Solar Photovoltaic Glint & Glare Study Aviation Specific

For roof mounted PV panels at a proposed residential development at Units 66 & 67 Fourth Avenue, Cookstown Industrial Estate, Tallaght, Dublin 24

September 2020

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Executive Summary

This report assesses the potential for ocular impact of glare emanating from sunlight reflections from proposed rooftop solar PV panels and its potential to cause an impact to users of the nearby Casement Aerodrome or the helipad at Tallaght Hospital. Receptors considered for assessment include the final approaches to Runways 05, 11, 23 & 29, the Air Traffic Control Tower (ATCT) at Casement Aerodrome as well as several potential approaches to the helipad at Tallaght Hospital.

Using sun-path algorithms for every minute of the year, it was calculated if and when glare may theoretically occur at a particular receptor. If reflection was found geometrically possible at a particular location, further desk analysis was then carried out to ascertain if a view of the proposal (and thus potential for glare) would indeed be possible in reality.

The level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV systems such as shed roofs, poly tunnels and still lakes.

This is an aviation specific glint and glare report focusing only on the nearby Casement Aerodrome and the helipad at Tallaght Hospital. It does not consider ground based receptors such as nearby roads, railway lines, residences or other aerodromes. However, due to the small scale of residential rooftop solar PV panels, it would not be deemed necessary to assess these receptors.

For the purpose of aviation analysis the US Federal Aviation Administration (FAA) recommend the use of the Solar Glare Hazard Plot (Figure 10) to measure the ocular impact of a solar array. Receptors with theoretical potential for glare can fall into one of three different areas: Green - “Low potential for after-image”, Yellow - “Potential for after-image” and Red - “Potential for Permanent Eye Damage (retinal burn)”.

Figures 1 & 2 below gives a brief overview of the results of this glint and glare report. From Figure 1 it can be seen that (based on the specified solar panel parameters) only runway 05 will have the theoretical potential to experience glare. All other runways (11, 23, 29) and the ATCT at Casement Aerodrome will not be impacted as a result of glint and glare from this proposal. Figure 2 shows that six out of the twelve assessed approach paths at Tallaght Hospital Helipad have theoretical potential to experience glare from the proposed roof mounted solar panels at Units 66 & 67 Fourth Avenue, Cookstown Industrial Estate, Tallaght, Dublin 24. It will be shown from the report and analyses herein that, based on the specified solar panel parameters, major nuisance or hazardous glare **can not** be expected for aircraft landing at any of the runways or the ATCT at Casement Aerodrome. This is due to the fact that there will be no geometric posibility for glare at any time of year for the ATCT or final approaches to runways 11, 23 & 29. Negligible amounts of glare could potentially be experienced on the final approach to runway 05 but in reality, this would most likely be undetected by a pilot.

Similarly, hazardous glare can not be expected for helicopters landing at Tallaght Hospital's helipad, based on the helicopter landing parameters assessed in this report. Durations and intensities of glare higher than those at Casement could be experienced at certain times of the day and year (provided the sun is shining on the panels). However, all glare intensities fall into the "green" area of the glare hazard plot. These results achieve a pass by FAA standards based on the fact that no glare falls in the "yellow" area of the hazard plot.

Receptor	No. of Assessed Arrays	No. with Theoretical Potential for Glare	No. with no Theoretical potential for Glare
Runway 05	2	2	0
Runway 11	2	0	2
Runway 23	2	0	2
Runway 29	2	0	2
Casement ATCT	2	0	2

FIGURE 1: RESULTS AT A GLANCE (CASEMENT AERODROME)

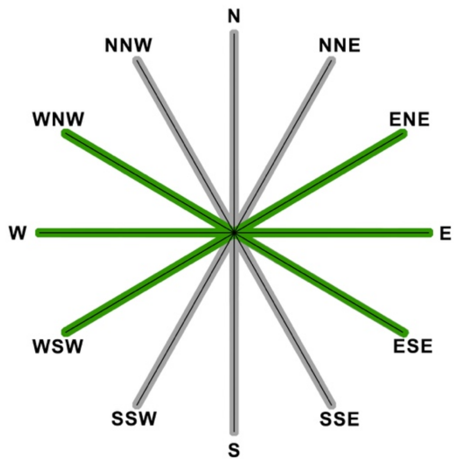

FIGURE 2: RESULTS AT A GLANCE (TALLAGHT HOSPITAL HELIPAD)

Introduction

Innovision has been appointed by Steelworks Property Development Ltd. to carry out an aviation specific glint and glare study for roof mounted solar PV panels at a proposed residential development at Units 66 & 67 Fourth Avenue, Cookstown Industrial Estate, Tallaght, Dublin 24. The subject site is located approximately 4.5km east of Casement Aerodrome and 200m northeast of Tallaght Hospital Helipad (Figure 3). The proposed development consists of several different building blocks at various different elevations. It is proposed to mount solar PV panels to a small portion of the roof of two of the blocks.

Innovision is a leading visualisation, mapping & geographical information systems (GIS) analysis company. Our innovative team has over ten years' experience in the photomontage and 3D visualisation industry, working on a wide range of proposed commercial developments including numerous wind and solar farms, both in Ireland and abroad. Innovision is also a certified Forge Solar 'Glare Expert'. This is currently the only glint and glare assessor qualification available internationally.

Using desk-based analysis, this report has assessed the potential for glare on aircraft taking off and landing at Casement Aerodrome and the helipad at Tallaght Hospital. Using sun-path algorithms for every minute of the year (assuming 100% sunshine for all daylight hours), it is determined if and when reflections may occur at these selected receptors. If reflection is found geometrically possible from a particular location, further analysis is then carried out. This further analysis determines the significance of the glare that could potentially be experienced and also if, in reality, these effects are likely to be experienced by an observer at that location. In certain cases, where glare is found to be significant and a likely source of hazard or nuisance, mitigation factors can then be discussed.

Note on Casement Runway Designations

As discussed in the Aeronautical Assessment Report carried out by O'Dwyer & Jones Design Partnership, In February 2019, Casement's runway designations were changed: its main runway (formerly 11/29, as in the SDCC Development Plan) was redesignated as **10/28**, and its subsidiary runway (formerly 05/23) was redesignated as **04/22.** This report refers to the **old** numbering as per the SDCC Development plan.

Proposed Solar PV Array Details

For the purpose of this report, the site has been broken up into two different areas where solar PV panels may potentially be placed. Please refer to Map 1 for a breakdown of these areas.

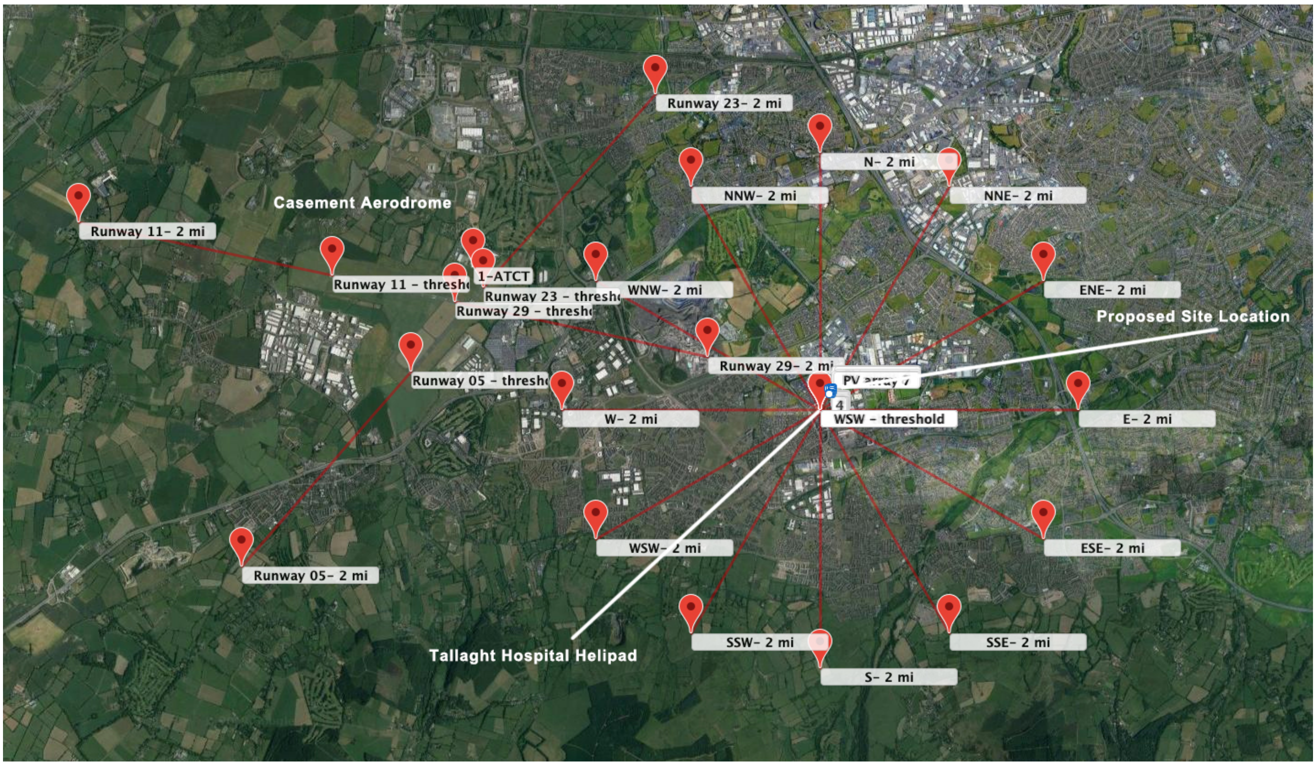

FIGURE 3: SITE LOCATION RELATIVE TO CASEMENT AERODROME

Both the pitch angle and the orientation angle of the panels will be fixed so the panels will not track the sun throughout the day/year. A pitch angle of 30° and an orientation of 180° (i.e. panels facing due south) are the paramaters proposed for these solar arrays. Please refer to Planning Drawing No. 001009 for details of potential panel configurations.

Glint and Glare Overview

What are Glint and Glare?

Glint and glare are phenomenon caused by many reflective materials, whereby light from the sun is reflected off such materials with a potential to cause hazard, nuisance or unwanted visual impact. Glint and glare have been best defined by the United States Federal Aviation Administration (FAA) in their "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[1]:

Glint is a momentary flash of bright light.

Glare is a continuous source of bright light.

Glint and Glare are also commonly referred to as 'solar reflection'. To determine the impact that solar reflection could potentially have on members of the public, it is sometimes necessary to carry out a glint and glare assessment for proposed solar PV farms or roof mounted arrays.

When do Glint and Glare Occur?

The sun rises in the east and sets in the west and in the northern hemisphere, tracks a southerly arc across the sky (Figure 4). The elevation angle that the sun reaches varies depending on the time of year, with high angles in the summer months and much lower angles in winter.

Once the sun reaches a certain elevation in the sky, the incident angle of the sun will reflect off the solar panels at an opposing angle that will not impact on any ground-based receptors. As a result of this, for ground-based receptors, glint and glare from solar farms will generally only occur in the mornings and the evenings. At these times, the sun will also be shining from a similar direction as any potential glare. For aviation receptors however, glare can potentially occur at any time of day depending on the location of the aircraft.

[1] Federal Aviation Administration, November 2010: *Technical Guidance for Evaluating Selected Solar Technologies on Airports*

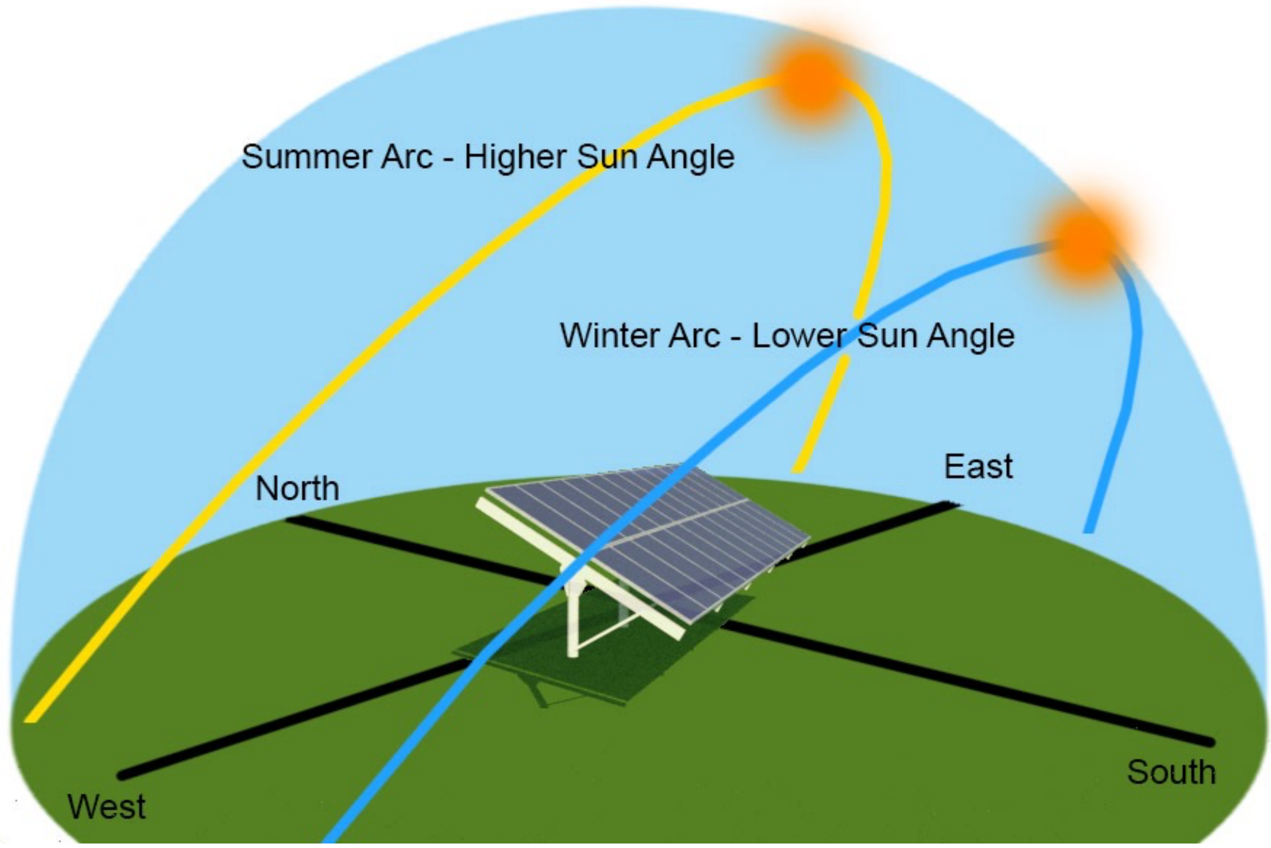

FIGURE 4: ARCS TRACKED BY SUN AT DIFFERENT TIMES OF YEAR

Meteorological & Atmospheric Conditions

It is also worth noting that glint and glare can only occur when there is direct sunlight reaching the solar panels. In overcast or rainy conditions, no glint or glare will occur. Met Éireann, Ireland's National Meteorological Service, suggests that due to Ireland's position off the northwest of Europe we are kept in humid, cloudy airflows for much of the time. *"Irish skies are completely covered by cloud for well over fifty percent of the time."*[2]

For this proposed development, historical sunshine duration data from 1981-2010, recorded at Casement Aerodrome has been analysed. Casement is the nearest Met Éireann weather station to the proposed development that records sunshine data. From looking at Figure 5 & Figure 6 below it can be seen that for this particular site, the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

[2] Met Éireann "Sunshine and Solar Radiation" www.met.ie.

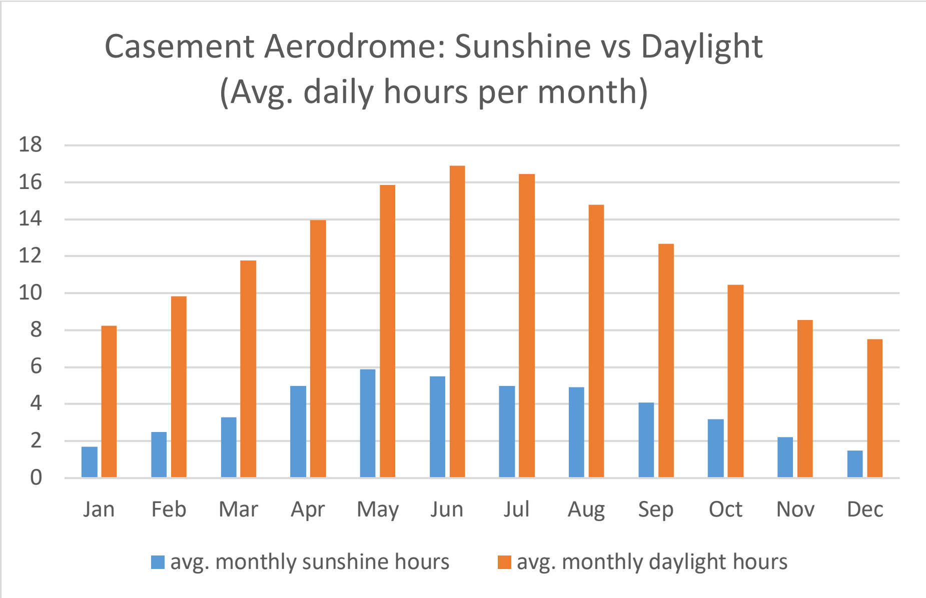

FIGURE 5: CASEMENT AERODROME: SUNSHINE VS DAYLIGHT (AVG. DAILY HOURS PER MONTH)

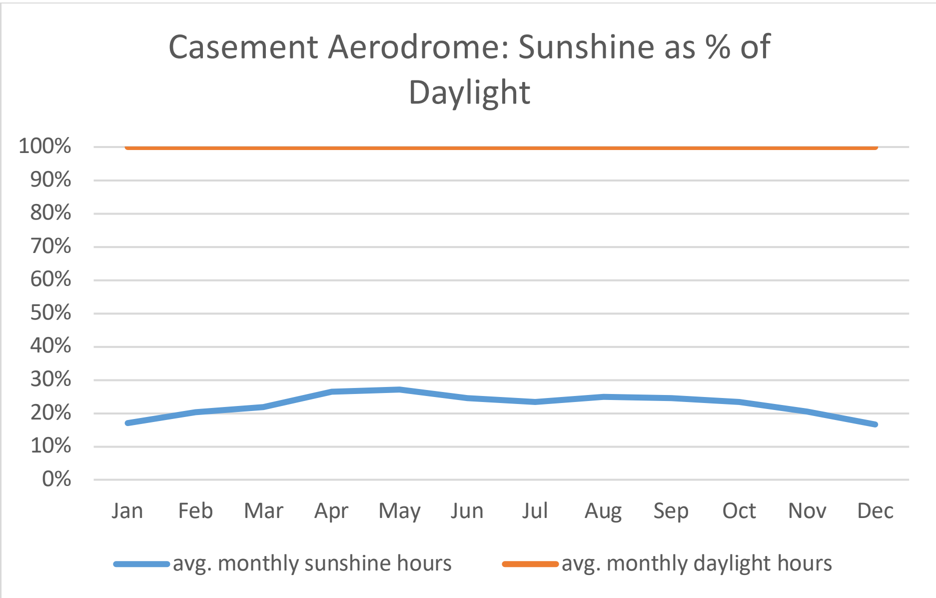

FIGURE 6: CASEMENT AERODROME: SUNSHINE AS A PERCENTAGE OF DAYLIGHT

Solar Reflectance from PV Panels

Surface Reflectance

All surface types have different reflectivity characteristics. This results in varying degrees of sunlight reflection. Solar panels, by their nature, are designed to absorb as much sunlight as possible, thus converting the sun's energy to electricity. As a result, the amount of light reflected off these installations is far less than one might expect. The figure below (Figure 7) is taken from the FAA 2010 Solar Guidance and illustrates that the reflectance of solar PV panels is of a similar nature to water. Typical values for the reflectance levels of solar PV panels are far less than that of materials such as snow, concrete and even vegetation. It should be noted however, that at certain times of the day, generally early morning and late evening, with the sun low in the sky, the amount of light reflected off solar panels can increase, causing a potential for glare in certain directions.

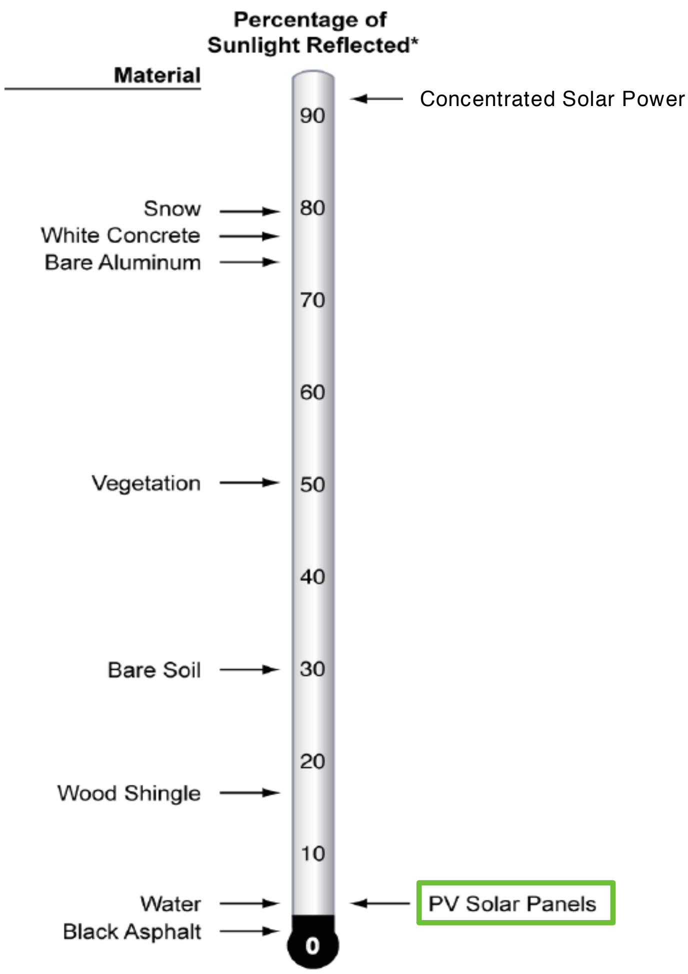

FIGURE 7: REFLECTIVITY PRODUCED BY DIFFERENT SURFACES (SOURCE: FAA)

Types of Reflection

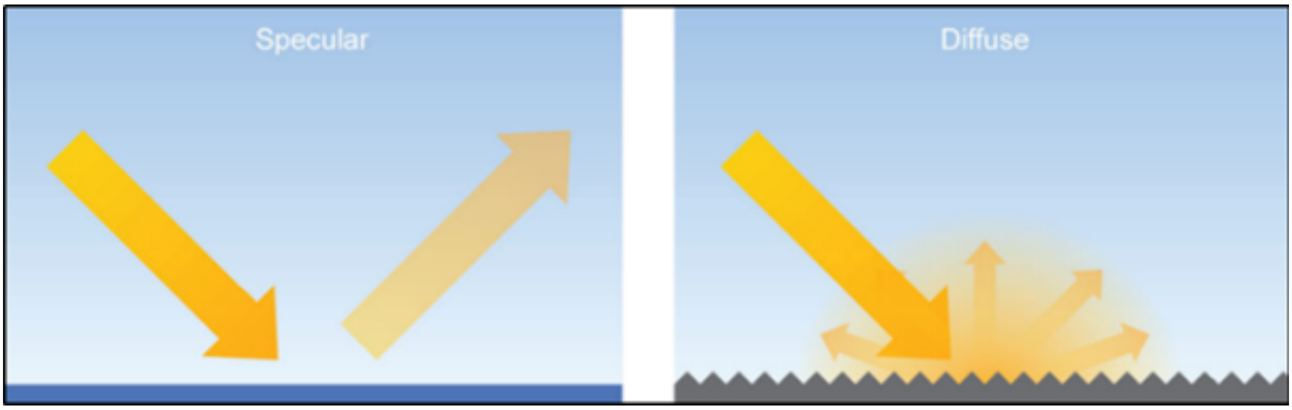

FIGURE 8: DIFFERENT TYPES OF REFLECTION (SOURCE: FAA)

There are two types of reflection which can occur on a surface; specular and diffuse. Specular reflection is a direct reflection which produces a more "focused" type of light. It occurs when light reflects off a smooth or polished surface like glass or still water. Diffuse reflection, on the other hand, produces a less "focused" type of light. Diffuse reflection occurs as a result of light reflecting off a rough surface such as vegetation, concrete or wavy water. Figure 8 helps to illustrate the difference between these two types of reflection. The main type of reflectance from solar PV panels is specular due to the glass like texture of the outer layer of the panels. However, in reality, like all surfaces, there will be a combination of both specular and diffuse reflection

As discussed earlier, the level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV systems such as shed roofs, still lakes and even the strips of plastic sheeting used on farms to produce maize (Figure 9).

FIGURE 9: PLASTIC MAIZE WRAP IN A FIELD WITH POTENTIAL TO CAUSE SIMILAR LEVELS OF GLARE AS SOLAR PV FARMS

Relevant Guidance & Studies

Republic of Ireland

In the Republic of Ireland (ROI), there is currently no guidance, policy or recommendations in relation to the assessment of glint and glare effects on aviation, road & rail users or residential buildings. Future Analytics in conjunction with the Sustainable Energy Authority of Ireland (SEAI) have produced planning and development guidance recommendations for utility scale solar photovoltaic schemes in Ireland [3]. While this is not formal guidance, it does set out recommended elements of the assessment based on international practice.

United Kingdom

In the United Kingdom (UK), where the development of large scale solar PV is more mature, certain studies have been carried out which help to establish an accepted best practice and planning guidance recommends the assessment of glint and glare effects. However, there is still no specific guidance by way of a prescriptive methodology document. In the absence of formal policy, the Civil Aviation Authority (CAA) have provided interim guidance in relation to the development of solar PV systems on, and in the vicinity (<15km) of aerodromes. This guidance recommends that solar PV developers should *"provide safety assurance documentation regarding the full potential impact of the SPV installation on aviation interests."* [4] The Building Research Establishment (BRE) have also issued several relevant papers, however neither the BRE nor the CAA have produced a methodology for assessing the effects of glint and glare on aviation, road & rail users or residential buildings.

Germany

In Germany, glare is considered an emission not unlike noise, odour or vibration. *"Licht-Leitlinie"* [5] or Light Guidelines produced by The Federal Ministry of the Environment defines acceptable levels of glare as being anything less than 30 minutes per day or 30 hours per year. The guidance also states that there is only additional impact to an observer as a result of glare from a solar array if the angle between the source of the glare and the sun is greater than ten degrees. These factors are taken into consideration at classification of impact stage in this report.

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[3] *Future Analytics. October 2016. Planning and Development Guidance Recommendations for Utility Scale Solar Photovoltaic Schemes in Ireland*

[4] Civil Aviation Authority. December 2010. *"Interim CAA Guidance - Solar Photovoltaic Systems".*

[5] Leitlinie des Ministeriums fur Umwelt. Gesundheit und Verbraucherschutz zur Messung und Beurteilung von Lichtimmissionen (Licht-Leitlinie). 2014 Available: http://www.mlul.brandenburg.de/media_fast/4055/licht_leitlinie.pdf

United States of America

The main form of guidance in assessing the likely effects of glint and glare (on aviation infrastructure) comes from the FAA in the United States. Their document, "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"[6] is accepted internationally as the most detailed methodology for assessing the effects of glint and glare. This document is currently under review and an interim policy document[7] was produced in October 2013. The 2013 interim policy further addresses glint and glare issues and recommends the use of a particular analysis tool, the Solar Glare Hazard Analysis Tool (SGHAT), when carrying out glint & glare assessments of solar PV systems. This is a tool that was developed by the US Department of Energy research laboratories, Sandia National Laboratories, to assess the ocular impact of proposed solar energy systems.

Innovision has created a methodology for assessing glint and glare taking all of the above studies and guidelines into consideration. Although SGHAT is a tool which was created to assess the impact of solar PV systems on aviation infrastructure, Innovision has employed this tool and prescribed methodology to all receptor types including road & rail users, aviation & residential buildings. This is currently the **only FAA approved tool** for measuring the ocular impact of solar PV systems on receptors. Until formal guidance is provided in Ireland, Innovision will continue to follow international guidelines and best practice.

Methodology

Innovision's methodology can be broken down into seven key stages:

1. Study Area Selection
2. Receptor Identification
3. Geometric Analysis
4. Examination of Screening and Receptor Orientation
5. Determination of Impact
6. Mitigation

[6] Federal Aviation Administration. November 2010. "*Technical Guidance for Evaluating Selected Solar Technologies on Airports*"
[7] Federal Aviation Administration. October 2013. *"Interim Policy, FAA Review of Solar Energy System Projects on Federally Obligated Airports."*

1. Study Area Selection

The first stage of any glint and glare assessment is to identify the study area. In the case of this development the runways and ATCT at Casement Aerodrome will be considered along with the helipad at Tallaght Hospital which would be regularly used by Coast Guard rescue helicopters. For ease of interpretation, the site has been broken up into two different areas and each solar array has been given a unique identification number. Please refer to Map 1 for a breakdown of these areas.

2. Receptor Identification

Once the study area has been defined, receptors can then be identified. For this site, the four runways and ATCT at Casement Aerodrome are being considered along with the helipad at Tallaght Hospital.

AIRPORTS & AIRSTRIPS

The two main receptors that need to be considered when assessing the glint and glare effects of solar PV farms on aerodromes are Air Traffic Control Towers (ATCT) and the final approach path to a runway. An ATCT is assessed much like any other receptor point using the correct altitude of the tower. For final runway approach paths, a line is extrapolated 2 miles back from the runway threshold (the point at which an aircraft enters the runway) at an angle of 3 degrees. This results in a continuous analysis of every point along the final approach to the runway. For this report, the above process is carried out for Casement Aerodrome only. For utility scale solar PV systems any aerodromes within the vicinity of a proposed solar PV farm would be assessed. “Vicinity” in this case is within 15km as defined by the CAA interim guidance referred to earlier. It should also be noted that these calculations take the pilots field of view into consideration and thus limit the angle of view to 100 degrees in the horizontal and a downward viewing angle of 30 degrees.

HELIPADS

Although there are no specific guidelines to assess glint and glare impacts on helipads, Innovision has employed a similar system to that used for runway approach paths. This involves a line being extrapolated 2 miles back from the helipad centre. However, the angle of approach used is steeper than that of an airplane landing on a runway. Helicoptor pilots would approach the helipad at an angle close to 8 degrees. In addition, a helicopters approach direction is not bound by a physical runway direction and depending on a number of factors including wind direction, a pilot can approach from any direction. For this reason, we have analysed approaches from 12 different directions to account for the various different approaches that could be taken. It should also be noted that these calculations take the pilots field of view into consideration and thus limit the angle of view to 100 degrees in the horizontal and a downward viewing angle of 30 degrees.

3. Geometric Analysis

As discussed previously in this document, Innovision employs the use of the SGHAT in order to run the calculations for its glint and glare analysis. This is currently the only FAA approved tool for measuring the ocular impact of solar PV systems on receptors.

A number of parameters are considered in order to run these geometric analyses. These include, but are not limited to:

- The apparent position and height of the sun at a particular time of day and year (for every minute of the year).
- The position, height, orientation & pitch of the solar PV array.
- The position and height of the receptor.

The severity of the glare is influenced mainly by two factors:

- The distance of the observer from the glare spot, and
- The angle of the sunlight hitting the solar panels relevant to the observer

4. Examination of Screening and Receptor Orientation

The geometrical glare analysis does not consider screening from landform such as hills and mountains, or any vegetative or built environment elements of the landscape that may screen the development from view. For this reason, once the receptors that could potentially experience glare have been identified, their level of existing screening must be assessed. This is done through a combination of desk-based analysis of both Google StreetView and aerial photography and sometimes requires a site visit for further verification. Receptor orientation is also considered. Geometric analysis may suggest that a dwelling will experience glare, but the orientation of the dwelling also needs to be considered. If a dwelling is facing away from the solar array, any potential glare could have little or no impact. Similarly, a road may show up as having potential to experience glare, but unless the direction of travel is towards the source of glare, it is unlikely to cause significant impact.

5. Determination of Impact

Once all of the above steps are carried out, a determination of likely impacts can be made for each receptor. Results are collated into a comprehendable table with comments as to the likely glint and glare impact or otherwise, of the propsed solar PV panels on all assessed receptors. An initial determination is made using the table below, based purely on the theroetical amount of time a receptor may potentially experience glare.

Classification	Description
High	Potential for more than 45 mins of glare per day and/or more than 50 hours per year
Medium	Potential for no more than 45 mins of glare per day and/or no more than 50 hours per year
Low	Potential for 20 - 30 mins of glare per day and/or no more than 30 hours per year
Very Low	Potential for 10 - 20 mins of glare per day and/or no more than 20 hours per year
Negligible	Potential for less than 10 mins of glare per day and/or less than 10 hours per year
None	No geometric potential for glare / Any potential for glare fully screened by intervening landform, vegetation or the built environment

The above table is used as a guide only and final classification is based on a combination of additional factors including level of intervening screening (vegetative or otherwise), receptor orientation, position of sun in relation to source of glare, as well as professional judgement.

6. Mitigation

If it is determined that glare will be experienced at a particular receptor and there is no screening between the receptor and the solar array, mitigation may be recommended depending on the severity of the glare. Mitigating glare impact from a solar array can be achieved in a number of different ways. The most common method is to add vegetative screening to essentially form a visual barrier between the receptor and the development. This type of mitigation is often required for ecological and visual impact reasons also. Other forms of mitigation include changing the design of the solar array, such as a change in pitch and orientation of the panels.

Receptor Selection

As discussed, this report assesses the final approach at all runways and the ATCT at Casement Aerodrome as well as the helipad at Tallaght Hospital. These receptors have been analysed for glint and glare effects that may be experienced during take off and landing as a result of the propsed roof mounted solar PV arrays. The accompanying Maps 1 - 10 will help in identifying solar array locations and also give a graphical overview of any arrays that could potentially be a source of glare (or otherwise) to aircraft.

Results & Discussion

Tables 1 - 17 give an overview of the findings of this glint and glare report and can be used to assist in comprehension of the following discussion, along with the included maps (Maps 1 - 10). For more detailed information on the particulars of potential glare experienced at each receptor, please refer to the appendix of this report. The appendix contain graphs for any solar array showing the potential for glare. The date and time of potential glare, the potential duration of the glare, the hazard plot indicating the magnitude of the potential glare and also where along the final approach the glare might potentially be experienced.

Please note, all references to time herein refer to Irish Standard Time (IST) which equates to UTC/GMT +1 hour. Between mid-March and early November Ireland uses Daylight Savings Time (DST) and as a result, 1 hour needs to be subtracted from any results occuring outside this time period.

TABLE 1: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 05

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	Yes	No	1.1	2	204	7.21	7.49	23/03/2020	17/09/2020	-	-	Green
Array2	Yes	No	1.2	2	187	7.21	7.49	23/03/2020	17/09/2020	-	-	Green

TABLE 2: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 11

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 3: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 23

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 4: RESULTS OF GLINT AND GLARE ANALYSIS ON FLIGHT PATH ON APPROACH TO RUNWAY 29

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 5: RESULTS OF GLINT AND GLARE ANALYSIS ON CASEMENT ATCT

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 6: RESULTS OF GLINT AND GLARE ANALYSIS ON NORTHERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 7: RESULTS OF GLINT AND GLARE ANALYSIS ON NORTH/NORTH-EASTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 8: RESULTS OF GLINT AND GLARE ANALYSIS ON EAST/NORTH-EASTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
No	Yes	6.9	8	996	18.31	19.05	03/03/2020	13/05/2020	28/07/2020	07/10/2020	Green
No	Yes	9.5	11	1385	18.26	19.05	02/03/2020	13/05/2020	29/07/2020	09/10/2020	Green

TABLE 9: RESULTS OF GLINT AND GLARE ANALYSIS ON EASTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
No	Yes	4.5	5	789	18.38	19.01	25/03/2020	16/09/2020	-	-	Green
No	Yes	4.5	5	825	18.38	19.04	21/03/2020	09/09/2020	-	-	Green

TABLE 10: RESULTS OF GLINT AND GLARE ANALYSIS ON EAST/SOUTH-EASTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
-	-	Glare not geometrically possible from this solar array									No Glare
No	Yes	1.1	2	30	18.38	18.43	07/06/2020	03/07/2020	-	-	Green

TABLE 11: RESULTS OF GLINT AND GLARE ANALYSIS ON SOUTH/SOUTH-EASTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 12: RESULTS OF GLINT AND GLARE ANALYSIS ON SOUTHERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 13: RESULTS OF GLINT AND GLARE ANALYSIS ON SOUTH/SOUTH-WESTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

TABLE 14: RESULTS OF GLINT AND GLARE ANALYSIS ON WEST/SOUTH-WESTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	Yes	No	1	1	15	8.03	8.06	13/06/2020	27/06/2020	-	-	Green

TABLE 15: RESULTS OF GLINT AND GLARE ANALYSIS ON WESTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	Yes	No	14.8	24	2600	7.44	8.13	25/03/2020	29/08/2020	-	-	Green
Array2	Yes	No	15.8	25	2852	7.38	8.09	22/03/2020	11/08/2020	-	-	Green

TABLE 16: RESULTS OF GLINT AND GLARE ANALYSIS ON WEST/NORTH-WESTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	Yes	No	7.7	10	1065	7.35	8.01	10/03/2020	17/05/2020	24/07/2020	30/09/2020	Green
Array2	Yes	No	7.6	9	1029	7.32	7.57	12/03/2020	18/05/2020	24/07/2020	29/09/2020	Green

TABLE 17: RESULTS OF GLINT AND GLARE ANALYSIS ON NORTH/NORTH-WESTERN APPROACH TO TALLAGHT HOSPITAL HELIPAD

Array Number	Theoretical Potential for Glare		Average Daily Duration	Max Daily Duration	Max Annual Duration	Potential Times Affected		Potential Dates Affected				FAA Glare Level
	am	pm	(mins)	(mins)	(mins)	Start Time	End Time	1st Start Date	1st End Date	2nd Start Date	2nd End Date	
Array1	-	-	Glare not geometrically possible from this solar array									No Glare
Array2	-	-	Glare not geometrically possible from this solar array									No Glare

Interpreting the Results

For the purpose of aviation analysis, the methodology produced by SANDIA National Laboratories must be followed to comply with FAA guidance. This approach adopts the Solar Glare Hazard Plot (Figure 10) to measure the ocular impact of a solar array. Receptors with theoretical potential for glare can fall into one of three different areas: Green - “Low potential for after-image”, Yellow - “Potential for after-image” and Red - “Potential for Permanent Eye Damage (retinal burn)”.

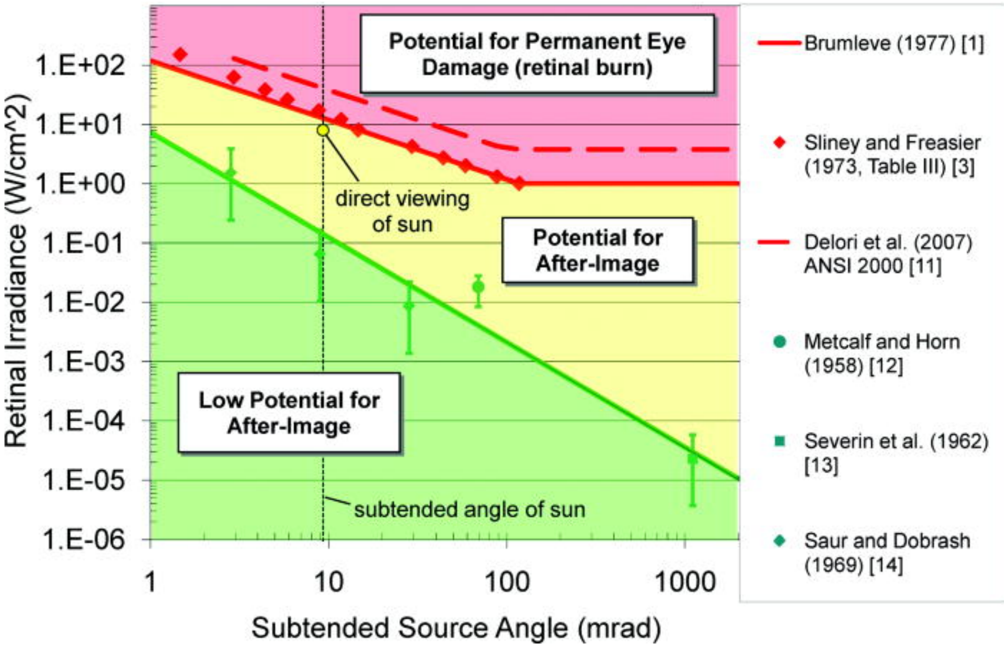


FIGURE 10: SOLAR GLARE HAZARD ANALYSIS PLOT (FIGURE 1 FROM FAA POLICY DOCUMENT)

The hazard plot above displays the ocular impact as a function of glare subtended source angle (the amount of an observer’s field-of-view taken up by a glare spot) and retinal irradiance (the amount of light reaching the observer’s retina). Each minute of potential glare is plotted on the chart. As a guide, a reference point which illustrates the hazard from viewing the sun without filtering is displayed on every graph.

From the 2013 FAA interim guidance, in order to obtain FAA approval for a proposed solar array the development must demonstrate that it meets the following standards:

“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 1) along the final approach path for any existing landing threshold or future landing thresholds (including any planned interim phases of the landing thresholds) as shown on the current FAA-approved Airport

Layout Plan (ALP). The final approach path is defined as two (2) miles from fifty (50) feet above the landing threshold using a standard three (3) degree glidepath."

Runway 05 (Now Named Runway 04)

From Table 1 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), both of the proposed arrays have the theoretical potential to impact on aircraft landing at Runway 05. In reality, given the negligible levels of glare and proximity of the development to Casement Aerodrome (4.5km), any glare experienced by a pilot landing at Runway 05 as a result of this development would be considered negligible by Innovision's classification set out above. Further to this, all potential glare would fall into the green area of the hazard plot which is deemed an acceptable level of glare according to FAA guidance.

Runway 11 (Now Named Runway 10)

From Table 2 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on aircraft landing at Runway 11.

Runway 23 (Now Named Runway 22)

From Table 3 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on aircraft landing at Runway 23.

Runway 29 (Now Named Runway 28)

From Table 4 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on aircraft landing at Runway 29.

Casement ATCT

From Table 5 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on the ATCT at Casement Aerodrome.

Tallaght Hospital Helipad – Northern Approach

From Table 6 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on a helicopter landing at Tallaght Hospital from a Northern approach.

Tallaght Hospital Helipad – North/North-Eastern Approach

From Table 7 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on a helicopter landing at Tallaght Hospital from a North/North-Eastern approach.

Tallaght Hospital Helipad – East/North-Eastern Approach

From Table 8 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), both of the proposed arrays have theoretical potential to impact on a helicopter landing at Tallaght Hospital from an East/North-Eastern approach. On sunny evenings in early March to mid May and again in late July to early October between the hours of 18:26 and 19:05 there is a potential for a pilot to experience glare emanating from both proposed arrays. Glare durations reach a maximum of 11 minutes per day with a maximum daily average of 9.5 minutes. It is likely that a helicopter approaching along this flight path will be past any glare in a matter of seconds. Any glare experienced by an observer here would fall into the green area of the hazard plot which is deemed an acceptable level of glare for landing aircraft, according to FAA guidance. It is worth mentioning however, while this approach was assessed using typical helicopter landing parameters, there is every possibility that a helicopter may deviate from this approach in both azimuth angle and glide path angle for various operational reasons. Given the proximity of the development to the helipad, this could result in an increase, or indeed a decrease in the levels of glare experienced by the observer.

Tallaght Hospital Helipad – Eastern Approach

From Table 9 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), both of the proposed arrays have theoretical potential to impact on a helicopter landing at Tallaght Hospital from an Eastern approach. On sunny evenings in late March to mid September between the hours of 18:38 and 19:04 there is a potential for a pilot to experience glare emanating from both proposed arrays. Glare durations are very low and reach a maximum of

5 minutes per day with a maximum daily average of 4.5 minutes. It is likely that a helicopter approaching along this flight path will be past any glare in a matter of seconds. Any glare experienced by an observer here would fall into the green area of the hazard plot which is deemed an acceptable level of glare for landing aircraft, according to FAA guidance. It is worth mentioning however, while this approach was assessed using typical helicopter landing parameters, there is every possibility that a helicopter may deviate from this approach in both azimuth angle and glide path angle for various operational reasons. Given the proximity of the development to the helipad, this could result in an increase, or indeed a decrease in the levels of glare experienced by the observer.

Tallaght Hospital Helipad – East/South-Eastern Approach

From Table 10 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), one of the proposed arrays (Array 2) has theoretical potential to impact on a helicopter landing at Tallaght Hospital from an East/South-Eastern approach. On sunny evenings in early June to early July between the hours of 18:38 and 18:43 there is a potential for a pilot to experience glare emanating from Array 2. Glare durations are negligible and reach a maximum of 2 minutes per day with a maximum daily average of 1.1 minutes. It is likely that a helicopter approaching along this flight path will be past any glare in a matter of seconds. Any glare experienced by an observer here would fall into the green area of the hazard plot which is deemed an acceptable level of glare for landing aircraft, according to FAA guidance. It is worth mentioning however, while this approach was assessed using typical helicopter landing parameters, there is every possibility that a helicopter may deviate from this approach in both azimuth angle and glide path angle for various operational reasons. Given the proximity of the development to the helipad, this could result in an increase, or indeed a decrease in the levels of glare experienced by the observer.

Tallaght Hospital Helipad – South/South-Eastern Approach

From Table 11 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on a helicopter landing at Tallaght Hospital from an East/South-Eastern approach.

Tallaght Hospital Helipad – Southern Approach

From Table 12 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on a helicopter landing at Tallaght Hospital from a Southern approach.

Tallaght Hospital Helipad – South/South-Western Approach

From Table 13 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on a helicopter landing at Tallaght Hospital from a South/South-Western approach.

Tallaght Hospital Helipad – West/South-Western Approach

From Table 14 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), one of the proposed arrays has theoretical potential to impact on a helicopter landing at Tallaght Hospital from a West/South-Western approach. On sunny mornings in mid June to late June between the hours of 08:03 and 08:06 there is a potential for a pilot to experience glare emanating from Array 2. Glare durations are negligible and reach a maximum of 1 minute per day. It is likely that a helicopter approaching along this flight path will be past any glare in a matter of seconds. Any glare experienced by an observer here would fall into the green area of the hazard plot which is deemed an acceptable level of glare for landing aircraft, according to FAA guidance. It is worth mentioning however, while this approach was assessed using typical helicopter landing parameters, there is every possibility that a helicopter may deviate from this approach in both azimuth angle and glide path angle for various operational reasons. Given the proximity of the development to the helipad, this could result in an increase, or indeed a decrease in the levels of glare experienced by the observer.

Tallaght Hospital Helipad – Western Approach

From Table 15 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), both of the proposed arrays have theoretical potential to impact on a helicopter landing at Tallaght Hospital from a Western approach. On sunny mornings in late March to late August between the hours of 07:38 and 08:13 there is a potential for a pilot to experience glare emanating from both arrays. Glare durations are low and reach a maximum of 25 minutes per day. While glare durations are relatively long here, it is likely that a helicopter approaching along this flight path will be past any glare in a matter of seconds. Any glare experienced by an observer here would fall into the green area of the hazard plot which is deemed an acceptable level of glare for landing aircraft, according to FAA guidance. It is worth mentioning however, while this approach was assessed using typical helicopter landing parameters, there is every possibility that a helicopter may deviate from this approach in both azimuth angle and glide path angle for various operational reasons. Given the proximity of the development to the helipad, this could result in an increase, or indeed a decrease in the levels of glare experienced by the observer.

Tallaght Hospital Helipad – West/North-Western Approach

From Table 16 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), all of the proposed arrays have theoretical potential to impact on a helicopter landing at Tallaght Hospital from a West/North-Western approach. On sunny mornings in early March to mid May and late July to late September between the hours of 07:32 and 08:01 there is a potential for a pilot to experience glare emanating from both arrays. Glare durations are very low and reach a maximum of 10 minutes per day. It is likely that a helicopter approaching along this flight path will be past any glare in a matter of seconds. Any glare experienced by an observer here would fall into the green area of the hazard plot which is deemed an acceptable level of glare for landing aircraft, according to FAA guidance. It is worth mentioning however, while this approach was assessed using typical helicopter landing parameters, there is every possibility that a helicopter may deviate from this approach in both azimuth angle and glide path angle for various operational reasons. Given the proximity of the development to the helipad, this could result in an increase, or indeed a decrease in the levels of glare experienced by the observer.

Tallaght Hospital Helipad – North/North-Western Approach

From Table 17 above it can be seen that, using the specified parameters (pitch angle of 30° and an orientation angle of 180°), none of the proposed arrays have the potential to impact on a helicopter landing at Tallaght Hospital from a North/North-Western approach.

For all of the above approach path’s analysed a number of factors should also be noted, which add to the argument that hazardous glare as a result of the roof mounted PV panels on the proposed residential development at Units 66 & 67 Fourth Avenue, Cookstown Industrial Estate, Tallaght, Dublin 24 can not be expected.

Duration of Glare: While a detailed breakdown of the duration of potential glare has been provided, in reality, as mentioned above, an aircraft will be past any reflectance in a matter of seconds.

Obstacle Screening & Self Screening: The SGHAT utilized in this report does not account for screening of the panels from an observer by elements in the landscape including buildings, vegetation or even the solar panels themselves. It therefore generally overstates predicted impacts as there are almost always elements in the landscape blocking potential views, if only even partially.

Weather: As mentioned previously in this report, in order for glare to be experienced, the sun needs to be shining on the panels. From analysis of historical data it can be shown that the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

Conclusion

In conclusion, it can be shown from the above analyses that, based on the specified solar panel parameters, major nuisance or hazardous glare **can not** be expected for aircraft landing at any of the runways or the ATCT at Casement Aerodrome. This is due to the fact that there will be no geometric posibility for glare at any time of year for the ATCT or final approaches to runways 11, 23 & 29. Negligible amounts of glare could potentially be experienced on the final approach to runway 05 but in reality, this would most likely be undetected by a pilot. Similarly, hazardous glare can not be expected for helicopters landing at Tallaght Hospital's helipad, based on the helicopter landing parameters assessed in this report. Durations and intensities of glare higher than those at Casement could be experienced at certain times of the day and year (provided the sun is shining on the panels). However, all glare intensities fall into the "green" area of the glare hazard plot. These results achieve a pass by FAA standards based on the fact that no glare falls in the "yellow" area of the hazard plot.

The level of potential glare from solar PV panels is similar to that of water and much less than that of materials such as concrete and vegetation. Many common elements of the Irish landscape offer similar, if not higher levels of glare than that caused by solar PV panels.

In order for glare to be experienced by a pilot, there needs to be direct sunlight shining on the solar PV panels. From analysis of historical sunshine data near the proposed site, the number of days glare could potentially be experienced at each receptor could realistically be reduced by 70% and still offer an overstated prediciton of glare.

Appendix

Please note the following assumptions will apply to the following graphs:

- Please note, all references to time herein refer to Irish Standard Time (IST) which equates to UTC/GMT +1 hour. Between mid-March and early November Ireland uses Daylight Savings Time (DST) and as a result, 1 hour needs to be subtracted from any results occuring outside this time period.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions.

Site Configuration: Cookstown Phase 2a Rev1

Project site configuration details and results.

Created **June 16, 2020 3:34 p.m.**
Updated **June 23, 2020 6:30 a.m.**
DNI **varies** and peaks at **1,000.0 W/m^2**
Analyze every **1** minute(s)
0.5 ocular transmission coefficient
0.002 m pupil diameter
0.017 m eye focal length
9.3 mrad sun subtended angle
Timezone **UTC1**
Site Configuration ID: 40355.5580

Summary of Results Glare with low potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	30.0	180.0	5,654	0	-
PV array 2	30.0	180.0	6,323	0	-

Component Data

PV Array(s)

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 30.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 160 sq-m

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.291967	-6.374823	104.67	22.63	127.30
2	53.291964	-6.374581	104.82	22.48	127.30
3	53.292052	-6.374576	104.60	22.70	127.30
4	53.292056	-6.374819	104.50	22.80	127.30

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 30.0 deg
Orientation: 180.0 deg
Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad
Approx. area: 159 sq-m

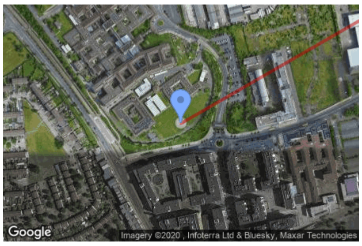
Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	53.291450	-6.374686	105.66	21.64	127.30
2	53.291364	-6.374683	105.60	21.70	127.30
3	53.291367	-6.374435	106.18	21.12	127.30
4	53.291451	-6.374432	106.27	21.03	127.30

2-Mile Flight Path Receptor(s)

Name: E
Description:
Threshold height : 3 m
Direction: 270.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

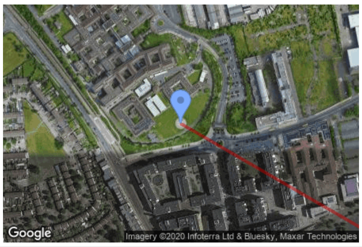
Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289501	-6.376778	103.75	3.00	106.75
2-mile point	53.289501	-6.328354	67.99	491.12	559.11

Name: ENE
Description:
Threshold height : 3 m
Direction: 240.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg



Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289500	-6.376778	103.75	3.00	106.75
2-mile point	53.303956	-6.334841	59.60	499.51	559.11

Name: ESE
Description:
Threshold height : 3 m
Direction: 300.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg



Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289501	-6.376778	103.75	3.00	106.75
2-mile point	53.275045	-6.334841	99.61	459.51	559.11

Name: N
Description:
Threshold height : 3 m
Direction: 180.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289501	-6.376775	103.75	3.00	106.75
2-mile point	53.318413	-6.376775	80.25	478.86	559.11

Name: NNE
Description:
Threshold height : 3 m
Direction: 210.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289499	-6.376775	103.75	3.00	106.75
2-mile point	53.314538	-6.352563	58.45	500.66	559.11

Name: NNW
Description:
Threshold height : 3 m
Direction: 150.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289501	-6.376772	103.75	3.00	106.75
2-mile point	53.314540	-6.400984	72.52	486.60	559.11

Name: Runway 05
Description:
Threshold height : 15 m
Direction: 41.0 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.293829	-6.453445	98.24	15.24	113.48
2-mile point	53.272011	-6.485223	153.89	128.27	282.16

Name: Runway 11
Description:
Threshold height : 15 m
Direction: 101.8 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.304623	-6.468283	86.32	15.24	101.56
2-mile point	53.310546	-6.515697	73.62	196.62	270.24

Name: Runway 23
Description:
Threshold height : 15 m
Direction: 221.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

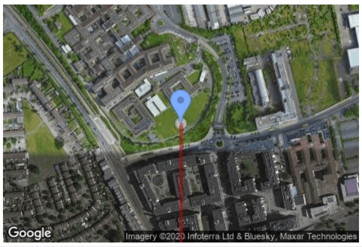
Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.303268	-6.439791	93.37	15.24	108.61
2-mile point	53.324896	-6.407643	62.85	214.45	277.30

Name: Runway 29
Description:
Threshold height : 15 m
Direction: 282.4 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.301696	-6.445147	96.10	15.24	111.34
2-mile point	53.295498	-6.397836	105.99	174.04	280.03

Name: S
Description:
Threshold height : 3 m
Direction: 0.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289504	-6.376775	103.75	3.00	106.75
2-mile point	53.260591	-6.376775	161.85	397.26	559.11



Name: SSE
Description:
Threshold height : 3 m
Direction: 330.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289500	-6.376775	103.75	3.00	106.75
2-mile point	53.264461	-6.352563	130.67	428.45	559.11

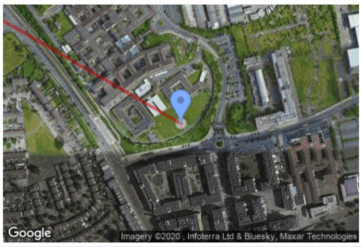
Name: SSW
Description:
Threshold height : 3 m
Direction: 30.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289504	-6.376774	103.75	3.00	106.75
2-mile point	53.264465	-6.400985	262.66	296.45	559.11

Name: W
Description:
Threshold height : 3 m
Direction: 90.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

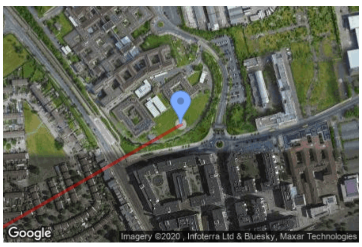
Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289503	-6.376772	103.75	3.00	106.75
2-mile point	53.289503	-6.425196	110.02	449.09	559.11

Name: WNW
Description:
Threshold height : 3 m
Direction: 120.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg



Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289501	-6.376771	103.75	3.00	106.75
2-mile point	53.303957	-6.418707	91.10	468.01	559.11

Name: WSW
Description:
Threshold height : 3 m
Direction: 60.0 deg
Glide slope: 8.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

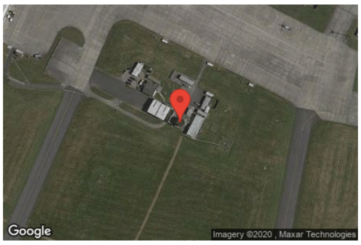


Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	53.289502	-6.376774	103.75	3.00	106.75
2-mile point	53.275046	-6.418710	143.66	415.45	559.11

Discrete Observation Receptors

Number	Latitude	Longitude	Ground elevation	Height above ground	Total Elevation
	deg	deg	m	m	m
1-ATCT	53.305497	-6.441786	93.54	6.00	99.54

1-ATCT map image



PV Array Results

Summary of PV Glare Analysis PV configuration and predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	30.0	180.0	5,654	0	-	
PV array 2	30.0	180.0	6,323	0	-	

Click the name of the PV array to scroll to its results

PV & Receptor Analysis Results detailed results for each PV array and receptor

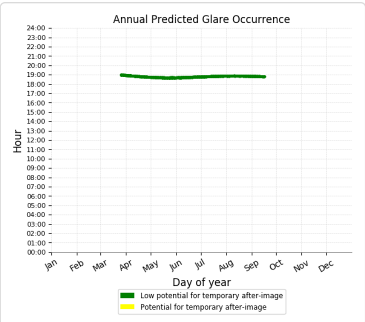
PV array 1 low potential for temporary after-image

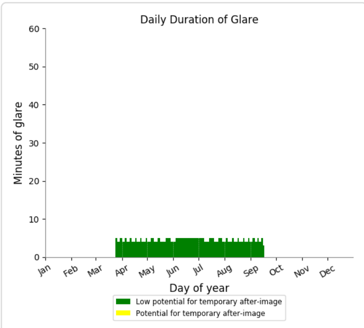
Component	Green glare (min)	Yellow glare (min)
FP: E	789	0
FP: ENE	996	0
FP: ESE	0	0
FP: N	0	0
FP: NNE	0	0
FP: NNW	0	0
FP: Runway 05	204	0
FP: Runway 11	0	0
FP: Runway 23	0	0
FP: Runway 29	0	0
FP: S	0	0
FP: SSE	0	0
FP: SSW	0	0
FP: W	2600	0
FP: WNW	1065	0
FP: WSW	0	0
OP: 1-ATCT	0	0

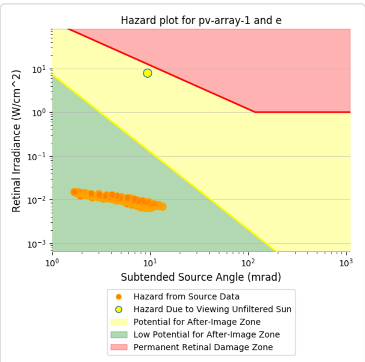
PV array 1 - Receptor (E)

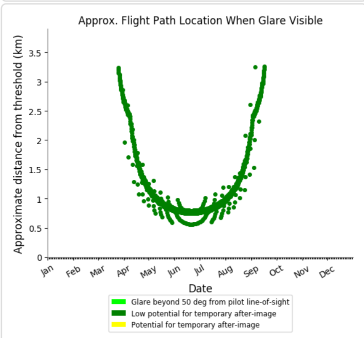
PV array is expected to produce the following glare for observers on this flight path:

- 789 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





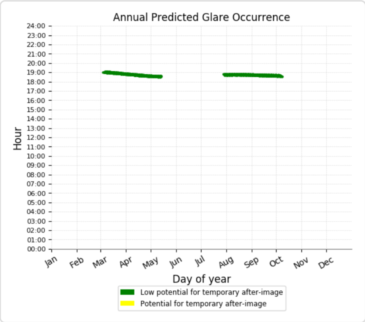


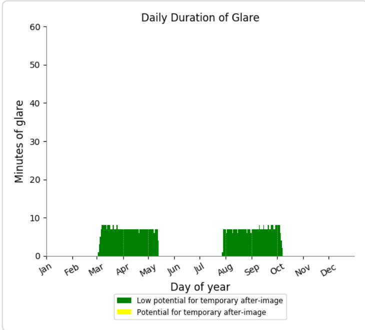


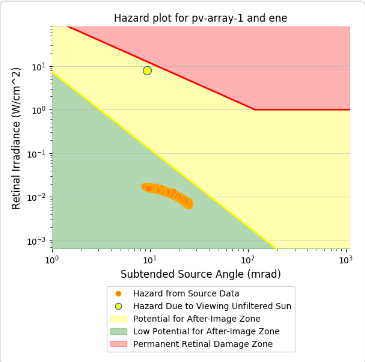
PV array 1 - Receptor (ENE)

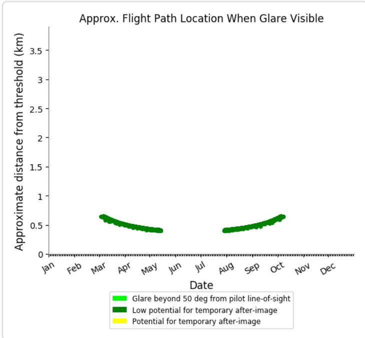
PV array is expected to produce the following glare for observers on this flight path:

- 996 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - Receptor (ESE)

No glare found

PV array 1 - Receptor (N)

No glare found

PV array 1 - Receptor (NNE)

No glare found

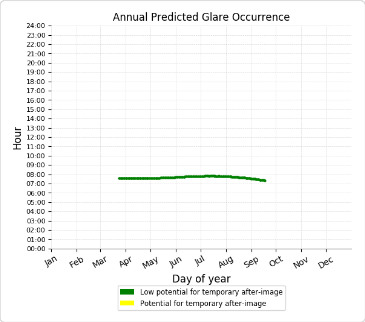
PV array 1 - Receptor (NNW)

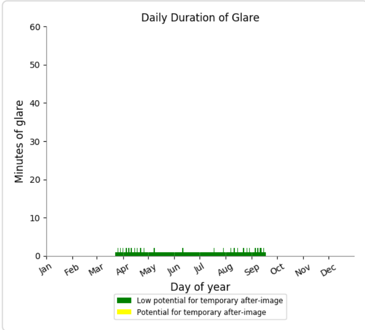
No glare found

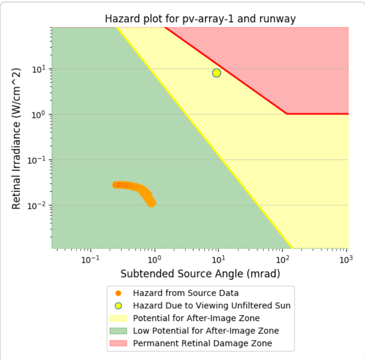
PV array 1 - Receptor (Runway 05)

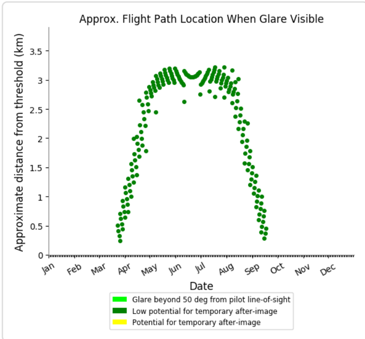
PV array is expected to produce the following glare for observers on this flight path:

- 204 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - Receptor (Runway 11)

No glare found

PV array 1 - Receptor (Runway 23)

No glare found

PV array 1 - Receptor (Runway 29)

No glare found

PV array 1 - Receptor (S)

No glare found

PV array 1 - Receptor (SSE)

No glare found

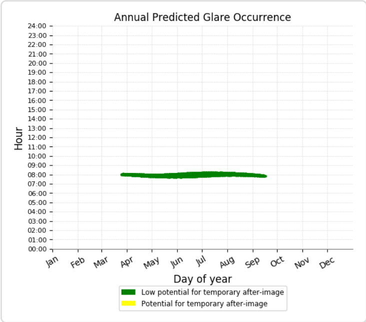
PV array 1 - Receptor (SSW)

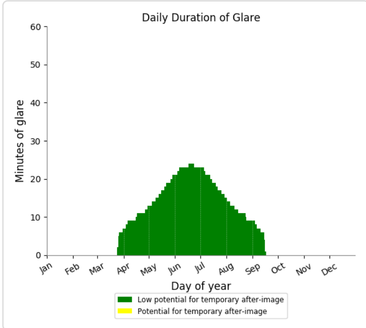
No glare found

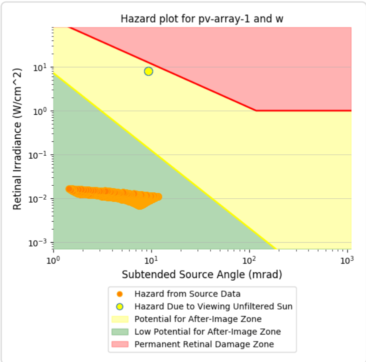
PV array 1 - Receptor (W)

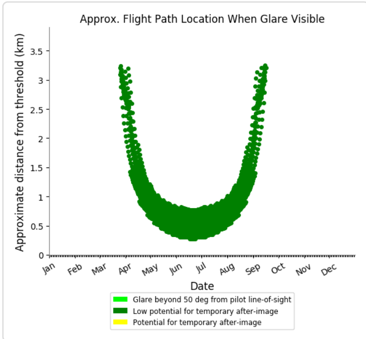
PV array is expected to produce the following glare for observers on this flight path:

- 2,600 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





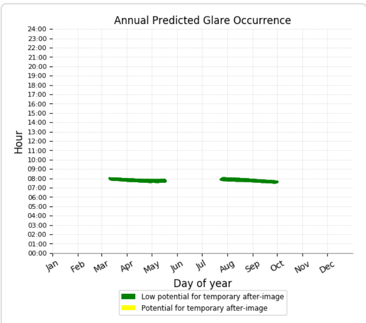


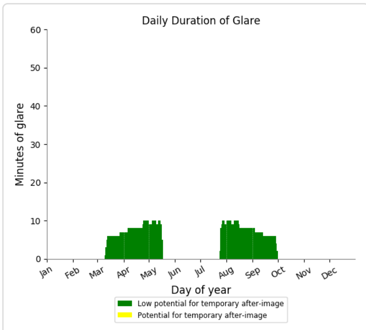


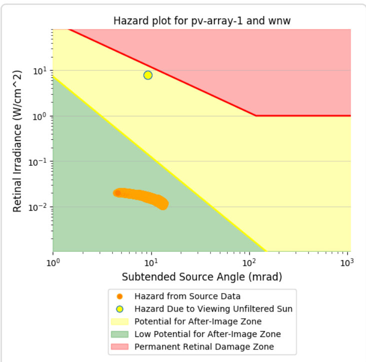
PV array 1 - Receptor (WNW)

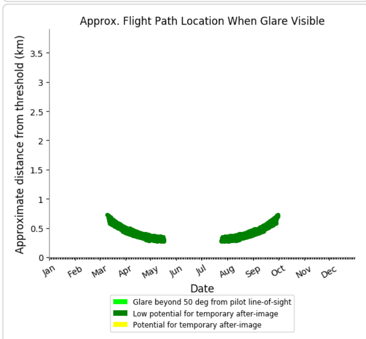
PV array is expected to produce the following glare for observers on this flight path:

- 1,065 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 1 - Receptor (WSW)

No glare found

PV array 1 - OP Receptor (1-ATCT)

No glare found

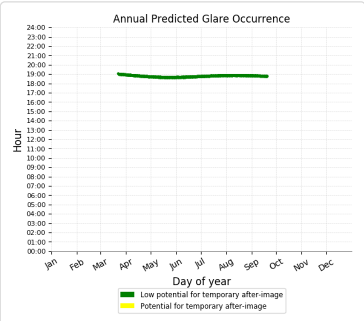
PV array 2 low potential for temporary after-image

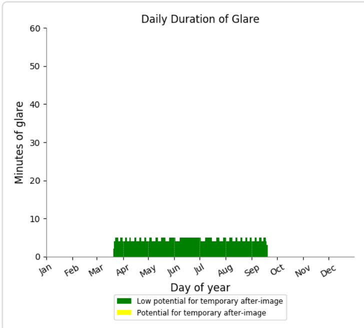
Component	Green glare (min)	Yellow glare (min)
FP: E	825	0
FP: ENE	1385	0
FP: ESE	30	0
FP: N	0	0
FP: NNE	0	0
FP: NNW	0	0
FP: Runway 05	187	0
FP: Runway 11	0	0
FP: Runway 23	0	0
FP: Runway 29	0	0
FP: S	0	0
FP: SSE	0	0
FP: SSW	0	0
FP: W	2852	0
FP: WNW	1029	0
FP: WSW	15	0
OP: 1-ATCT	0	0

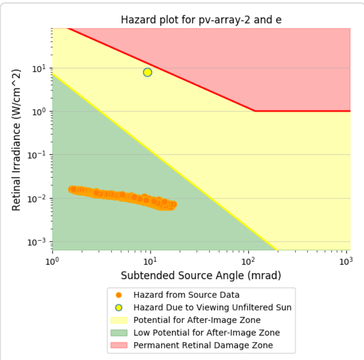
PV array 2 - Receptor (E)

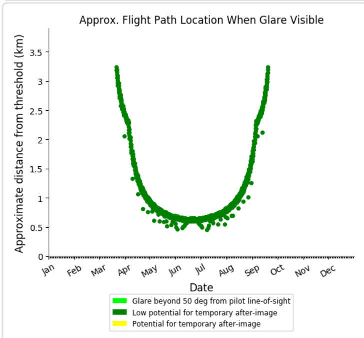
PV array is expected to produce the following glare for observers on this flight path:

- 825 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





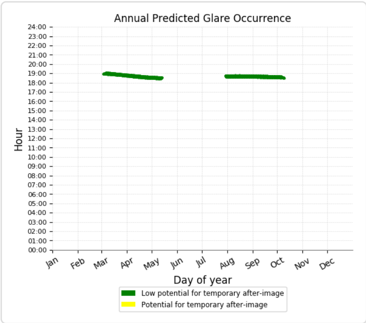


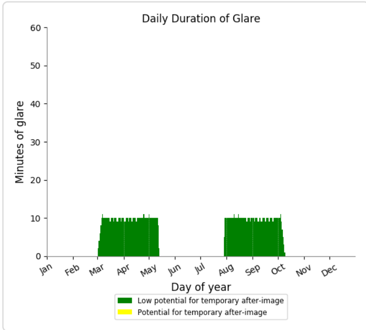


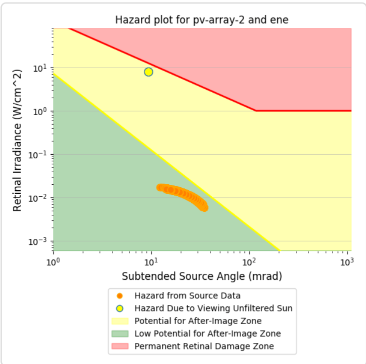
PV array 2 - Receptor (ENE)

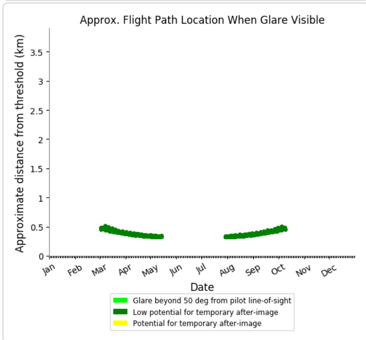
PV array is expected to produce the following glare for observers on this flight path:

- 1,385 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





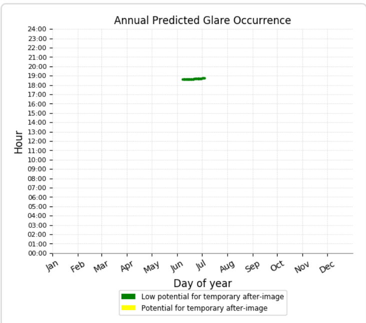


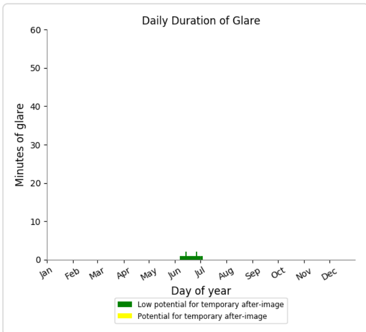


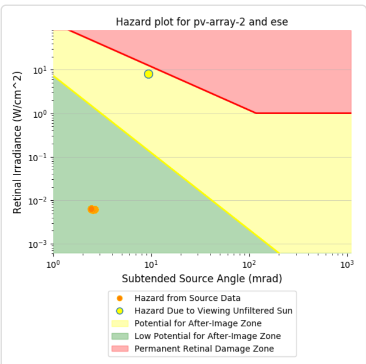
PV array 2 - Receptor (ESE)

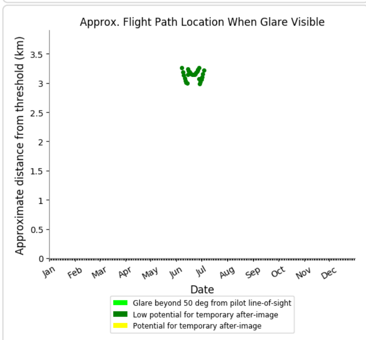
PV array is expected to produce the following glare for observers on this flight path:

- 30 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 2 - Receptor (N)

No glare found

PV array 2 - Receptor (NNE)

No glare found

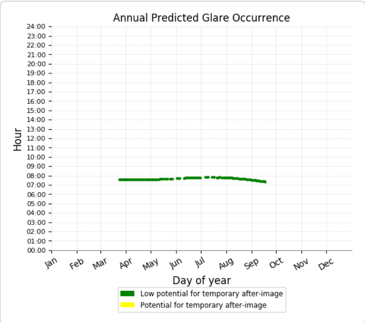
PV array 2 - Receptor (NNW)

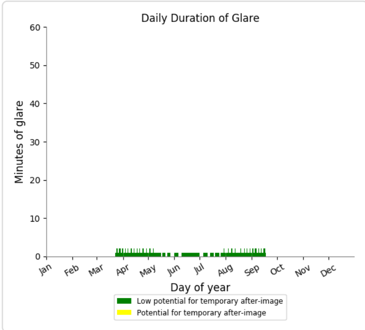
No glare found

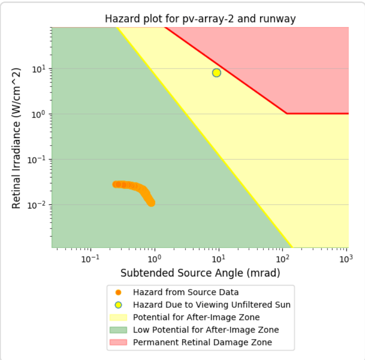
PV array 2 - Receptor (Runway 05)

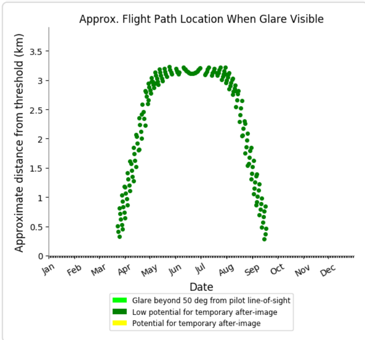
PV array is expected to produce the following glare for observers on this flight path:

- 187 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









PV array 2 - Receptor (Runway 11)

No glare found

PV array 2 - Receptor (Runway 23)

No glare found

PV array 2 - Receptor (Runway 29)

No glare found

PV array 2 - Receptor (S)

No glare found

PV array 2 - Receptor (SSE)

No glare found

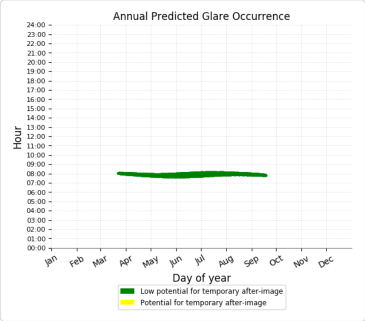
PV array 2 - Receptor (SSW)

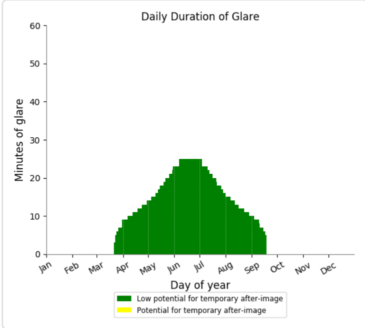
No glare found

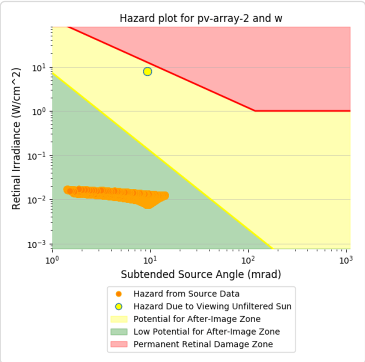
PV array 2 - Receptor (W)

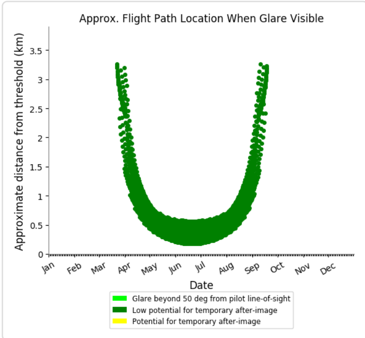
PV array is expected to produce the following glare for observers on this flight path:

- 2,852 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





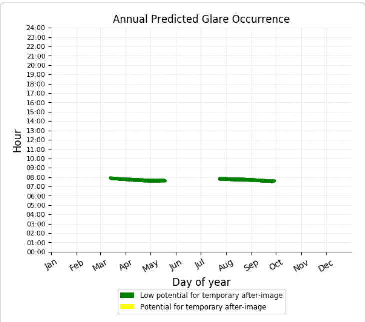


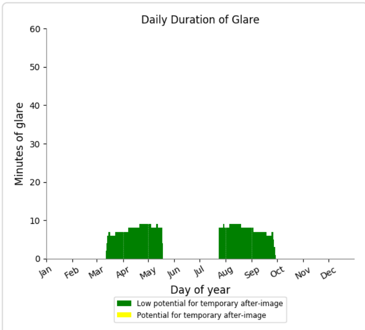


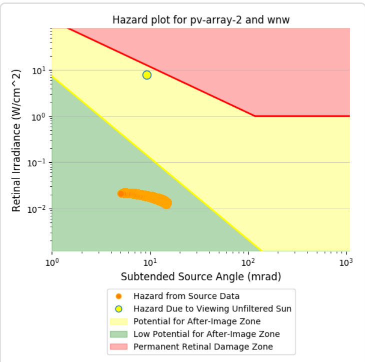
PV array 2 - Receptor (WNW)

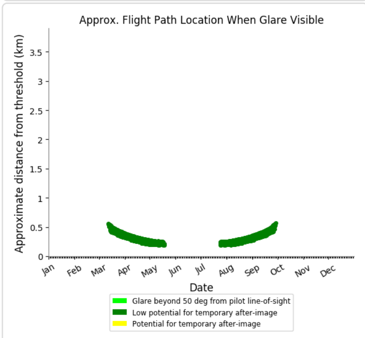
PV array is expected to produce the following glare for observers on this flight path:

- 1,029 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





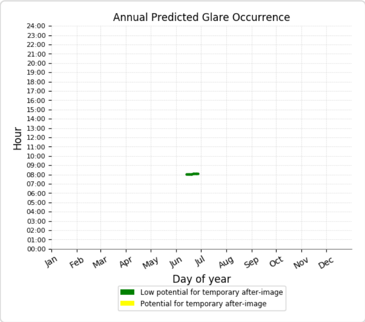


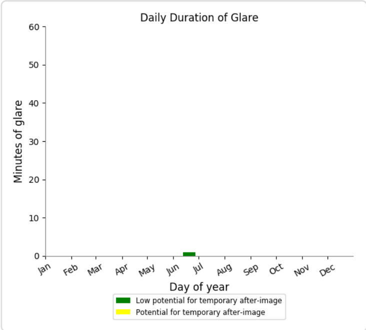


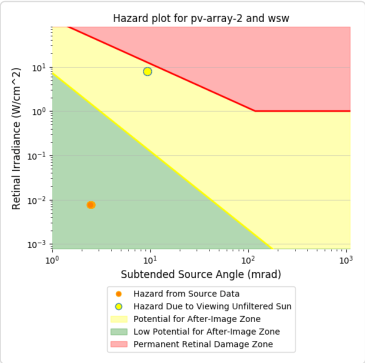
PV array 2 - Receptor (WSW)

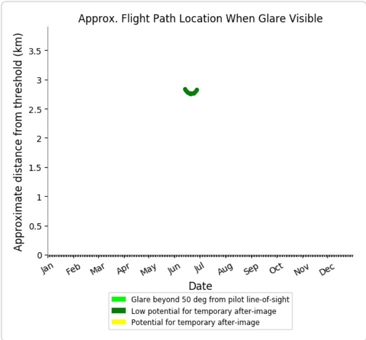
PV array is expected to produce the following glare for observers on this flight path:

- 15 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









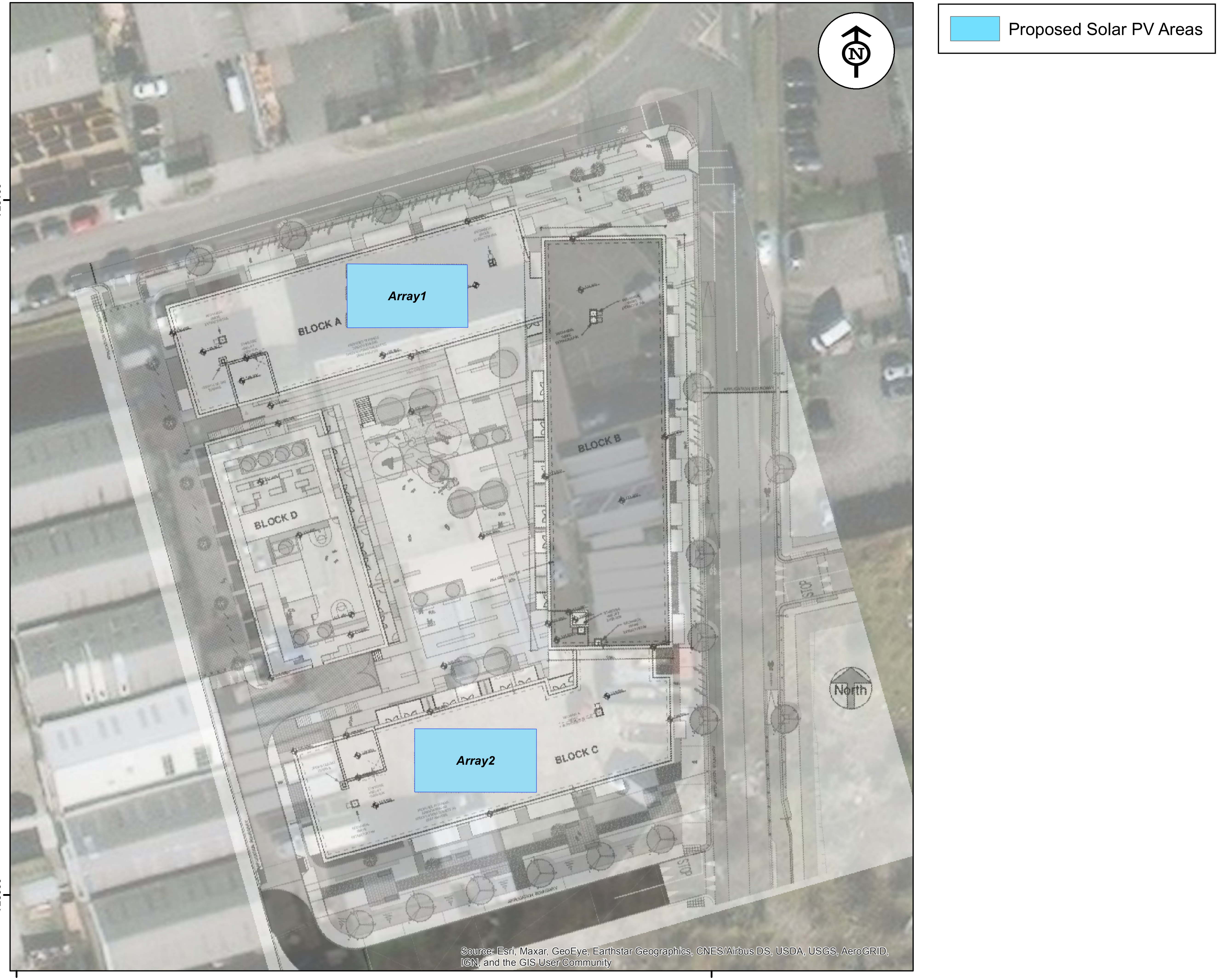
PV array 2 - OP Receptor (1-ATCT)

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 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not 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.
- Glare analysis methods used: OP V1, FP V1, Route V1
- Refer to the **Help page** for assumptions and limitations not listed here.

Map 1 Glint and Glare Zones Overview Map - Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



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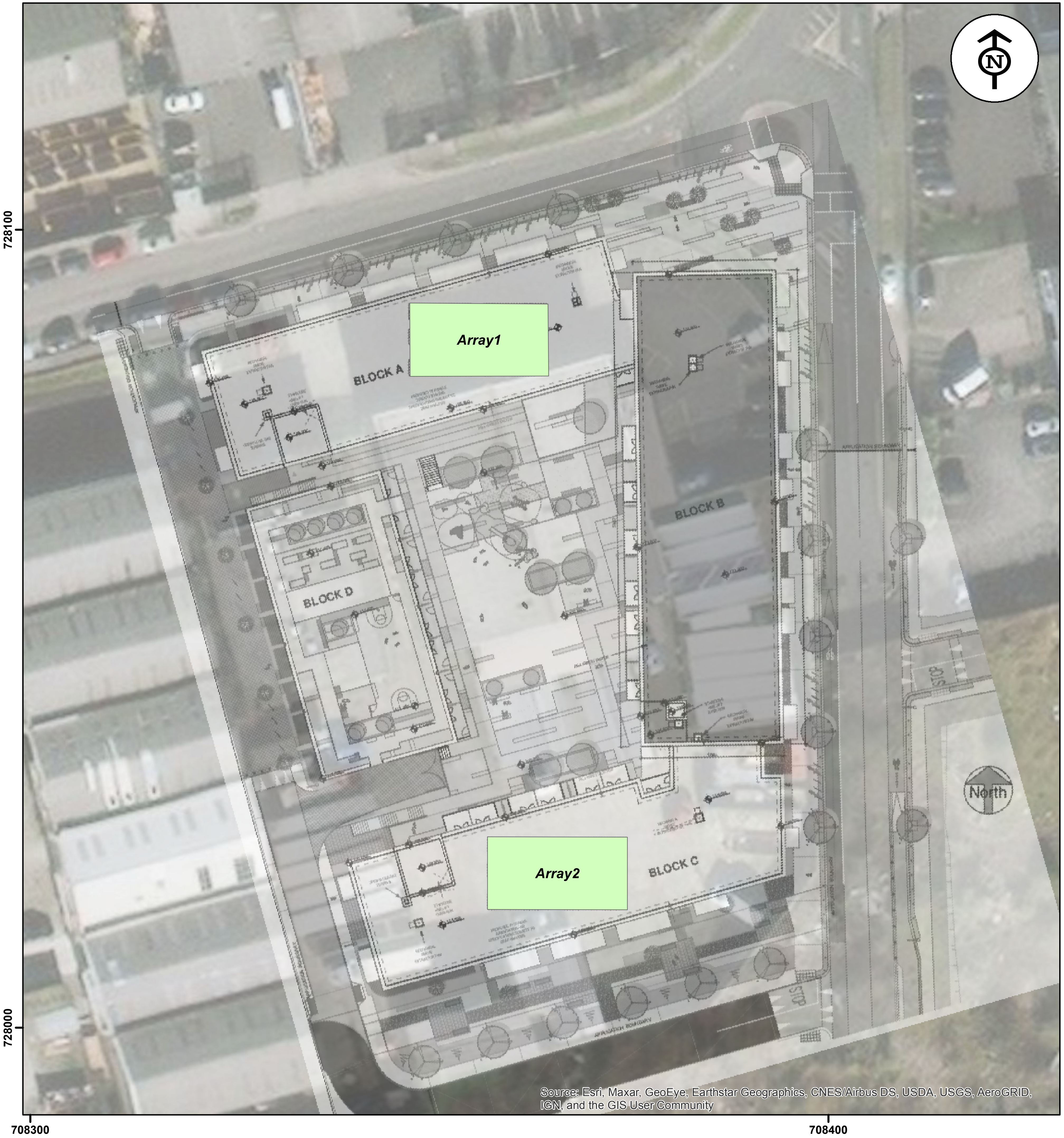
Map 2 Potential Glint and Glare Impact on final approach to Casement Aerodrome Runway 05 as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500

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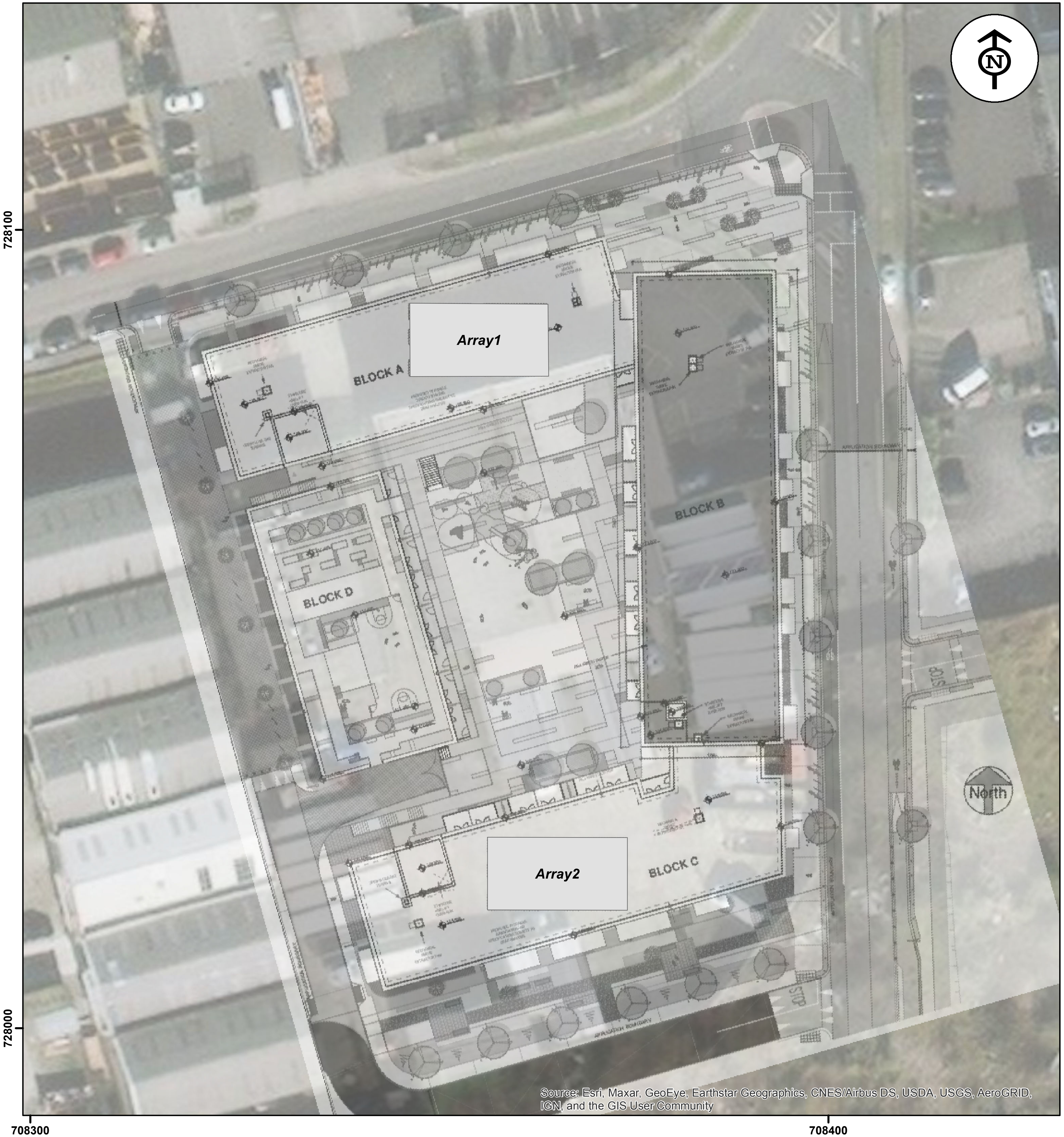
Map 3 Potential Glint and Glare Impact on final approach to Casement Aerodrome Runways 11, 23 & 29 as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave development



Annual Potential Glare Values (Minutes)

No Glare Predicted

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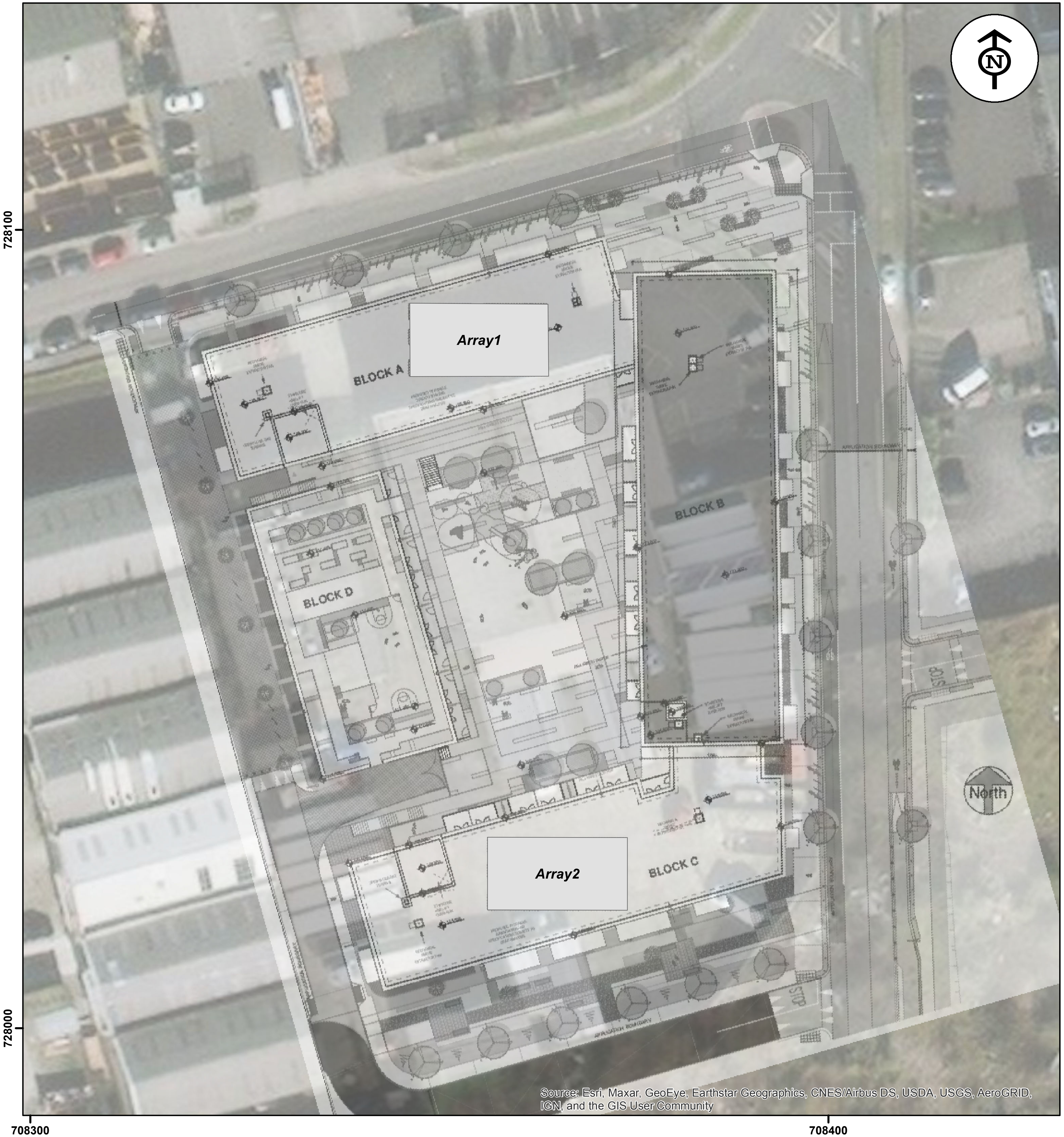
Map 4 Potential Glint and Glare Impact on Casement Air Traffic Control Tower as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

No Glare Predicted

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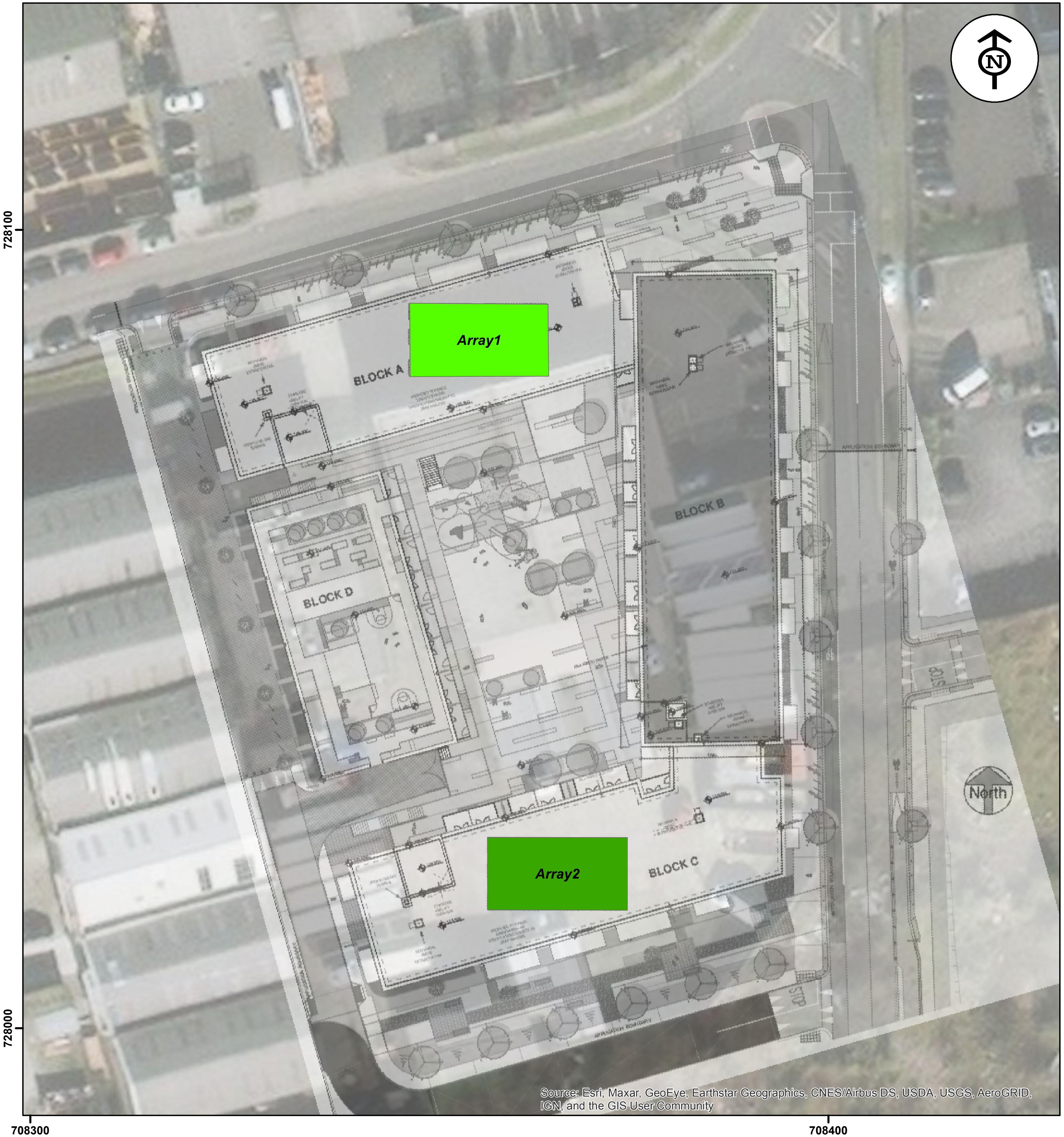
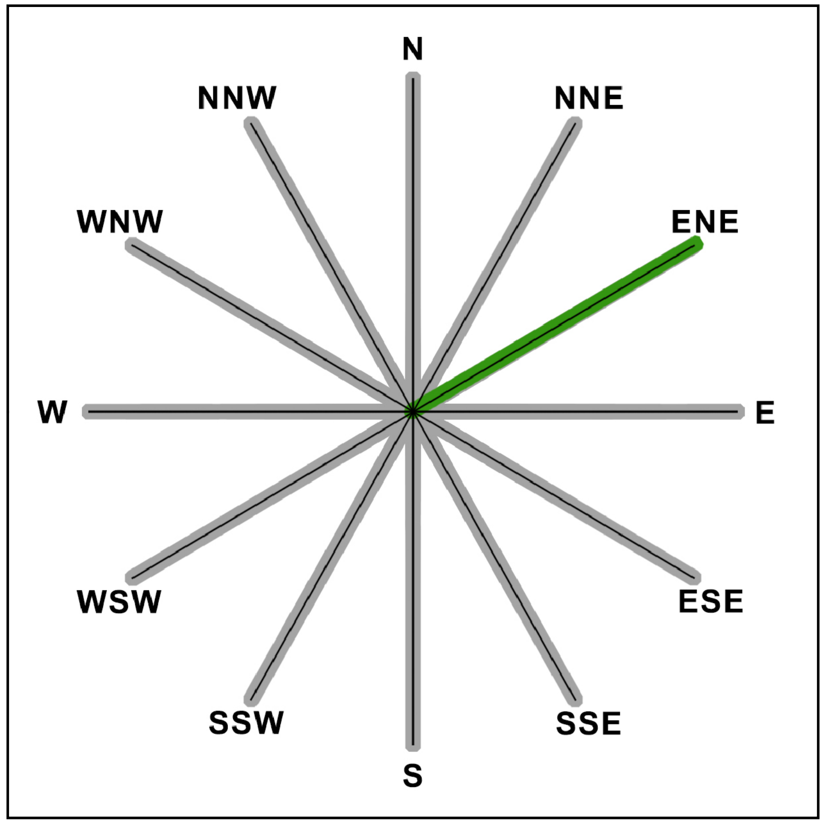
Map 5 Potential Glint and Glare Impact on east/north-eastern approach at Tallaght Hospital Helipad as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500
- Between 501 and 1000
- Between 1001 and 2000



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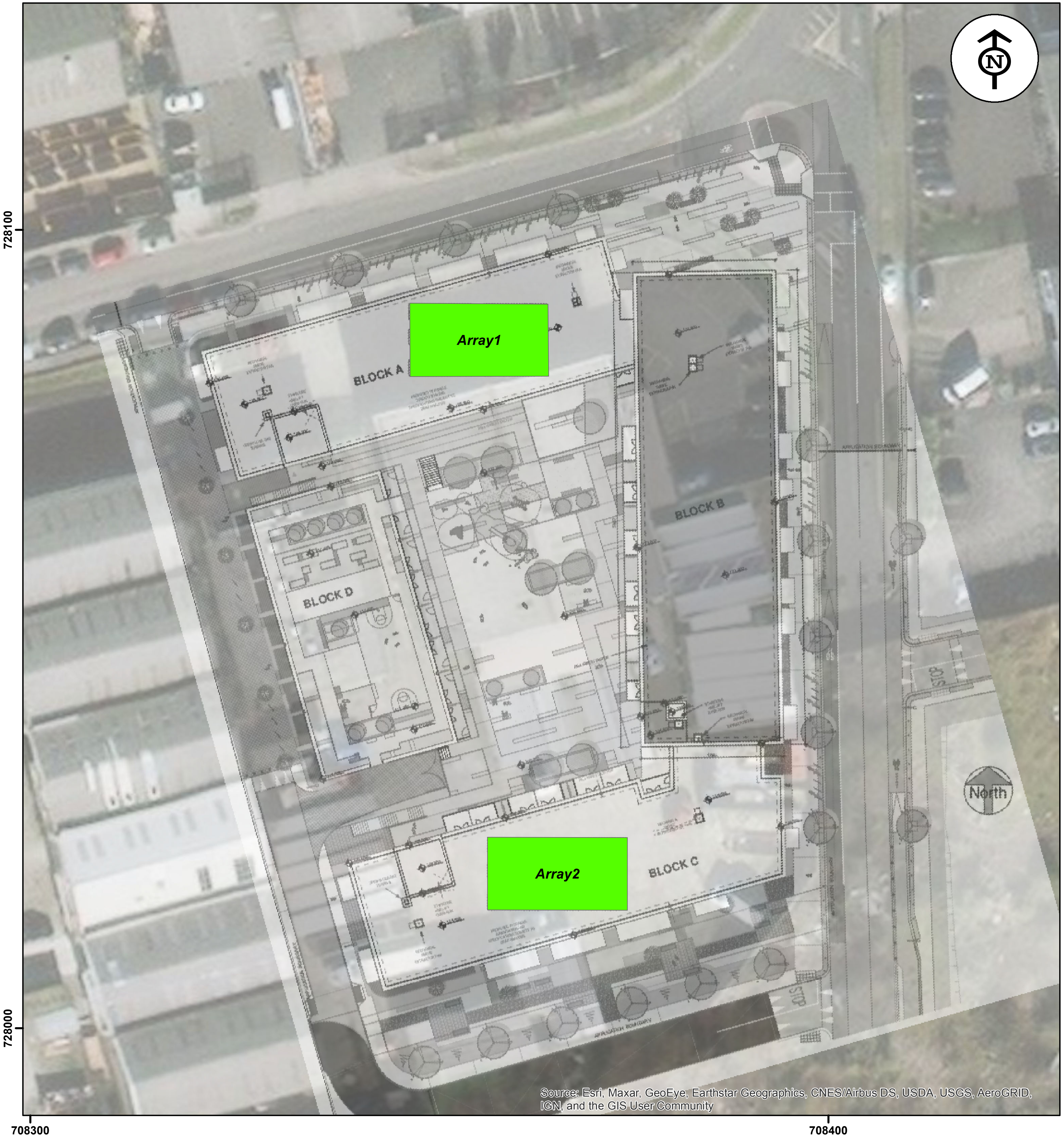
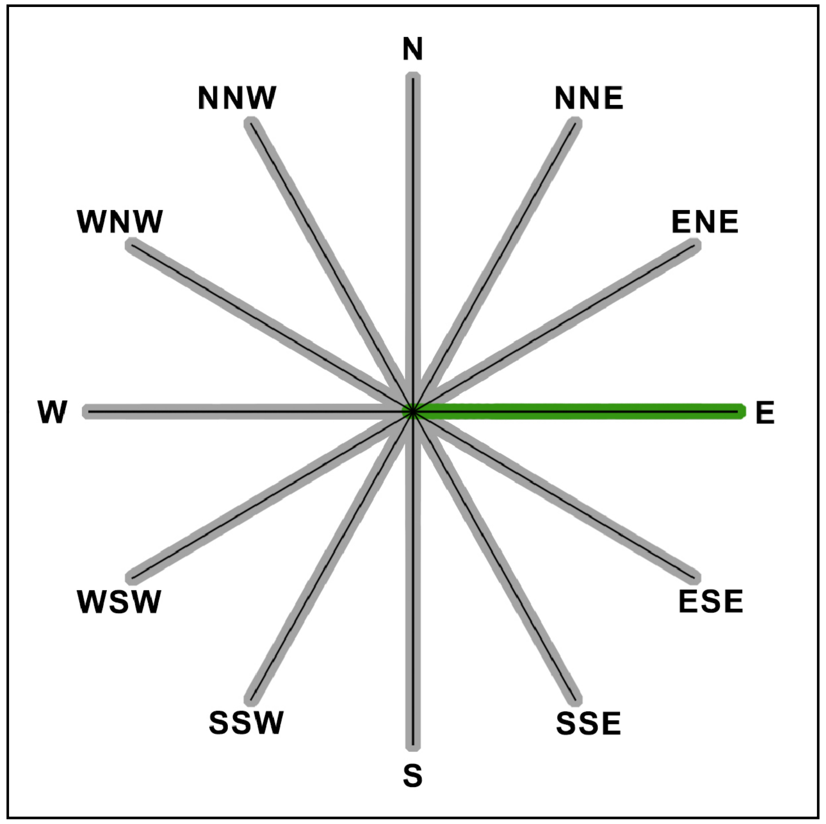
Map 6 Potential Glint and Glare Impact on eastern approach at Tallaght Hospital Helipad as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500
- Between 501 and 1000



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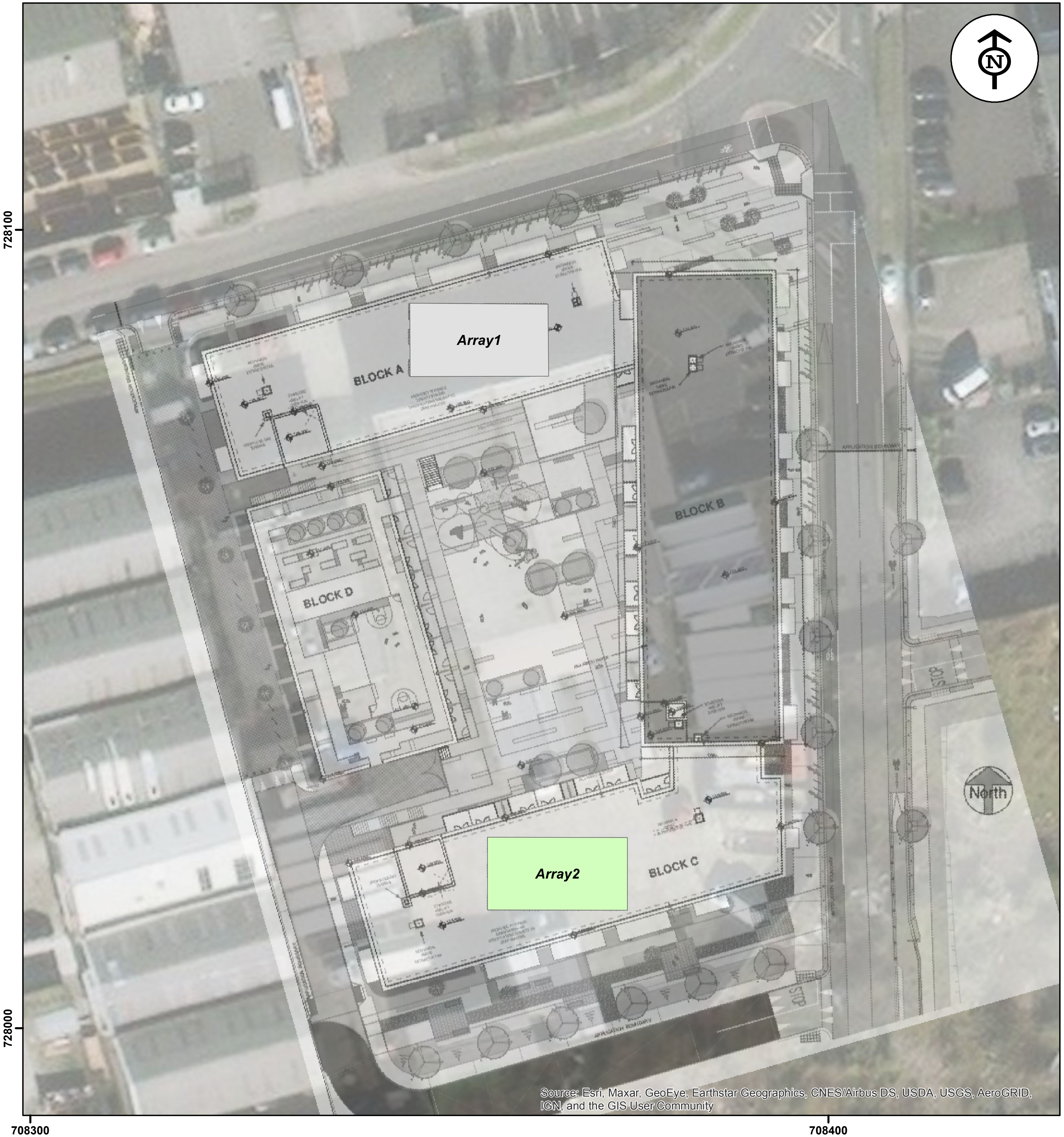
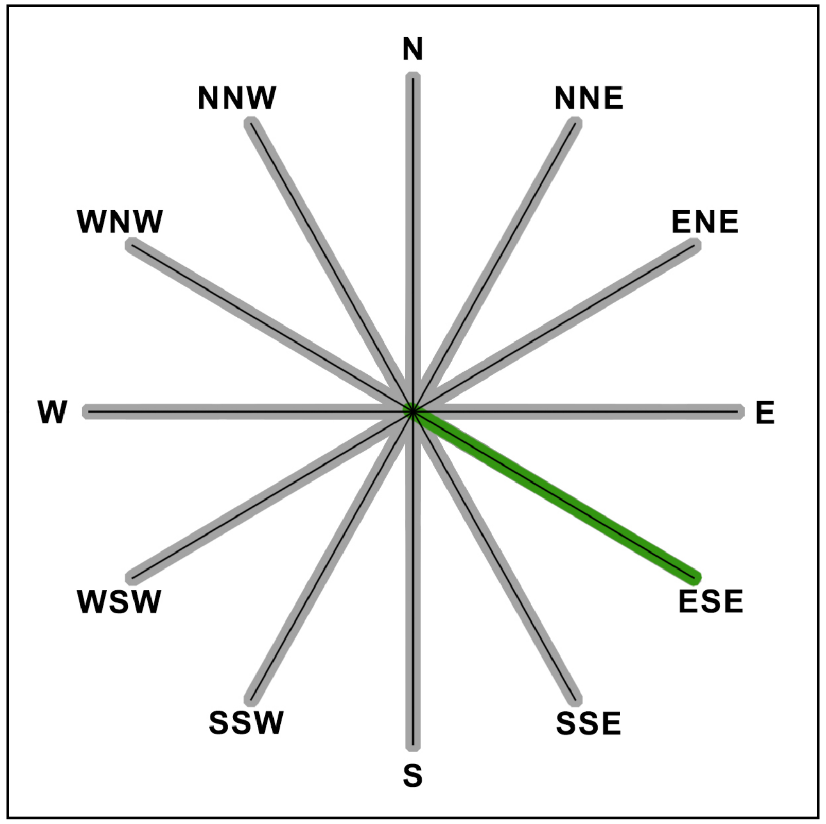
Map 7 Potential Glint and Glare Impact on east/south-eastern approach at Tallaght Hospital Helipad as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500



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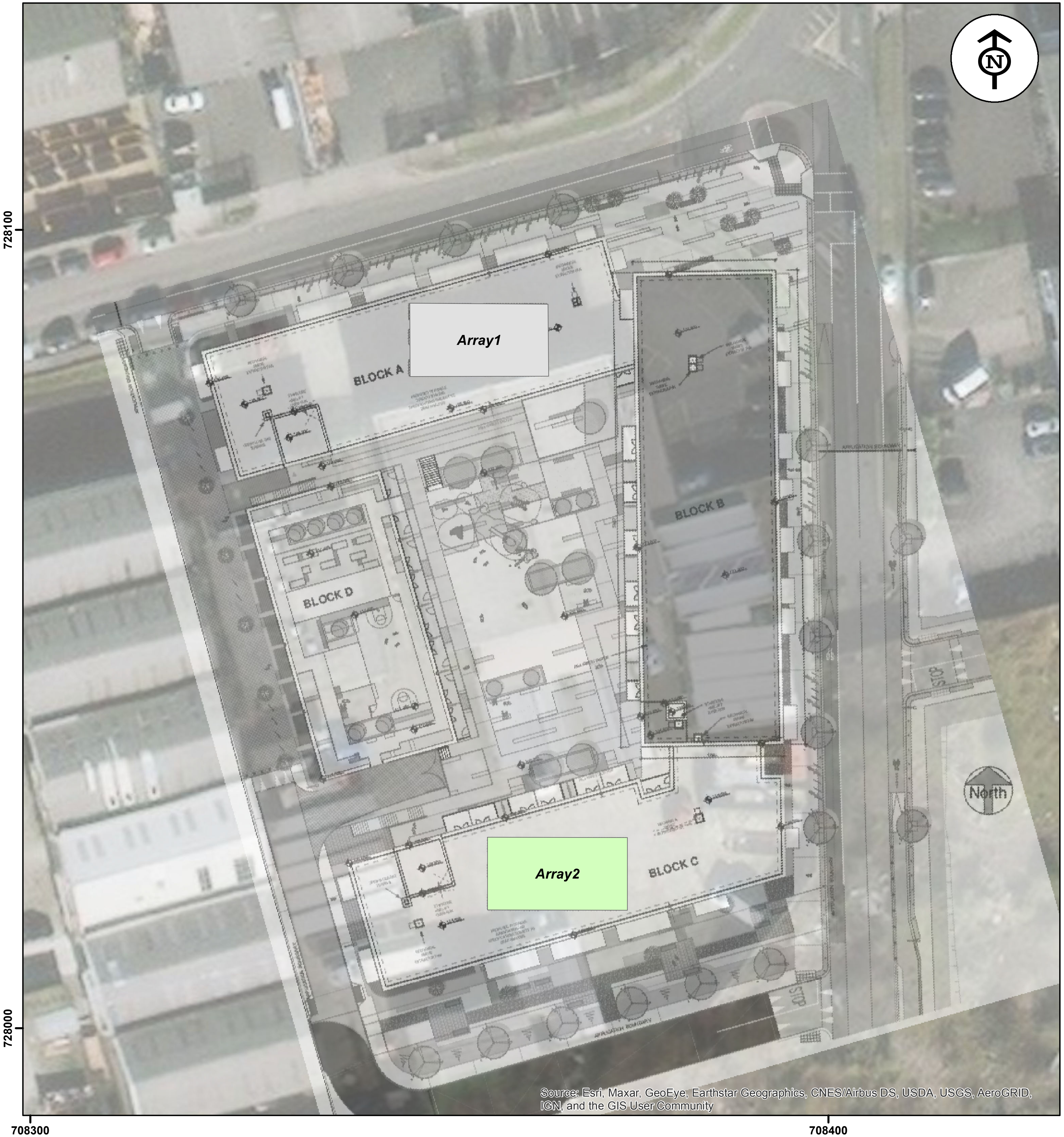
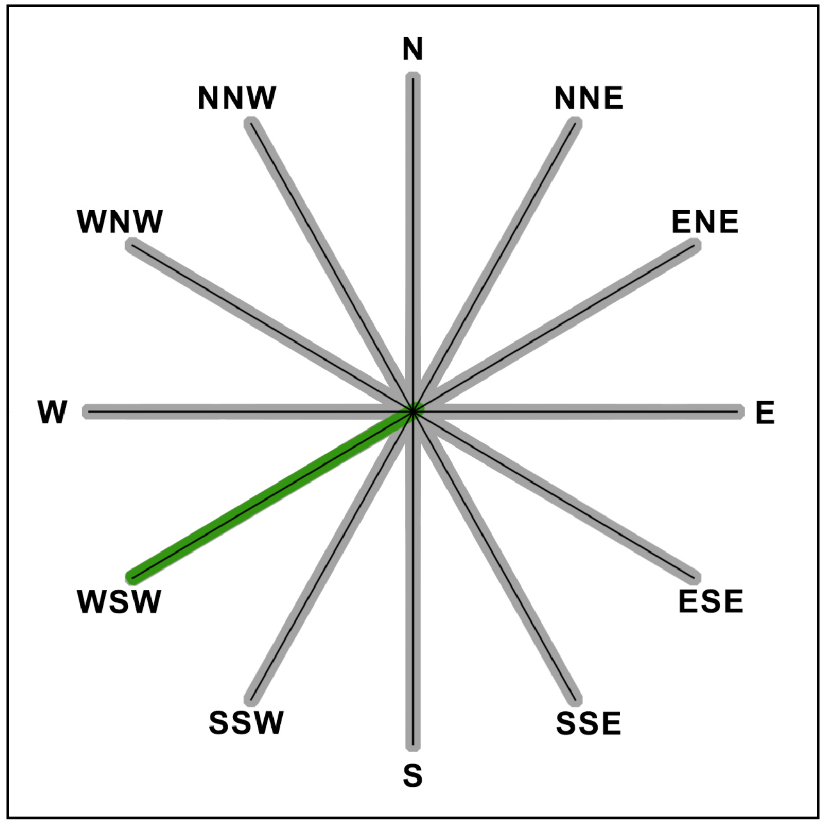
Map 8 Potential Glint and Glare Impact on west/south-western approach at Tallaght Hospital Helipad as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500



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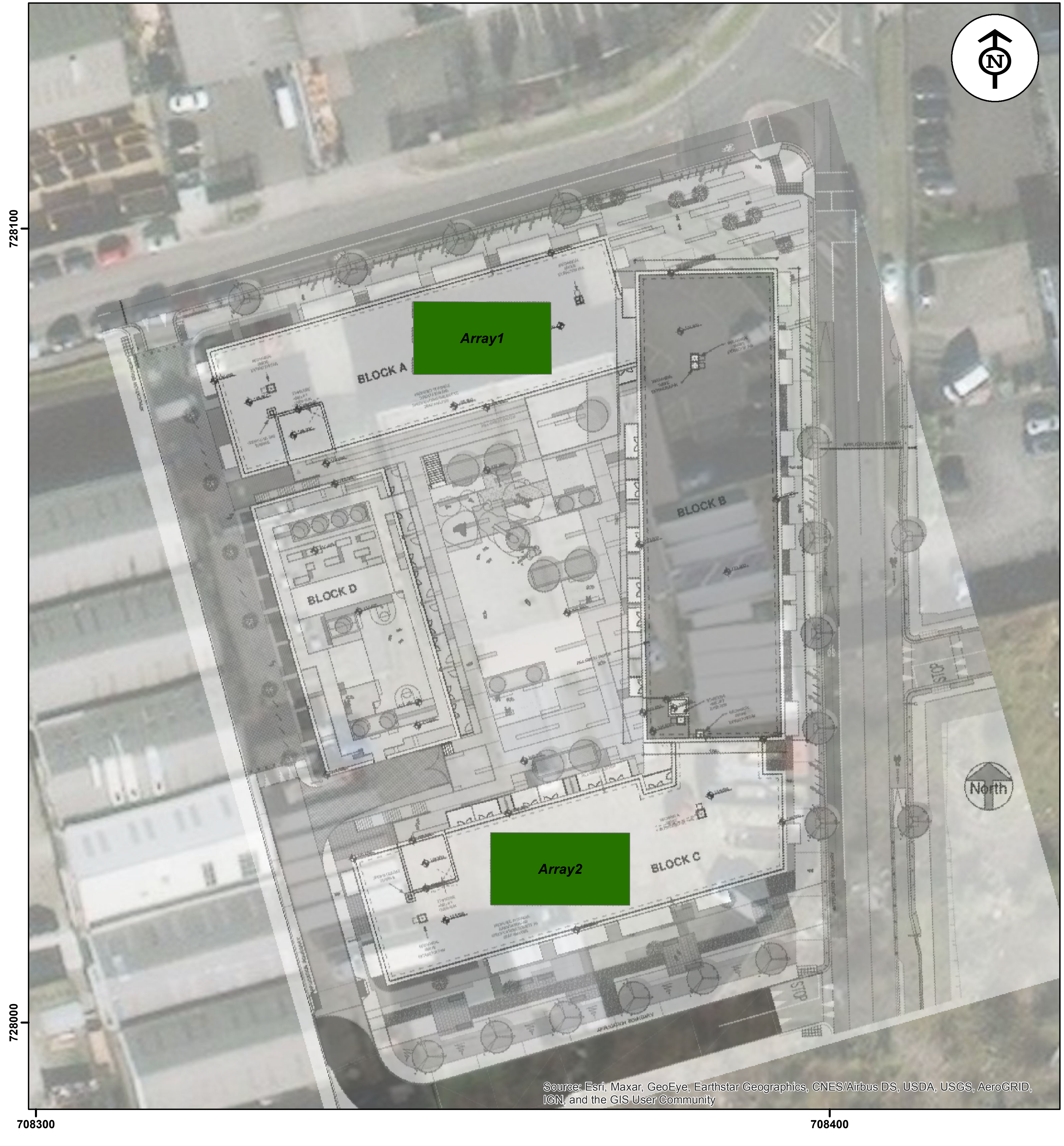
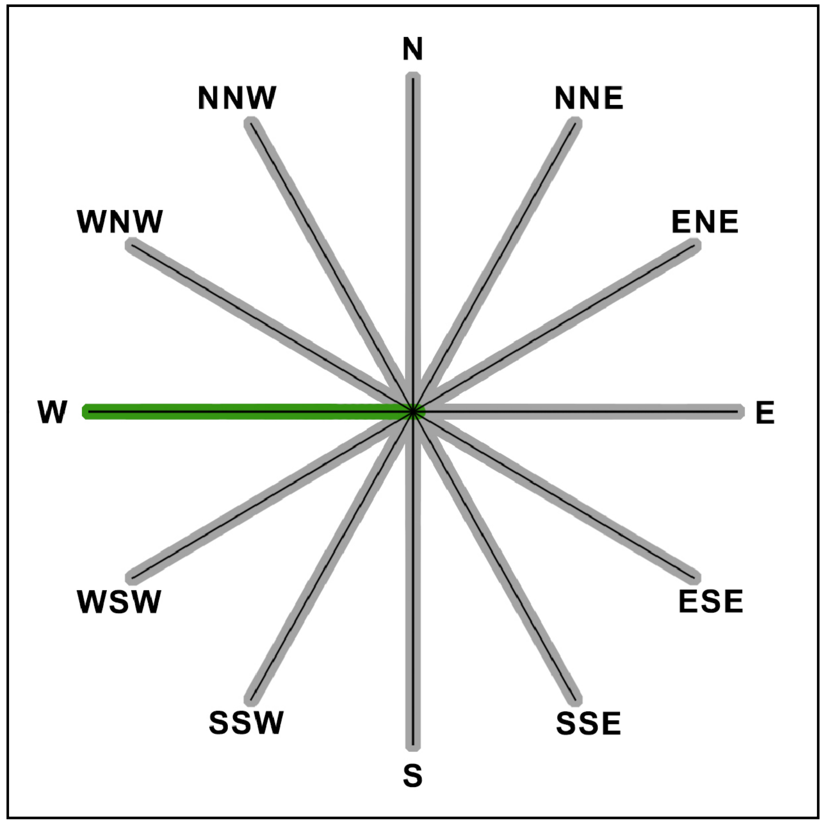
Map 9 Potential Glint and Glare Impact on western approach at Tallaght Hospital Helipad as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500
- Between 501 and 1000
- Between 1001 and 2000
- Between 2001 and 3000



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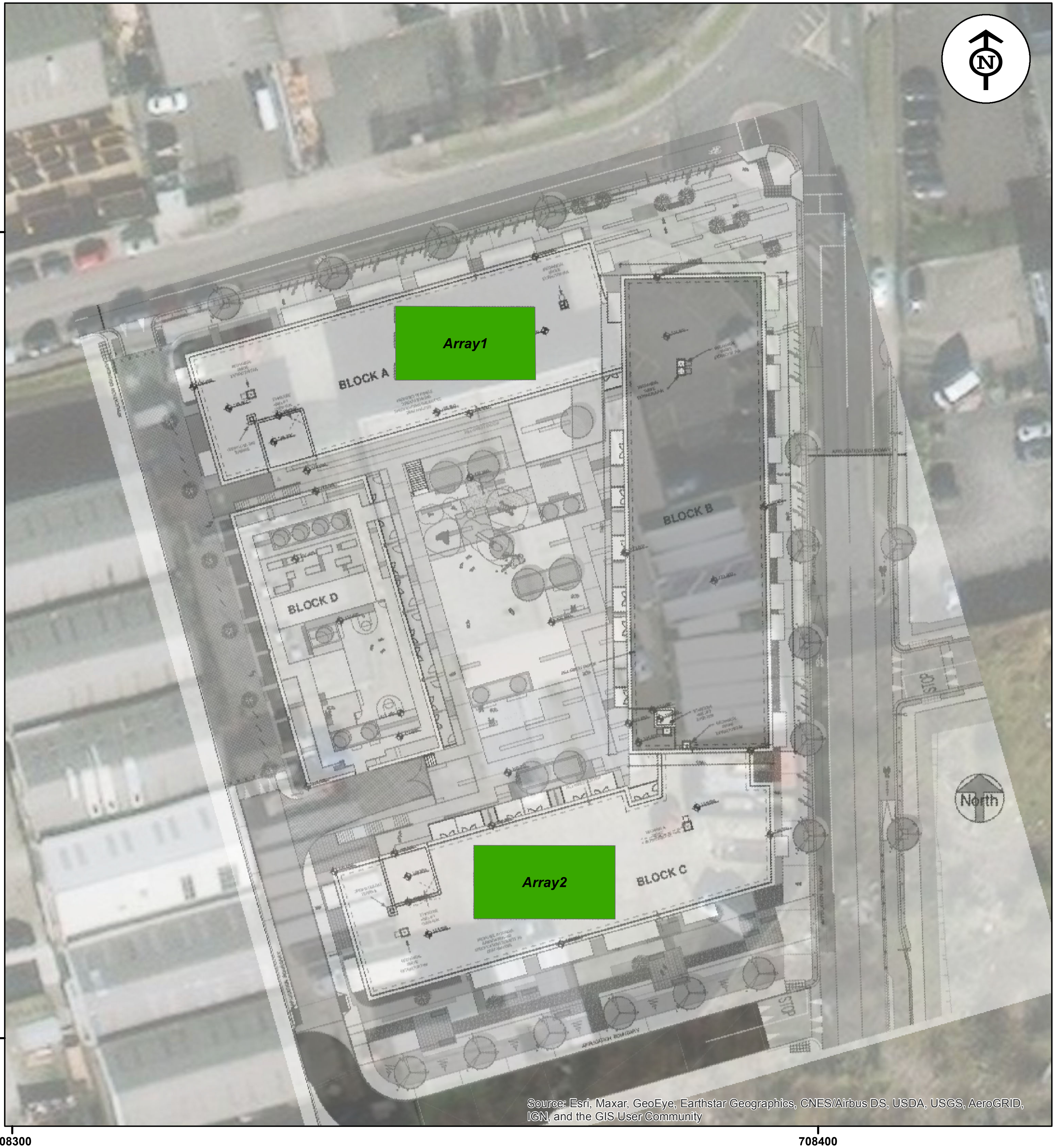
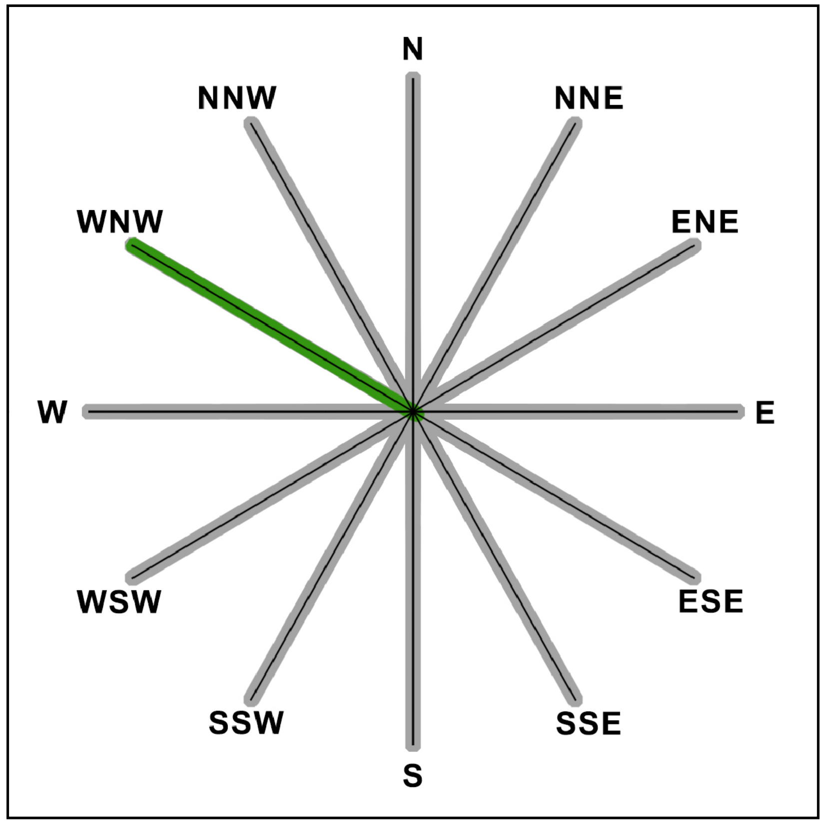
Map 10 Potential Glint and Glare Impact on west/north-western approach at Tallaght Hospital Helipad as a result of Roof Mounted Solar PV Arrays at the proposed Cookstown Crescent, 4th Ave residential development



Annual Potential Glare Values (Minutes)

- No Glare Predicted
- Less than 500
- Between 501 and 1000
- Between 1001 and 2000



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