



**NSF Kirkwood Site 1, LLC, NSF Kirkwood Site  
2, LLC, NSF Kirkwood Site 3, LLC Glare Hazard  
Analysis**

Broome County, New York

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Prepared for:

Norbut Solar Farms

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# NSF KIRKWOOD SITE 1, LLC, NSF KIRKWOOD SITE 2, LLC, NSF KIRKWOOD SITE 3, LLC GLARE HAZARD ANALYSIS

## Executive Summary

Stantec Consulting Services Inc. (Stantec) utilized the web-based ForgeSolar glare hazard analysis program to analyze the potential for glare from the proposed NSF Kirkwood Sites 1, 2, and 3 Solar Project (the Project), a utility-scale solar-powered electric generation facility located in Broome County, New York, and depicted in **Figure 1**. The Project will include photovoltaic (PV) solar panels mounted as a single axis rotation system to maximize solar energy capture and electric generation of the array. The Project area encompasses approximately 146 acres in a rural area in the Town of Kirkwood in Broome County.

The ForgeSolar program identifies the three following types of glare (no color indicates no glare predicted):

GREEN - Low potential for temporary after-image.

YELLOW - Potential for temporary after-image.

RED - Potential for permanent eye damage.

No glare is predicted for any of the eight approach paths to the Chenango Bridge Airport or the Greater Binghamton Airport. Glare is also not predicted for helicopters hovering 500 feet above the helipad located at the UHS Wilson Medical Center.

No glare is predicted for any of the 20 road segments included in the analysis, including Blair Street/Harry L Drive, Colpitts Drive, Daisy Lane, Easy Street, Foley Road east, Foley Road west, Frances Street, Haskins Johnson Road, Haskins Road, Haskins Road west, High Street, Howard Street, I-81 northbound, I-81 southbound, I-86 eastbound ramp, I-86 off ramp, Quilty Hill Road north, Quilty Hill Road south, Ramp eastbound, and Service Road.

No glare is predicted for the 88 structures, primarily residences, included in the analysis.

These results assume a 30-degree resting angle. In addition, a viewshed analysis was conducted and the results from the viewshed analysis were used to limit glare analysis sensitive receptors to areas that are predicted to be visible from the array.

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## **Abbreviations**

AGL	Above Ground Level
ARC	anti-reflective coating
ATCT	Air Traffic Control Tower
deg	degrees (0 is due north, 180 is due south)
DNI	Direct Normal Irradiance
FAA	Federal Aviation Administration
FP	Flight Path (landing path from threshold to two miles out)
ft	Foot/Feet
GMT	Greenwich Mean Time
kW	Kilowatt
kWh	kilowatt hour
m	Meter
mi	Mile
min	Minute
mrad	Milliradian
MWac	Megawatt alternating current
MSL	Mean Sea Level
OP	Observation Point (e.g., control tower, structure)
PV	Photovoltaic
W	watt

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**Glossary**

Correlate Slope Error with Surface Type?	Correlates the slope error value based on the surface material type; default value is 8.43 milliradians (mrads).
Eye Focal Length (m)	Typical distance between the cornea and the retina of the human eye, default is 0.017 meters (m), though some sources indicate that the typical length is 0.022m.
Glide Slope (deg)	Angle at which the plane approaches the runway during landing (default is 3 degrees [deg] from horizontal).
Maximum Tracking Angle (deg)	Rotation limit of panels in either direction. Full rotation is 2x maximum tracking angle. E.g., maximum tracking angle of 60 deg indicates full panel rotation range of 120 deg.
Resting Angle (deg)	Angle modules return to after maximum angle is reached.
Observation Point	A specific location, such as a control tower or structure, from which an observer might experience glare.
Ocular Transmission Coefficient	Related to the ability of the eye to transmit light, set at 0.5 by Forge Solar.
Offset angle of module (deg)	Additional tilt/elevation angle between the tracking axis and the panel.
Orientation of Tracking Axis (deg)	Azimuthal position of tracking axis measured clockwise from true north. Tracking systems in the northern hemisphere are typically oriented near 180 deg. Tracking systems in the southern hemisphere are typically oriented near 0 deg.
Peak DNI (W/m <sup>2</sup> )	This value is set at 1,000 by ForgeSolar and is the amount of solar radiation per unit surface area by a surface perpendicular to the sun's rays in a straight line from the direction of the sun at its current position in the sky.
Pupil Diameter (m)	Typical pupil diameter for observer, default is 0.002 m.
PV Array Axis Tracking	Panel tracking mode, if any. Panel can be set to track along one (single) or two (dual) axis tracking. This parameter affects the positioning of the panels at every time step when the sun is up.
PV Array Panel Material	Surface material of panels, including use of anti-reflective coating (ARC). Options include: smooth glass without ARC, smooth glass with ARC, light-textured glass without ARC, light-textured glass with ARC, and deeply textured glass.
Rated Power (kW)	Power rating of the solar array - used to estimate the energy output per year of the array (optional).
Slope Error (mrad)	Accounts for beam scatter of sunlight on the array. Default is 8.43 mrads but the value may be adjusted based on the panel material type.
Subtended Angle of Sun (mrad)	The angle above horizontal at which the viewer observes the sun, default value is 9.3 mrad.
Threshold	The physical beginning of the runway. Aircraft are typically expected to be 50 ft above ground at this point.
Time Interval (min)	Time step intervals used by the program for analyses. Default is set to analyze for glare at every one-minute interval throughout the year.

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Time zone	Time zone difference from Greenwich Mean Time (GMT) at the location of the analysis.
Tilt of Tracking Axis (deg)	The elevation angle of the tracking axis upon which panels rotate (e.g., torque tube), measured from flat ground. 0 deg implies the axis is on level, flat ground. Values between 0 and 30 deg are typical.
Vary Reflectivity	Varies panel reflectivity with sun position at each time step.
Maximum Downward Viewing Angle (deg)	The angle extending downward from the horizon indicating the maximum downward viewing angle from the cockpit. Used to determine whether glare is visible by the pilot along the flight path. Default is 30 degrees.

Sources:

Ho, Clifford, K., Cianan A. Sims, Julius E. Yellowhair. 2015. Solar Glare Hazard Analysis Tool (SGHAT) User's Manual v. 2H. Sandia National Laboratories.

ForgeSolar – PV Planning & Glare Analysis. <https://www.forgesolar.com/>

# NSF KIRKWOOD SITE 1, LLC, NSF KIRKWOOD SITE 2, LLC, NSF KIRKWOOD SITE 3, LLC GLARE HAZARD ANALYSIS

## 1.0 INTRODUCTION

On behalf of Norbut Solar Farms (NSF) Stantec Consulting Services Inc. (Stantec) utilized the web based ForgeSolar glare hazard analysis program to complete a glare analysis for the NSF Kirkwood Site 1, LLC, NSF Kirkwood Site 2, LLC, and NSF Kirkwood Site 3, LLC Solar Project (the Project) to determine the potential for glint/glare from the photovoltaic (PV) solar panels to affect residents in the area, automobile drivers passing through the vicinity of the array, and aircraft flying or landing in the vicinity of the array. The Project is located in a rural area of Broome County, in central New York (**Figure 1**), in the Town of Kirkwood.

ForgeSolar is an interactive tool that provides a quantified assessment of (1) when and where glare will occur throughout the year for a prescribed solar project, and (2) potential effects on the human eye at locations where glare occurs. Glare can occur from the reflection of sunlight on the PV solar panels of utility-scale, solar-powered, electric generating facilities. While PV solar panels absorb direct sunlight, some reflection can occur especially when the panels are tilted close to horizontal, as depicted in **Figure 2** below.

ForgeSolar employs an interactive Google map for site location, mapping the proposed PV array(s), and specifying observer locations, vehicular travel routes, or flight paths. Latitude, longitude, and elevation are automatically recorded through the Google interface, providing necessary information for sun position and vector calculations. Additional information regarding the orientation and tilt of the PV solar panels, reflectance, environment, and ocular factors are entered by the user.

If glare is found, the tool calculates the retinal irradiance and subtended angle (size/distance) of the glare source to predict potential ocular hazards ranging from temporary after-image to retinal burn. The results are presented in a plot that specifies when glare will occur throughout the year, with color codes indicating the potential ocular hazard.

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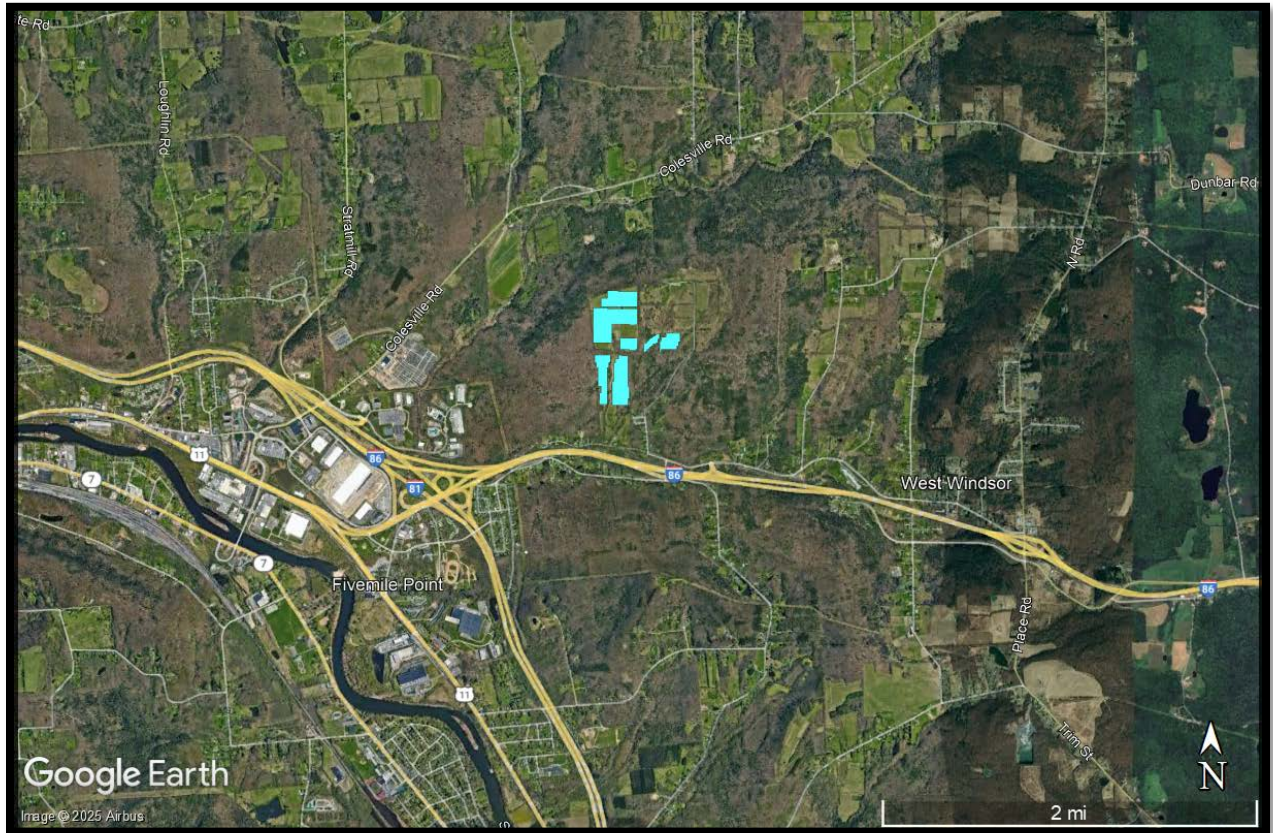
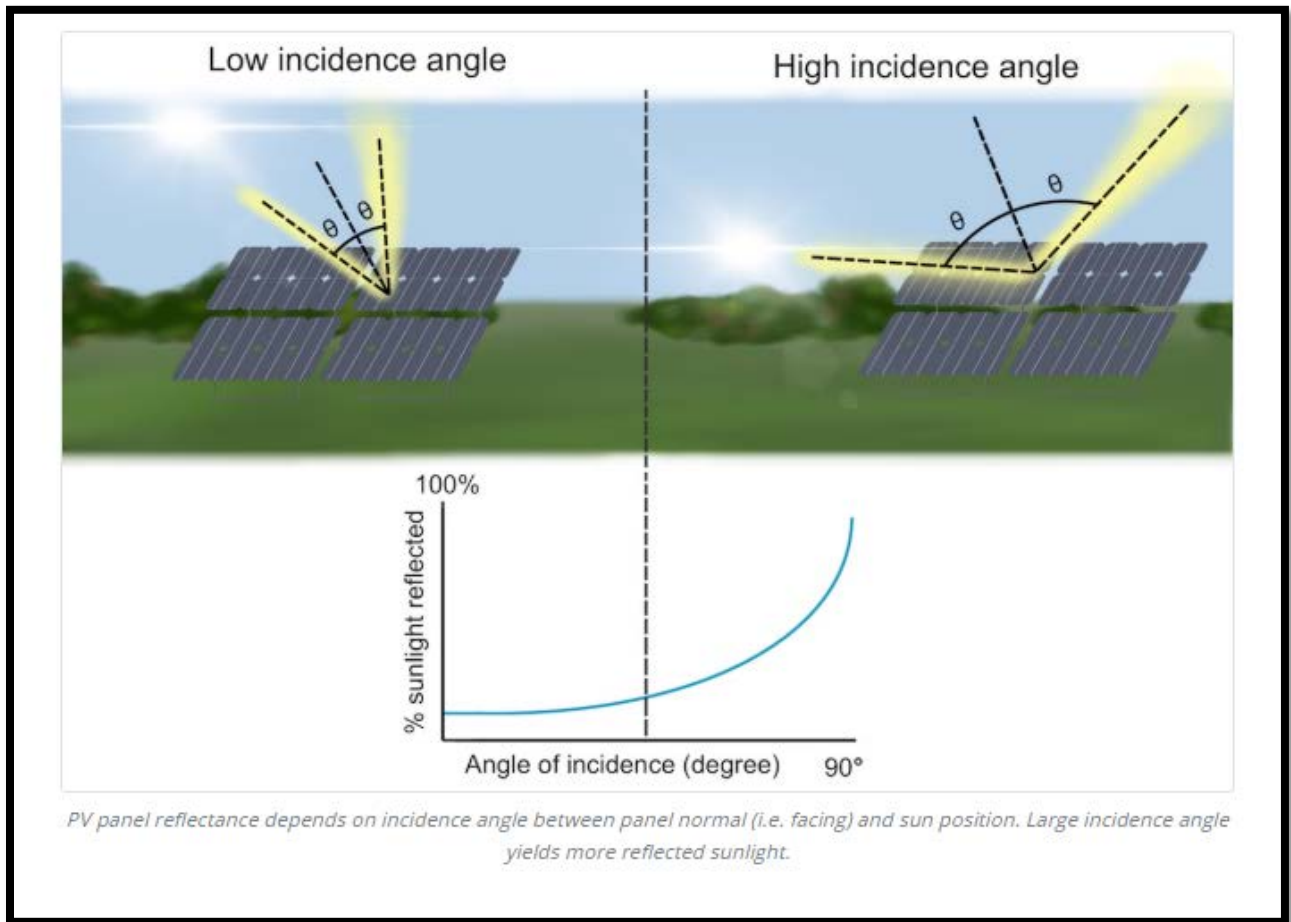


Figure 1. Project Location Map \*Blue polygons represent the PV array.  
Imagery Source: Google Earth Imagery

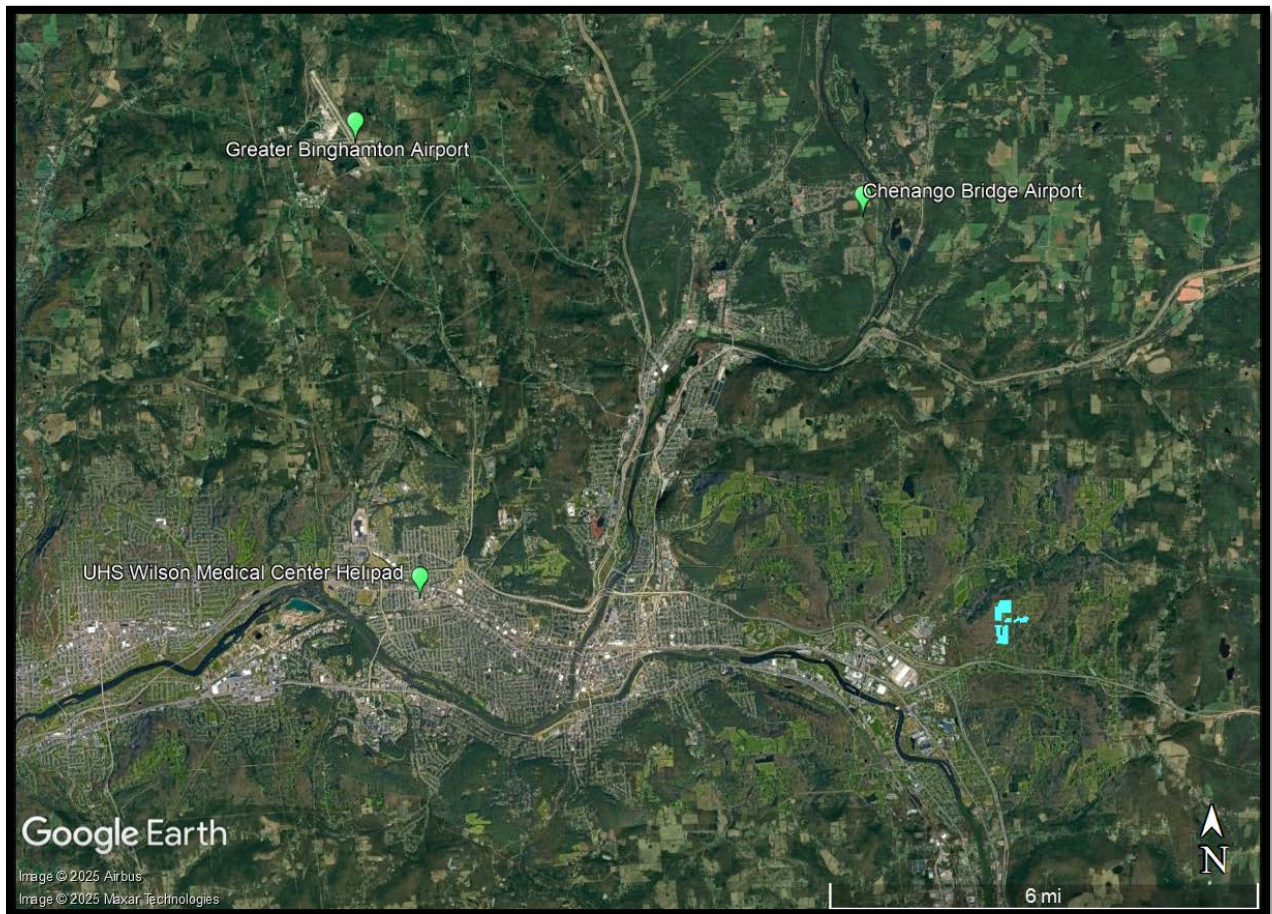
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**Figure 2. Reflectivity differences between low and high incidence angles.**

Source: ForgeSolar.com

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**Figure 3: Project Analysis Area and Aerodromes.** Blue polygons represent the PV array Source: Google Earth Imagery

## 2.0 DATA INPUT SUMMARY

The parameters used for the analyses are listed in **Table 1** below. “Default” indicates the default parameter value set by ForgeSolar and is generally considered a conservative value for the parameter. “Provided” parameters are Project-specific information provided by the client. Arrays, routes, and structures are shown in **Figure 4** below. All features were analyzed using both 3-ft and 12.5-ft above ground level (AGL) panel heights for the single axis tracking panels. In addition, a viewshed analysis was conducted and used to eliminate receptors from the glare analysis where the receptors do not have a view of the array (**Appendix A**).

### 2.1 SOLAR ARRAY

The location of the solar array and array parameters used for the analyses are based on information provided by NSF. A detailed description of each parameter is provided in the Glossary.

**Table 1: Solar Panel Parameters Used for the Glare Analysis**

Parameter	Value Used	Default or Provided?
Axis tracking	Single Axis Tracking	Provided
Tilt (deg)	Calculated by ForgeSolar	Shade Slope Backtracking Chosen
Tracking Axis Orientation (deg)	180.0	Provided
Tracking Axis Panel Offset (deg)	NA	Provided
Maximum Tracking Angle (deg)	60	Provided
Resting Angle (deg)	30	Provided
Rated Power (kW)	Not Used	NA
Vary reflectivity?	Yes	Default
Panel material	Glass with anti-reflective coating	Provided
Time zone offset	-5	Based on site location
Subtended angle of sun (mrad)	9.3	Default
Peak DNI (W/m <sup>2</sup> )	1,000	Default
Ocular transmission coefficient	0.5	Default
Pupil diameter (m)	0.002	Default
Eye focal length (m)	0.017	Default
Time interval (min)	1	Default
Correlate slope error with surface type?	Yes	Default
Slope error (mrad)	8.43	Default
Ground Cover Ratio (%)	49	Provided

## 2.2 AIRPORT APPROACH PATHS AND AIR TRAFFIC CONTROL TOWER

There are two airports and one helipad within ten miles of the project area, including Chenango Bridge Airport, Greater Binghamton Airport, and the helipad at UHS Wilson Medical Center (**Figure 3**).

## 2.3 ROADWAYS AND PROPERTIES LOCATED ADJACENT TO THE SOLAR ARRAYS

Glare was analyzed for twenty road segments within close proximity to the Project, including Blair Street/Harry L Drive, Colpitts Drive, Daisy Lane, Easy Street, Foley Road east, Foley Road west, Frances Street, Haskins Johnson Road, Haskins Road, Haskins Road west, High Street, Howard Street, I-81 northbound, I-81 southbound, I-86 eastbound ramp, I-86 off ramp, Quilty Hill Road north, Quilty Hill Road south, Ramp eastbound, and Service Road.

The ForgeSolar program sets the default viewing angle of the array at 50 degrees from the driver's direct line of sight (when looking forward). The Federal Aviation Administration (FAA) has determined that glare beyond 50 degrees from the line of sight will be mitigated for the viewer<sup>1</sup>. Potential glare to drivers was evaluated for both passenger vehicles and semi-trucks, where the passenger vehicles were assumed to have a maximum viewing height of 5-ft AGL while the viewing height for drivers of semi-trucks was assumed to be a maximum of 9-ft AGL.

Potential glare to viewers at 88 structures, primarily houses, shown as observation points (OPs 2 through 60) in **Figure 4**, in the vicinity of the Project was also analyzed at 16-ft AGL viewing heights. All structures and roadways were analyzed for 3-ft and 12.5-ft panel heights with a 30-degree resting angle. ForgeSolar has a limitation of 60 OPs per analysis and OP1 is the helipad, and therefore the analyses are split into two House Groups in the analyses.

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<sup>1</sup> Rogers, J. A., et al. (2015). Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach, Federal Aviation Administration  
([https://www.faa.gov/sites/faa.gov/files/data\\_research/research/med\\_humanfacs/oamtechreports/201512.pdf](https://www.faa.gov/sites/faa.gov/files/data_research/research/med_humanfacs/oamtechreports/201512.pdf))

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**Figure 4. Project Analysis Area, Structures, and Roadways\***

\*Blue polygons indicate PV arrays, turquoise lines indicate roads, and red pins indicate structures. Source: ForgeSolar, Google Earth Imagery.

### 3.0 GLARE ANALYSES RESULTS

The web-based ForgeSolar program was used to analyze glare potential in one-minute increments throughout the year, and results are presented in **Appendix A** (ForgeSolar reports). The program identifies the three following types of glare (no color indicates no glare predicted):

**GREEN** - Low potential for temporary after-image.

**YELLOW** - Potential for temporary after-image.

**RED** - Potential for permanent eye damage.

#### 3.1 AIRPORT APPROACH PATHS AND CONTROL TOWERS

There are two airports and one helipad located within ten miles of the Project. There are no air traffic control towers associated with either airport. No glare is predicted for any of the eight approach paths to the Chenango Bridge Airport or the Greater Binghamton Airport. Glare is also not predicted for helicopters hovering 500 feet above the helipad located at the UHS Wilson Medical Center.

#### 3.2 ROADWAYS AND PROPERTIES LOCATED ADJACENT TO THE SOLAR ARRAYS

Glare is not predicted for the 20 road segments included in this analysis. Glare is also not predicted for any of the 88 structures included in the analysis.

### 4.0 CONCLUSIONS

No glare is predicted for any of the approach paths to the eight approach paths to the Chenango Bridge Airport or the Greater Binghamton Airport. Glare is also not predicted for helicopters hovering 500 feet above the helipad located at the UHS Wilson Medical Center.

No glare is predicted for any of the 20 road segments included in the analysis, including Blair Street/Harry L Drive, Colpitts Drive, Daisy Lane, Easy Street, Foley Road east, Foley Road west, Frances Street, Haskins Johnson Road, Haskins Road, Haskins Road west, High Street, Howard Street, I-81 northbound, I-81 southbound, I-86 eastbound ramp, I-86 off ramp, Quilty Hill Road north, Quilty Hill Road south, Ramp eastbound, and Service Road.

No glare is predicted for the 88 structures, primarily residences, included in the analysis.

These results assume a 30-degree resting angle. In addition, a viewshed analysis was conducted and the results from the viewshed analysis were used to limit glare analysis sensitive receptors to areas that are predicted to be visible from the array.