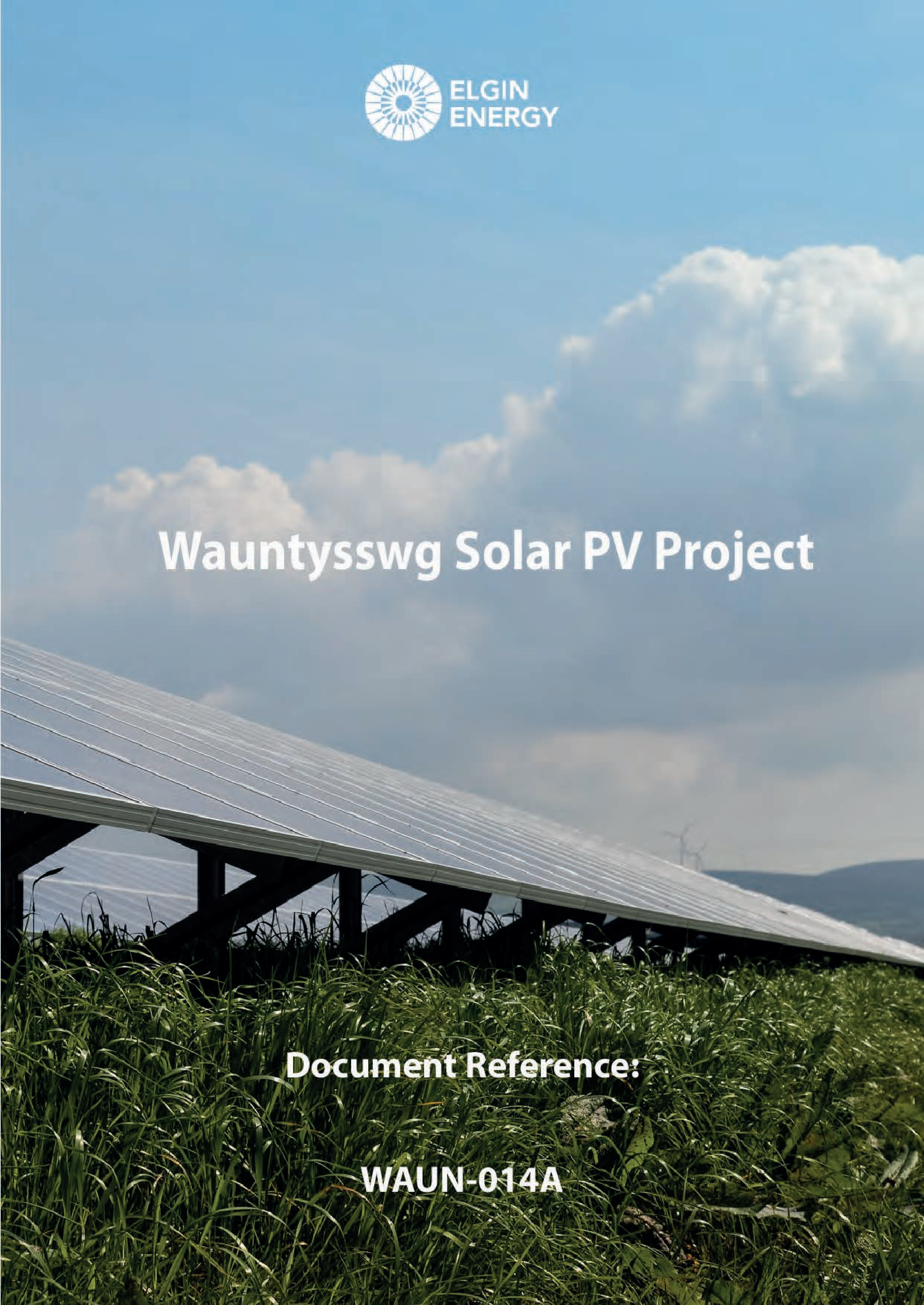
ELGIN ENERGY

Wauntysswg Solar PV Project



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WAUNTYSSWG PV
SOLAR FARM

Glint and Glare Assessment

NOVEMBER 2017

C P A

Charlotte Peacock Associates

ENVIRONMENTAL CONSULTANCY

WAUNTYSSWG PV
SOLAR FARM

Glint and Glare Assessment

Revision	Date Issued	Approved By
ORIGINAL	**02/11/17**	**Charlotte E Peacock** [redacted]

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CONTENTS

1 INTRODUCTION

1.1 Overview

1.1.1 Charlotte Peacock Associates Ltd. (CPA) was commissioned by Elgin Energy to complete an assessment of the potential for glint and glare effects as a result of the proposed Wauntysswg PV Solar Farm.

1.1.2 The purpose of this assessment is to determine whether there are potentially significant glint and glare effects in the vicinity of the proposed solar farm site.

1.2 Basic Principles

1.2.1 The reflection of the sun from solar panels occurs as either diffuse reflection where the light is reflected at many angles (scattered), or, as specular reflection where the light is reflected at a single angle.

1.2.2 The diffuse reflection gives solar panels their general appearance and perceived colour. The potential visual impacts of solar panels are considered within the Landscape and Visual Impact Assessment.

1.2.3 The effects of specular reflection can be experienced in two ways. The first is as a momentary flash or 'pin prick' of reflected light, often referred to as Glint. The second is a more prolonged reflection over a greater area of panels which is sometimes referred to as Glare. The potential impacts of both effects are considered within this assessment. Both of these effects are a result of specular reflection and are hereafter referred to collectively as Glint within this report.

1.2.4 Glint effects from solar panels can only occur if a receptor is directly in view of the reflected light. When views of the site are blocked by intervening topography, vegetation or buildings, glint effects will not be experienced. Similarly if cloud cover blocks the sunlight from reaching the panels then glint effects will be significantly reduced, however due to the transitory nature of clouds and variable nature of the screening provided, the potential effects of cloud cover are not considered further within this assessment.

1.2.5 When light strikes a surface it is either absorbed, transmitted or reflected depending upon the frequency of the light and the nature of the surface. If atoms within the material have the same vibrational frequency as the light striking them then the light will be absorbed. If they do not then the light will either be transmitted (as would generally be the case for a transparent material) or reflected (as would be the case for an opaque material).

1.2.6 Solar Panels work by allowing particles of light (photons) to strike atoms within the panel, releasing electrons and creating a flow of electricity. Solar Panels are therefore designed to capture as much light as possible, maximising their efficiency. To achieve this they are designed to minimise the amount of light which is reflected from the panel surface. The panel surface comprises glass which is used to encapsulate and protect the solar cells. The glass used is special glass with a low iron content which increases the amount of light which passes through it (transmitted to the solar cells).

Table 1 below shows that the light reflected from a solar panel surface is less than that reflected from ordinary glass, and is very similar to that from still water such as a lake.

Table 1; Common Reflective surfaces and Index of Refraction, “n” (data extracted from Sunpower 2010[1])

n	Common Reflective Surfaces
1.980	Snow
1.517	Standard Glass
1.333	Smooth Water
1.329	Solar Glass

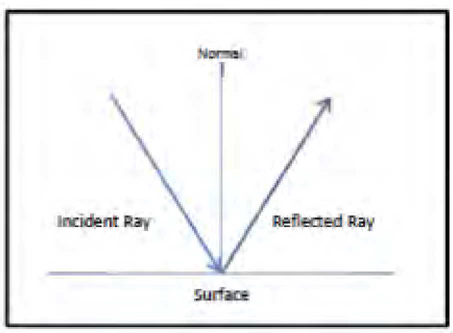
(the value “n” may vary by reference source, but the hierarchy of “n” values from one material to another will remain the same).

1.2.7 Two principles apply to the behaviour of light shining on the panels, one is that light travels in a straight line and the other is that the angle of incidence equals the angle of reflection.

1.2.8 The angle of incidence is the angle formed by a ray incident on a surface and a perpendicular to the surface at the point of incidence (the point that the ray hits the surface).

1.2.9 The angle of reflection is the angle formed by the reflected ray and a perpendicular at the point of incidence.

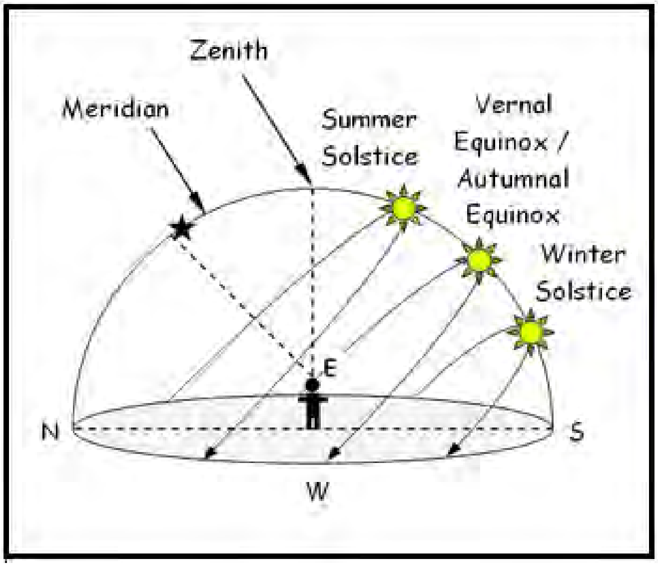
Figure A: Angle of Incidence and Reflection



[1] PV Systems: Low Levels of Glare and Reflectance vs. Surrounding Environment; Mark Shields; Sunpower; 2010

1.2.10 Examination of the azimuth of the sun on autumn equinox, the shortest day and spring equinox shows that the sun rises at north 90 degrees east or greater and sets at north 90 degrees west or greater. Figure A shows the path of the sun in the northern hemisphere at key points in the solar cycle.

1.2.11 Figure A: Northern Hemisphere Solar Path Showing Equinoxes[2]



1.2.12 When the sun is at an angle of greater than 90 degrees from north in an easterly direction and an angle of greater than 90 degrees from north in a westerly direction any reflection from the solar panels is at an angle above the horizontal.

1.2.13 As shown in Figure A above, for a flat site, there can be no glint effect at ground level from the autumn equinox to the vernal (spring) equinox because the sun is always to the southeast or southwest of the site. Glint can only occur when the sun is in the quadrants between north and east and between north and west of the site.

1.2.14 The computational model used to complete the quantitative glint assessment as detailed in Section 2.3 below identifies that due to the topography of the site (not flat) glint may occur on up to 24 days after the autumn equinox and 19 days before the spring equinox.

[2] www.mydarksky.org

2 METHODOLOGY

2.1.1 This assessment considers the potential glint effects as a result of solar panels which would be installed as part of the proposed solar farm development.

2.1.2 This assessment comprises 3 stages as detailed below.

2.2 Stage 1: Receptor Selection

2.2.1 A study area of 5km was selected, because although the site may be visible beyond this distance at some locations, it is considered that glint effects beyond this distance would appear over such a small part of the overall view that they would be negligible.

2.2.2 Receptor points were selected which were considered to be representative of sensitive receptors within 5km of the proposed solar farm site. The Zone of Theoretical Visibility (ZTV) was used to identify areas with potential views of the site. Five types of sensitive receptor were considered; residential, road users, footpaths, amenity and cultural heritage, and representative points for each were identified.

2.2.3 Representative points along roads are considered to be those located along main routes in the vicinity of the site at varying distances and directions from the site and which have potential views of the site.

2.2.4 Representative residential receptor points are considered to be those which either represent individual isolated properties or multiple points within a cluster of houses or along a street. Each individual property in a residential street or cluster is not necessarily considered as the selected points will provide a spread of data sufficient to allow the potential glint effects to be understood.

2.2.5 A total of 104 potential receptor points were selected for analysis. The locations of the selected receptors are shown in Figures A1 and A2. They include:

- 73 residential properties;
- 7 points along 2 roads;
- 21 points along 27 footpaths;
- 2 points at Scheduled Ancient Monuments; and
- 1 point at an amenity receptor

2.3 Stage 2: Quantitative Assessment

2.3.1 A computational model is used to determine potential glint effects at each receptor. The model relies upon the following site and development specific parameters:

- Latitude and Longitude
- Topography of the site
- Proposed panel height
- Proposed panel angle
- Receptor location in relation to the site
- Receptor elevation

2.3.2 The model determines the period over which glint may occur throughout the year and identifies any receptors which cannot technically experience glint due to their location relative to the site. For example, for an entirely south facing site, receptor points immediately north of the site are not able to experience glint because the angle of reflection makes this impossible.

2.3.3 For each receptor point which may experience glint the model output provides the following information:

- Which days in a year glint effects may be experienced;
- What time of the day glint may occur; and
- How long glint effects may occur on any one day.

2.3.4 The model generates data at minute intervals for an entire year.

2.3.5 The analysis was completed for 2018. However, the results of this analysis will apply to all years of operation albeit the specific dates of impact may vary slightly. With this in mind, key points in the solar cycle are identified in Section 10.4 below and the data is considered to be representative of the operational lifespan of the solar farm.

2.3.6 The modelling has been carried out for panels aligned facing south at an angle of 25 degrees to the horizontal.

2.3.7 It has been assumed that panels will be installed across the entire site. This represents a worst case scenario approach to the assessment.

2.4 Stage 3: Qualitative Assessment

2.4.1 It is important to note that the model does not take into account the screening benefits of any existing on and off site vegetation and buildings. In addition the model does not take into the micro topography surrounding the site which may screen parts of the site from receptors. Therefore, once the model has identified which of the selected receptors may experience glint effects, a qualitative assessment is completed for each receptor. The qualitative assessment is completed via reference to the landscape and visual impact assessment for the site, and other publically available information, to determine the presence of intervening vegetation, buildings and micro topography and the extent to which these screen each receptor from the site. The results of the qualitative assessment are provided in the final column in Table 2 below and Table 3 in Appendix 1.

3 RESULTS

3.1 Solar Cycle

3.1.1 The key points of the solar cycle in relation to glint are:

- **The longest day** - represents the worst case scenario as this is when the greatest glint would occur
- **The autumn equinox** (plus one day)[3]- The time at which the sun rises at north 90 degrees east and sets at north 90 degrees west.
- **The shortest day** - represents the best case scenario as this is when the least glint would occur
- **The spring equinox** (minus one day)[4]- The time at which the sun rises at north 90 degrees east and sets at north 90 degrees west.

3.1.2 The sunrise and sunset times for these periods at the proposed Wauntysswg PV Solar Farm are set out below.

<u>Longest Day</u>

Sunrise:	GMT 0357	BST 0457
Sunset:	GMT 2033	BST 2133
Hours of daylight:	16 hours 36 minutes	

<u>Autumn equinox (plus 1 day)</u>

Sunrise:	GMT 0604	BST 0704
Sunset:	GMT 1805	BST 1905
Hours of daylight:	12 hours 01 minutes	

<u>Shortest Day</u>

Sunrise:	GMT 0820
Sunset:	GMT 1602
Hours of daylight:	7 hours 42 minutes

<u>Spring equinox (minus 1 day)</u>

Sunrise:	GMT 0620
Sunset:	GMT 1822
Hours of daylight	12 hours 02 minutes

[3] Due to the latitude of the site and the refraction of the sun's rays through the atmosphere the sun does not appear to rise and set at a 90 degree angle during the true equinox but one day later.
[4] Due to the latitude of the site and refraction of the sun's rays through the atmosphere the sun does not appear to rise and set at a 90 degree angle during the true equinox but one day earlier.

3.1.3 The altitude of the sun and the azimuth (its position relative to the southern direction) has been determined and used as an input to the computer model.

3.2 Glint Potential

3.2.1 The location of the 104 representative receptors analysed is shown in Figures A1 and A2. The quantitative assessment has revealed that 78 of the receptor points analysed could not experience any glint effects due to their location and elevation in relation to the proposed solar farm site.

3.2.2 This means that only 26 of the receptor points analysed could potentially experience glint during the operation of the solar farm. The qualitative assessment has determined that 14 of the receptor points are entirely screened by existing vegetation, buildings and topography from any potential glint. These points are detailed in Table 3 in Appendix 1. The remaining 12 receptor points are detailed in Table 2 below. The duration of glint detailed in the table below is the total continuous glint effect from across the site on any one day. This glint will usually come from a small number of panels in a localised area moving across the site during the period stated, and not from the panels across the entire site.

G = Residential Receptor Point

A = Amenity Receptor Point

RD = Road Receptor Point

FP = Footpath Receptor Point

Table 2: Potential glint at receptor points analysed and not entirely screened by existing vegetation, buildings and topography

Receptor	Dates between which glint may occur[5]	Duration of glint affect on any one day (maximum)	Time of day (range)	Site Visibility
G1	101 days prior to the longest day – 101 days after the longest day	27 minutes	5:48 PM and 6:41 PM	Buildings to the west of the receptor will provide significant screening of panels causing glint effects. Panels close to receptor will screen panels across the site further reducing glint effects. Glint times significantly reduced by screening.
G2	Between 109 and 17 days prior to the longest day Between 17 and 109 days after the longest day	17 minutes	5:24 PM and 6:06 PM	Limited screening by vegetation close to receptor. Panels close to receptor will screen panels across the site further reducing glint effects.
G3	111 days prior to the longest day – 111 days after the longest day	15 minutes	5:22 PM and 6:06 PM	Panels close to receptor will screen panels across the site further reducing glint effects.
G6	88 days prior to the longest day – 89 days	6 minutes	6:05 AM and 6:23 AM	Site largely screened by existing vegetation

[5] These dates apply to 2018 and will vary by up to 1 day during the 25 years of operation

	after the longest day			surrounding site and between the receptor and site. Very limited glint may be visible at acute angle to property.
A1	106 days prior to the longest day – 107 days after the longest day	32 minutes	6:03 AM and 6:52 AM	Commercial premises (Golf Course Clubhouse) faces south/west away from site.
RD1	Between 97 and 44 days prior to the longest day Between 45 and 99 days after the longest day	17 minutes	6:02 AM and 6:36 AM	Eastern areas of the site visible from receptor. Western side of site blocked by intervening topography. Hills to the east of the site will also slightly reduce glint effects caused by site.
RD2	Between 96 and 12 days prior to the longest day Between 12 and 97 days after the longest day	20 minutes	6:01 AM and 6:38 AM	Glint restricted to north-eastern areas of the site only by topography between site and receptor. Hills to the east of the site will slightly reduce glint effects caused by site.
RD3	Between 95 and 94 days prior to the longest day Between 95 and 97 days after the longest day	1 minute	6:17 AM and 6:34 AM	Site visible
FP1	110 days prior to the longest day – 116 days after the longest day	39 minutes	6:03 AM and 7:06 AM	Panels close to receptor will provide limited screening of panels across the site reducing glint effects.
FP3	112 days prior to the longest day – 117 days after the longest day	17 minutes	5:09 PM and 6:00 PM	Site visible
FP4	112 days prior to the longest day – 113 days after the longest day	14 minutes	5:21 PM and 6:02 PM	Site to the northwest of receptor screened by vegetation close to receptor.
FP5	71 days prior to the longest day – 71 days after the longest day	6 minutes	5:24 PM and 5:45 PM	Topography will screen glint from northern area of site. Panels close to receptor will screen panels across the site further reducing glint effects.

4 IMPACT ASSESSMENT

4.1 Residential Receptors

4.1.1 Receptors have been selected for assessment within residential areas located around the site. These receptors have been selected taking into consideration the topography, location and building types in the surrounding area and are therefore considered to represent the potential for glint effects at surrounding properties. As shown in Table 2 and Table 3, of the 73 residential receptor points analysed 11 may experience glint effects.

4.1.2 When intervening vegetation, topography and buildings are taken into account, the potential for glint effects at 7 of these points is eliminated and as detailed in Table 2 glint effects at the remaining 4 points will be significantly reduced from that predicted.

4.1.3 Glint effects at 1 of these 4 receptor points are predicted to occur for no more than 6 minutes either during the early morning between 6:05 AM and 6:23 AM. Taking into consideration the short duration of these predicted glint effects and the time of day which they may occur, potential glint effects on this residential property are not considered to be significant. The remaining 3 receptors are predicted to experience glint effects for a maximum of between 15 and 27 minutes in the early evening between 5:22 PM and 6:41 PM. Screening, both by vegetation and buildings close to the receptors and by panel screening on site, will significantly reduce these durations. Furthermore, glint effects can only occur when there is a direct line of sight to the source of the glint. This means that any resident of these properties would need to be looking at the panels to experience glint effects. Glint effects would not be experienced by residents within the property who did not have a direct view of the panels causing the glint. In addition, the glint effects are likely to only come from a few panels on the site at any one time with this area moving across the site for the duration of the glint effects. For these reasons potential glint effects on residential properties are not considered to be significant.

4.2 Amenity Receptors

4.2.1 One amenity receptor was chosen due to its proximity to the site. Glint effects at this receptor are predicted to occur for no more than 32 minutes during the early morning between 6:03 AM and 6:52 AM. Due to the angle of the property (southwest away from the site) and early morning timing of the potential glint, the effects on this receptor are considered not to be significant.

4.3 Road Users

4.3.1 The road points selected are points at which the site is considered to be most visible from vehicles using these roads. As shown in Table 2, of the 7 potential road points analysed only 3 may experience glint effects.

4.3.2 Glint effects at these 3 road receptors are predicted to occur for no more than 20 minutes during the early morning between 6:01 AM and 6:38 AM. When intervening vegetation and topography are taken into account, the duration of these glint effects will be reduced. Due to the transitory nature of the road-based receptors and early morning timings of the potential glint effects the impacts are not considered to be significant.

4.4 Public Rights of Way

4.4.1 The points selected along footpaths are points at which the site is expected to be most visible by members of the public. As shown in Table 2 and Table 3, of the 21 potential points analysed, only 11 may experience glint effects.

4.4.2 When intervening vegetation, topography and buildings are taken into account, the potential for glint effects at 7 of these points is eliminated and as detailed in Table 2 glint effects at the remaining 4 points will be significantly reduced from that predicted.

4.4.3 Predicted glint effects at one of the receptors will occur in the early morning between 6:03 AM and 7:06 AM. These effects have the potential to last up to 39 minutes on any one day although panels close to the receptor should screen panels further away across the site, reducing this duration. Due to the transitory nature of the receptors and early morning timings of the potential glint effects the impacts at this receptor are not considered to be significant.

4.4.4 Predicted glint effects at the other 3 receptors are predicted to occur for no more than 17 minutes between 5:09 PM and 6:02 PM. Vegetation and topography will slightly reduce these effects. When the transitory nature of any views which would be experienced by people walking or cycling along these public rights of way is considered the potential significance of any glint effects is further reduced.

4.4.5 Taking into account the existing screening and worst case predictions for glint effects, glint is not considered to represent a significant impact on pedestrians or cyclists in the vicinity of the site.

4.5 Cultural Heritage Receptors

4.5.1 As shown in Figure A1 and A2 the two Scheduled Ancient Monuments analysed will not technically experience glint effects, therefore glint is not considered to represent a significant impact upon cultural heritage assets.

5 MITIGATION

5.1.1 No significant impacts are predicted as a result of glint effects from the proposed Wauntysswg PV Solar Farm.

5.1.2 Infilling of the existing hedgerows around the site will enhance the existing screening and further reduce any potential residual glint effects.

5.1.3 It is recommended that new and existing planting surrounding the site is maintained to provide continued screening benefits throughout the operation of the solar farm.

6 CONCLUSIONS

6.1.1 Existing screening by vegetation, topography and buildings will eliminate glint effects at the majority of the receptor points analysed. Potential residual glint effects on residential properties, amenity receptors, roads and public rights of way are not considered to be significant and therefore no additional mitigation measures are recommended or required.

Appendices

APPENDIX 1: POTENTIAL GLINT RECEPTORS ENTIRELY SCREENED BY EXISTING VEGETATION, BUILDINGS AND TOPOGRAPHY

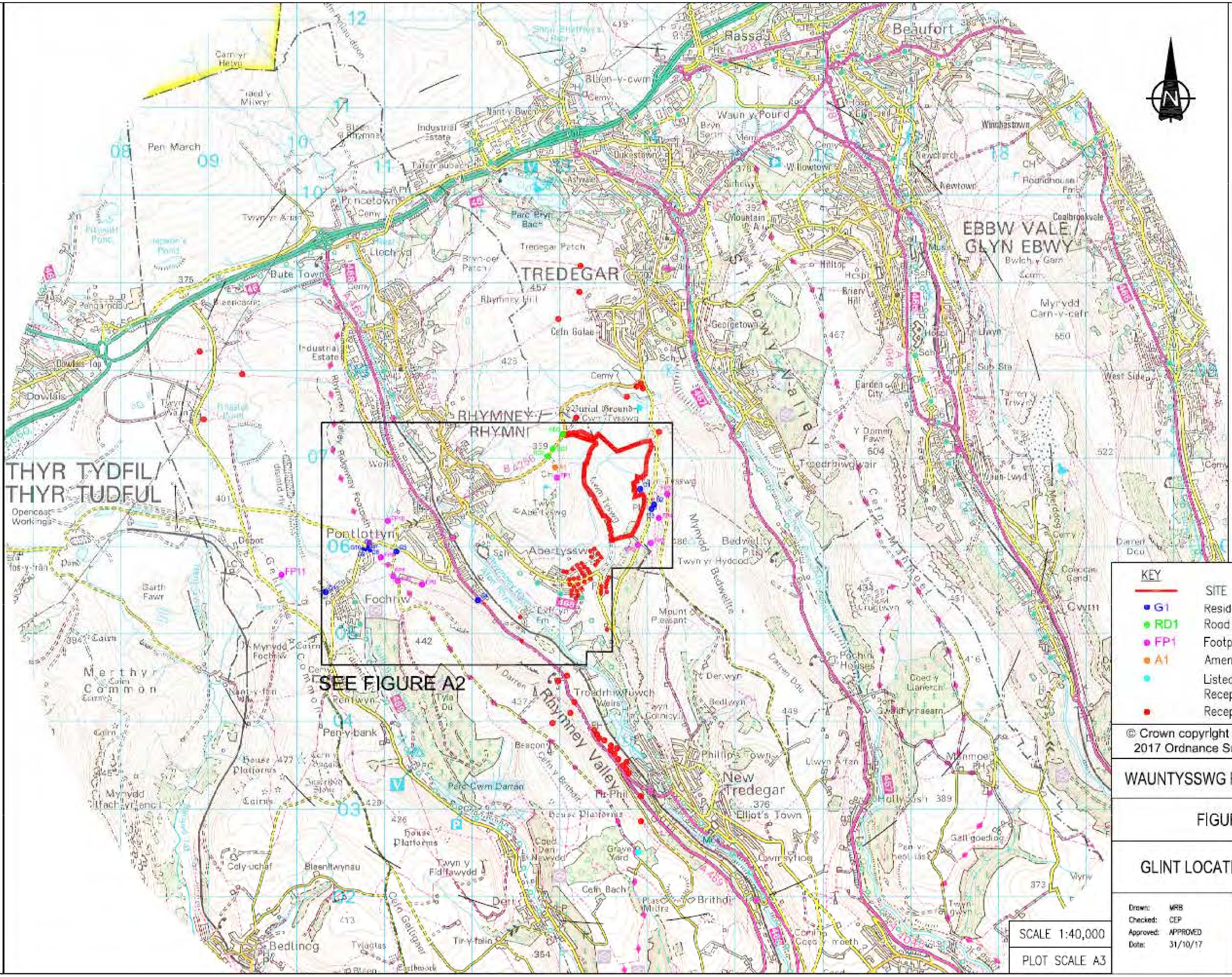
Table 3: Potential glint at receptor points analysed and entirely screened by existing vegetation, topography and buildings

Receptor	Dates between which glint may occur[6]	Duration of glint affect on any one day (maximum)	Time of day (range)	Site Visibility
G4	1 days prior to the longest day – 1 days after the longest day	1 minute	6:06 AM and 6:07 AM	Site entirely screened by existing vegetation surrounding site and between receptor and site.
G5	84 days prior to the longest day – 85 days after the longest day	6 minutes	6:05 AM and 6:23 AM	Site entirely screened by existing vegetation surrounding site and between receptor and site.
G7	87 days prior to the longest day – 88 days after the longest day	6 minutes	6:05 AM and 6:23 AM	Site entirely screened by existing vegetation surrounding site and between receptor and site.
G8	86 days prior to the longest day – 87 days after the longest day	6 minutes	6:05 AM and 6:23 AM	Site entirely screened by existing vegetation surrounding site and between receptor and site.
G9	86 days prior to the longest day – 87 days after the longest day	6 minutes	6:05 AM and 6:23 AM	Site entirely screened by existing vegetation and buildings surrounding site and between receptor and site.
G10	86 days prior to the longest day – 87 days after the longest day	6 minutes	6:05 AM and 6:23 AM	Site entirely screened by existing vegetation and buildings surrounding site and between receptor and site.
G11	65 days prior to the longest day – 65 days after the longest day	5 minutes	6:07 AM and 6:22 AM	Site entirely screened by existing vegetation surrounding site and between receptor and site.
FP2	42 days prior to the longest day – 41 days after the longest day	3 minutes	5:40 PM and 5:52 PM	Site totally screened by vegetation close to receptor.
FP6	56 days prior to the longest day – 57 days after the longest day	7 minutes	6:07 AM and 6:24 AM	Site area causing glint effects totally screened by topography between receptor and site.
FP7	63 days prior to the longest day – 64 days after the longest day	7 minutes	6:08 AM and 6:25 AM	Site area causing glint effects totally screened by topography and vegetation between receptor and site.
FP8	67 days prior to the longest day – 68 days after the longest day	6 minutes	6:08 AM and 6:24 AM	Site area causing glint effects totally screened by topography and vegetation between receptor and site.
FP9	80 days prior to the longest day – 81 days after the longest day	6 minutes	6:06 AM and 6:23 AM	Site area causing glint effects totally screened by topography between receptor and site.

[6] These dates apply to 2016 and will vary by up to 1 day during the 25 years of operation

FP10	Between 95 and 19 days prior to the longest day Between 20 and 96 days after the longest day	6 minutes	6:03 AM and 6:24 AM	Site area causing glint effects totally screened by topography between receptor and site.
FP11	76 days prior to the longest day – 77 days after the longest day	5 minutes	6:07 AM and 6:22 AM	Site area causing glint effects totally screened by topography between receptor and site.

Figures



KEY

(red line)	SITE BOUNDARY
G1	Residential Receptor
RD1	Road Receptor
FP1	Footpath Receptor
A1	Amenity Receptor
(cyan dot)	Listed Building/SAM Receptor – No Glint
(red dot)	Receptor – No Glint

WAUNTYSSWG PV SOLAR FARM

FIGURE A1

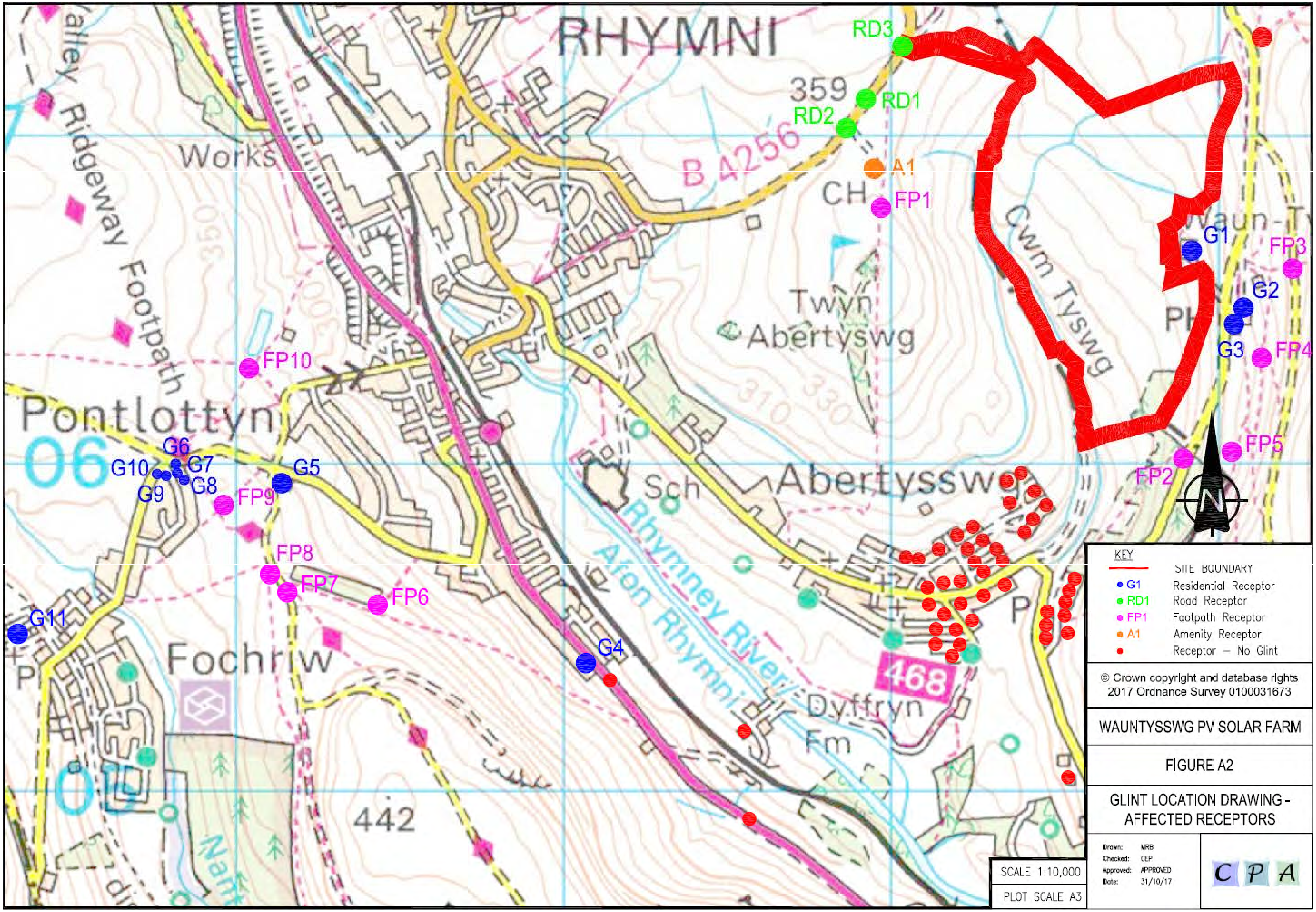
GLINT LOCATION DRAWING

SCALE 1:40,000

PLOT SCALE A3

Drawn: MRB
Checked: CEP
Approved: APPROVED
Date: 31/10/17

CPA


RHYMNI
RD3
RD1
RD2
359
B 4256
A1
CH
FP1
Works
Valley Ridgeway Footpath
Cwm Tyswg
Waun-Ty
G1
FP3
G2
G3
FP4
Twyn Abertyswg
FP10
Pontlottyn
06
G6
G7
G10
G8
G9
G5
FP9
FP5
FP2
Abertysswg
Sch
Rhymney River
Afon Rhymni
FP8
FP7
FP6
G11
Fochriw
G4
468
Dyffryn Fm
442
KEY
SITE BOUNDARY
G1 Residential Receptor
RD1 Road Receptor
FP1 Footpath Receptor
A1 Amenity Receptor
Receptor – No Glint
© Crown copyright and database rights 2017 Ordnance Survey 0100031673
WAUNTYSSWG PV SOLAR FARM
FIGURE A2
GLINT LOCATION DRAWING - AFFECTED RECEPTORS
SCALE 1:10,000
PLOT SCALE A3
Drawn: MRB
Checked: CEP
Approved: APPROVED
Date: 31/10/17
CPA