SA tracking	0	0	-	-
Array5	SA tracking	SA tracking	0	0	-	-

PV & Receptor Analysis Results

Results for each PV array and receptor

Array1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p8m	0	0
Route: Range Rd 183 - 1p8m	0	0
Route: TWP Rd 152 - 1p8m	0	0
Route: TWP Rd 154 - 1p8m	0	0
Route: Un-named Rural Service Road - 1p8m	0	0

No glare found

Array2 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p8m	0	0
Route: Range Rd 183 - 1p8m	0	0
Route: TWP Rd 152 - 1p8m	0	0
Route: TWP Rd 154 - 1p8m	0	0
Route: Un-named Rural Service Road - 1p8m	0	0

No glare found

Array3 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p8m	0	0
Route: Range Rd 183 - 1p8m	0	0
Route: TWP Rd 152 - 1p8m	0	0
Route: TWP Rd 154 - 1p8m	0	0
Route: Un-named Rural Service Road - 1p8m	0	0

No glare found

Array4 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p8m	0	0
Route: Range Rd 183 - 1p8m	0	0
Route: TWP Rd 152 - 1p8m	0	0
Route: TWP Rd 154 - 1p8m	0	0
Route: Un-named Rural Service Road - 1p8m	0	0

No glare found

Array5 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p8m	0	0
Route: Range Rd 183 - 1p8m	0	0
Route: TWP Rd 152 - 1p8m	0	0
Route: TWP Rd 154 - 1p8m	0	0
Route: Un-named Rural Service Road - 1p8m	0	0

No glare found

ForgeSolar

Wheatcrest Solar - April 2021 Updates

WC - April 2021 Updates -1p08m Assessment

Client: BluEarth

Created April 14, 2021
Updated April 14, 2021
Time-step 1 minute
Timezone offset UTC-7
Site ID 52445.9408

Project type Advanced
Project status: active
Category 10 MW to 100 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:

- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results No glare predicted!

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
Array1	SA tracking	SA tracking	0	0	-
Array2	SA tracking	SA tracking	0	0	-
Array3	SA tracking	SA tracking	0	0	-
Array4	SA tracking	SA tracking	0	0	-
Array5	SA tracking	SA tracking	0	0	-

Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
Array1	SA tracking	SA tracking	0	0	-	-
Array2	SA tracking	SA tracking	0	0	-	-
Array3	SA tracking	SA tracking	0	0	-	-
Array4	SA tracking	SA tracking	0	0	-	-
Array5	SA tracking	SA tracking	0	0	-	-

PV & Receptor Analysis Results

Results for each PV array and receptor

Array1 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p08m	0	0
Route: Range Rd 183 - 1p08m	0	0
Route: TWP Rd 152 - 1p08m	0	0
Route: TWP Rd 154 - 1p08m	0	0
Route: Un-named Rural Service Road - 1p08m	0	0

No glare found

Array2 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p08m	0	0
Route: Range Rd 183 - 1p08m	0	0
Route: TWP Rd 152 - 1p08m	0	0
Route: TWP Rd 154 - 1p08m	0	0
Route: Un-named Rural Service Road - 1p08m	0	0

No glare found

Array3 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p08m	0	0
Route: Range Rd 183 - 1p08m	0	0
Route: TWP Rd 152 - 1p08m	0	0
Route: TWP Rd 154 - 1p08m	0	0
Route: Un-named Rural Service Road - 1p08m	0	0

No glare found

Array4 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p08m	0	0
Route: Range Rd 183 - 1p08m	0	0
Route: TWP Rd 152 - 1p08m	0	0
Route: TWP Rd 154 - 1p08m	0	0
Route: Un-named Rural Service Road - 1p08m	0	0

No glare found

Array5 no glare found

Component	Green glare (min)	Yellow glare (min)
OP: OP 1	0	0
OP: OP 2	0	0
OP: OP 3	0	0
OP: OP 4	0	0
OP: OP 5	0	0
OP: OP 6	0	0
OP: OP 7	0	0
OP: OP 8	0	0
OP: OP 9	0	0
Route: Range Rd 182 - 1p08m	0	0
Route: Range Rd 183 - 1p08m	0	0
Route: TWP Rd 152 - 1p08m	0	0
Route: TWP Rd 154 - 1p08m	0	0
Route: Un-named Rural Service Road - 1p08m	0	0

No glare found

Assumptions

- 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
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.

- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg 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.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, no discrete, spectrum.
- 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

About DNV

We are the independent expert in assurance and risk management. Driven by our purpose, to safeguard life, property and the environment, we empower our customers and their stakeholders with facts and reliable insights so that critical decisions can be made with confidence. As a trusted voice for many of the world's most successful organizations, we use our knowledge to advance safety and performance, set industry benchmarks, and inspire and invent solutions to tackle global transformations.