Environmental Impact Statement

Glenellen Solar Farm

Appendix F: Visual Amenity Assessment (including a Glint and Glare Assessment)

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Glenellen Solar Farm Visual Impact Assessment

Prepared for
Glenellen Solar Farm Pty Ltd

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Abbreviations

Abbreviation	Description
AHD	Australia Height Datum
CWP	CWP Renewables Pty Ltd
DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EP&A Act	Environmental Planning and Assessment Act 1979
GIS	Geographic Information System
GLVIA	Guidelines for Landscape and Visual Impact Assessment
GSF	Glenellen Solar Farm
GWh	Gigawatt hours
Ha	Hectares
JSF	Jindera Solar Farm
kV	Kilovolt
LCU	Landscape Character Unit
LGA	Local Government Area
LVIA	Landscape Visual Impact Assessment
MW	Megawatt
PCT	Plant Community Type
PCU	Power Conditioning Unit
The Proponent	Glenellen Solar Farm Pty Ltd
PV array	Photovoltaic solar panels
PV	photovoltaic
SEARs	Secretary's Environmental Assessment Requirements
SSD	State Significant Development
ZVI	Zones of Visual Influence

1 Introduction

Eco Logical Pty Ltd has produced this Visual Impact Assessment (VIA) on behalf of Glenellen Solar Farm Pty Ltd to support the development of the proposed Glenellen Solar Farm (GSF, the 'Proposed Development'). Its purpose is to identify and outline the existing landscape character, identify visual receptors within the studied area, and to assess the potential impacts to visual amenity resulting from the introduction of the Proposed Development, including cumulative visual impacts. The assessment then considers how mitigation measures could be implemented to reduce the effect of any identified impacts.

This report provides a VIA for construction (including future decommissioning works) and operational infrastructure associated with the Proposed Development. The Proposed Development is classified as "state significant development" (SSD) under Schedule 1 of the *State Environmental Planning Policy (State and Regional Development) 2011*, which requires the preparation of an Environmental Impact Statement (EIS) and subsequent assessment and approval under Division 4.7 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

This report, in conjunction with a separate, specialist photovoltaic glint and glare study (Pager Power, 2018, Appendix D of this report), addresses the relevant Secretary's Environmental Assessment Requirements (SEARs) for the project, namely:

"An assessment of the likely visual impacts of the development (including any glare, reflectivity and night lighting) on surrounding residences, scenic or significant vistas, air traffic and road corridors in the public domain, including a draft landscaping plan for on-site perimeter planting, with evidence it has been developed in consultation with affected landowners."

The proponent has taken an adaptive approach to the project design based on consultation and feedback including a commitment to maintain strategic areas of existing on-site vegetation and new perimeter plantings in order to minimise visual impacts. This VIA adopts a conservative approach, considering all residences identified within 5 km of the Proposed Development and assessing potential impacts across the entire CWP Development Footprint (2019), rather than considering individual components separately, or the smaller Final Development Footprint (2020). Key visual components associated with the Proposed Development are described in the EIS document, and include:

- Installation of photovoltaic solar panels (the 'PV array');
- On-site invertors, batteries and electrical connection infrastructure; and
- Construction and operational support buildings, perimeter fencing and vehicular access tracks.

The Proposed Development will connect to the existing substation which is co-located within the Development Footprint. Potential cumulative impacts associated with other relevant developments are also considered.

1.1 Project overview

Glenellen Solar Farm Pty Ltd (the Proponent) propose to develop a utility-scale photovoltaic (PV) solar farm between Jindera and Glenellen, within the Greater Hume Shire Local Government Area (LGA), 4km north-east of Jindera and 20km north of Albury in southern NSW (Figure 1). The Proposed Development would have an electricity generation capacity of approximately 200 megawatts (MW) at the point of connection, producing enough energy (400 GWh) to power the equivalent of 94,899 average NSW households each year.

The Proposed Development would generate electricity through the conversion of solar radiation to electricity through PV panels laid out in rows on steel racks with piled screwed or ballasted supports. Other infrastructure will consist of electrical power conversion units, underground and/or above ground electrical cabling, telecommunications equipment, amenities and storage facilities, vehicular access and parking areas, along with security fencing and gates.

Land access leases have been negotiated for the life of the Proposed Development (the Proponent is seeking an initial term of 30 years, with a possible additional term). At the conclusion of the operational period, the Site will be decommissioned in accordance with landholder agreements and returned to a suitable condition to allow the continuation of agricultural activities.

1.2 Project description

A detailed Project description is presented in the EIS. This assessment has been undertaken based on the Project description provided within the EIS.

1.3 Site description

The Proposed Development is located in a rural setting with a predominantly flat to low rolling landscape on land which has been historically cleared for grazing and sown with improved pastures. There are small patches of retained native woodland scattered throughout the locality, mainly associated with road reserves, residences and areas unsuitable for agricultural development.

This assessment did not identify any landscape areas within the immediate development viewshed that are subject to any Local, State or Federal statutory designations for high landscape values or scenic quality and/or scenic protection. Furthermore, on-ground assessment did not identify any areas of public vistas or scenic amenity within the broader study area (up to 5 km from the Site boundary).

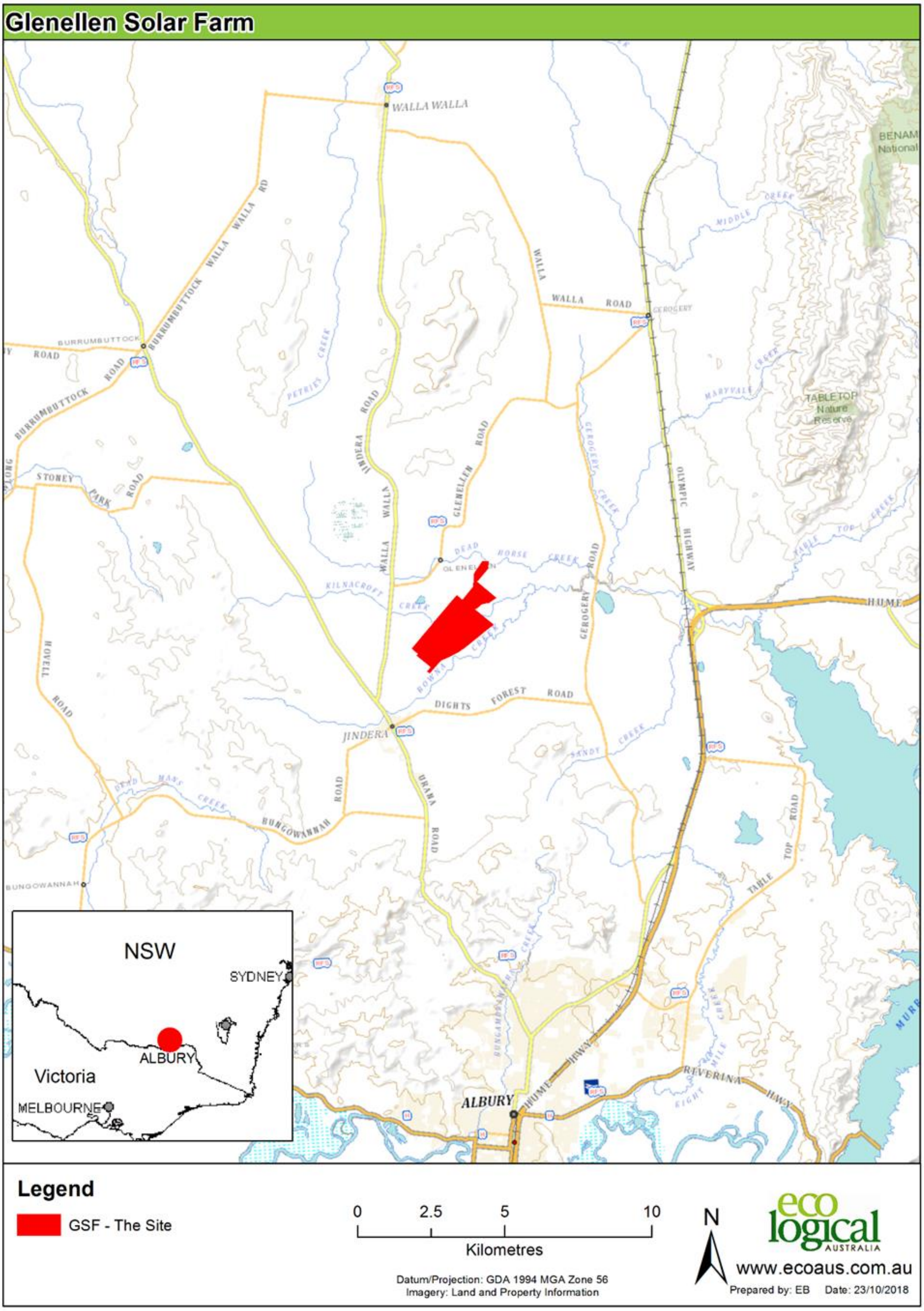

Figure 1: Location of the Proposed Development.

2 Assessment Methodology

2.1 General

The assessment methodology has been based on the following guidelines which are considered applicable to the evaluation of Visual Impacts relating to the Proposed Development:

- *Environmental Impact Assessment Guide Note – Guidelines for Landscape Character and Visual Impact* (NSW Roads and Traffic Authority, 2009); and
- *Guidelines for Landscape and Visual Impact Assessment* (GLVIA) (United Kingdom, The Landscape Institute and Institute of Environmental Management and Assessment, 2013).

In response to the SEARs for this Visual Impact Assessment, the assessment methodology considers potential impacts across a range of spatial scales, from regional to the immediate field of view, from adjoining public locations as well as private residential locations (viewpoints), considering the construction, operational and decommissioning phases of the Proposed Development.

2.2 Definition of assessment areas

The boundaries of the Proposed Development assessment areas vary depending upon which of the following impacts are being considered:

- Impacts in terms of landscape character - are more specific to the area of the landscape directly affected by, or close to, the Proposed Development; and
- Impacts to the visual amenity - considers a wider area that considers affected viewers within and beyond the Site.

In consideration of the nature and general visibility of PV solar farms within rural settings, the two assessment areas for the visual impact assessment are as follows (Figure 2):

- <u>Landscape Character Assessment Area</u> – covers the Site and its surrounds out to a distance of 2 km from the boundary of the Site; and
- <u>Visual Amenity Assessment Area</u> – considers an area out to 5 km from the Site boundary, beyond which the visual change would be of such a low nature that impacts would be negligible. This area also includes assessment of local/mid-ground or foreground views within 2 km of the Proposed Development, where any visual change and potential impacts are of most concern, along with mid-ground or subregional views.

In accordance with the principles for impact assessment, these distances are naturally conservative as they are based on the whole proposed Site boundary, rather than the actual impact area associated with the PV arrays and/or other site infrastructure located wholly within the Development Footprint.

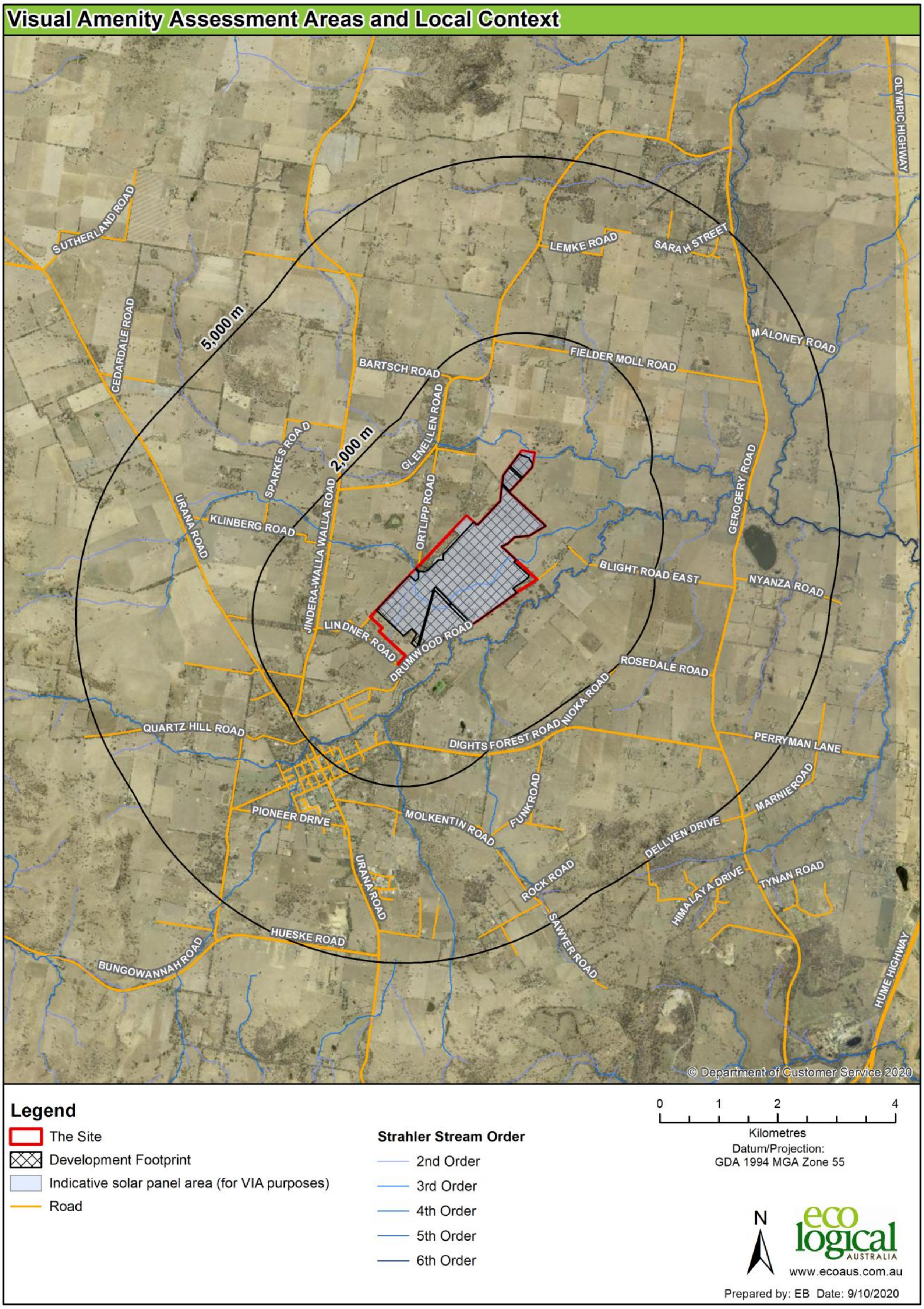

Figure 2: Visual Amenity Assessment Areas and local context.

2.3 Landscape Character – Impact Assessment Methodology

Landscape character can be defined as a distinct and recognisable pattern of elements that occur consistently across a particular landscape known discretely as a Landscape Character Unit (LCU). It refers to the physical characteristics of landscape based on features such as location, land use, vegetation cover and landform.

The first step in undertaking a landscape character assessment is to identify the LCUs that are associated with the Landscape Character Assessment Area (2 km buffer). Once identified, the following assessment method was adopted:

- Description of the existing landscape character area which defines its sensitivity to change or 'visual sensitivity';
- Description of the potential visual changes to a LCU that would result as a consequence of the proposal along with a "magnitude of change" rating;
- An assessment of impact, taking into account the relationship between visual sensitivity (the ability of a landscape character area to absorb a development) and magnitude of change;
- The identification of any mitigation measures that would reduce the visual impact identified; and then,
- Results of mitigation strategies were assessed to provide a final assessment of potential residual effects of the Proposed Development, using the same criteria outlined above.

The impact to landscape character is determined by balancing the visual sensitivity of the LCU and the magnitude of impact as a result of the construction, operation and decommissioning of the Proposed Development. The correlation between the sensitivity of landscape character and the magnitude of change to determine the level of impact is summarised in **Error! Reference source not found.**.

Table 1: Visual impact assessment matrix

Potential level		Magnitude of change			
		Very High	High	Moderate	Low or insignificant
Visual sensitivity	Very High	Very High Impact	High Impact	High Impact	Moderate Impact
	High	High Impact	High Impact	Moderate Impact	Low Impact
	Moderate	Moderate Impact	Moderate Impact	Moderate Impact	Low Impact
	Low or insignificant	Moderate Impact	Low Impact	Low Impact	Low or Insignificant Impact

2.3.1 Sensitivity Criteria

Each LCU is assessed for its sensitivity based on a review and analysis of the elements that make up its characteristic attributes. The visual sensitivity of landscape character in rural areas can largely be defined by considering aspects such as relative naturalness, key cultural attributes and uniqueness. The more disturbed or common a landscape, the less value is placed on it and consequently the less 'visually sensitive' it is to change. The visual sensitivity of a landscape character unit is evaluated according to the five-point scale presented in Table 2. The criteria used are based on guidance provided in GLVIA (2013).

Table 2: Visual sensitivity criteria used for Landscape Character

Visual Sensitivity levels	Landscape Character
Insignificant	Contains predominantly industrial or intensive agricultural infrastructure.
Low	General widespread rural landscape with low to moderate levels of native vegetation, and no identified special landscape features or interesting topographic features.
Moderate	Rural land with high levels of native vegetation or undisturbed native woodland with attractive landscape features such as watercourses or interesting topographic features.
High	Landscapes with well-preserved natural areas, highly valued for conservation or values relating to cultural heritage.
Very High	Iconic and dramatic natural landscapes such as those protected as World Heritage Areas or National Parks. Highly valued iconic cultural landscapes may also be included.

Magnitude of Visual Change Criteria

The magnitude of visual change considers the extent to which the existing landscape features or experience of that landscape would be modified as a consequence of the visual impacts of the Proposed Development. The magnitude of change likely to occur as a result of the construction, operation and decommissioning of the Proposed Development is evaluated according to a five-point scale as outlined in Table 3.

Table 3: Magnitude of visual change definitions used for Landscape Character

Magnitude of Visual Change	Landscape Character
Insignificant	Minor scales of landscape/landform change and vegetation removal, existing urban use, intensive agriculture or industrial infrastructure may be present.
Low	Moderate level of landscape/landform change and minor vegetation removal, existing industrial or intensive agriculture use may be present.
Moderate	Moderate scale of landscape/landform change and/or vegetation removal, minor water courses possibly impacted, existing industrial or intensive agriculture on or adjoining Site.
High	Large scale landscape/landform change and/or vegetation removal, minor water courses possibly affected, no existing industrial or intensive agriculture on or visible from Site.
Very High	Highly significant scale landscape/landform change, possibly major vegetation and water course impacts, no existing industrial or intensive agriculture on or visible from Site.

2.4 Visual Amenity – Impact Assessment Methodology

The visual amenity of an area broadly refers to how potential viewers respond to or value a particular landscape. To assess the impact of the Proposed Development on visual amenity, receptors and/or sensitive viewpoints within the potential area of impact (5 km Visual Amenity Assessment Area) are identified. The assessment then examines the potential impact for each identified viewpoint by balancing the visual sensitivity of the receptor and the magnitude of visual change as a result of the construction, operation and decommissioning of the Proposed Development. The correlation between visual sensitivity and the magnitude of visual change used to determine the level of impact is summarised in the visual impact assessment matrix previously presented in **Error! Reference source not found.**.

2.4.1 Assessment of Visual Impact

Potential visual impacts of the solar farm on surrounding view locations would result primarily from a combination of the potential visibility of the Proposed Development and the characteristics of the landscape between, and surrounding, the view locations and the Proposed Development. The potential degree of visibility and resultant visual impact would be partly determined by a combination of factors including:

- Category and type of situation from which people could view the solar farm (examples of view location categories include residents or motorists);
- Visual sensitivity of view locations surrounding the solar farm;
- Potential number of people with a view toward the proposed solar farm from any one location;
- Distance between view locations and the solar farm; and
- Duration of time people could view the solar farm from any particular static or dynamic view location.

An underpinning rationale for this visual assessment is that if people are not normally present at a particular location, such as agricultural areas, or they are screened by landform or vegetation, then there is likely to be no visual impact at that location.

If, on the other hand, a small number of people are present for a short period of time at a particular location then there is likely to be a low visual impact at that location, and conversely, if a large number of people are present then the visual impact is likely to be higher.

Although this rationale can be applied at a broad scale, this assessment also considers, and has determined, the potential visual impact for individual view locations that would have a higher degree of sensitivity to the solar farm development, including the potential impact on individual residential dwellings situated in the surrounding landscape. The determination of a visual impact is also subject to a number of situation specific factors, which are considered in more detail in this VIA.

Potential glint and glare impacts have been assessed and modelled in a separate specialist report (Pager Power, 2018 – Appendix D to this report). The findings of this assessment are summarised within this report.

2.4.2 Viewpoint Selection

A desktop assessment of potential sensitive receptors within the 5 km Visual Amenity Assessment Area identified a selection of public and private viewpoints that together would represent the overall visual amenity impacts of the Proposed Development. Topographic maps and aerial photographs were used to identify the locations and categories of potential view locations that could be verified during the fieldwork component of the assessment. The desktop study also outlined the visual character of the surrounding landscape including features such as landform, elevation, land cover and the distribution of rural residences and urban areas.

The desktop assessment included the generation of maps showing Zones of Visual Influence (ZVI) of the Proposed Development which illustrate areas of potential visibility within the 5 km Visual Amenity Assessment Area. ZVI's are generated using Geographic Information System (GIS) software and a Digital Elevation Model (DEM). A desktop study was carried out to identify an indicative viewshed for the GSF. This was carried out with reference to 1:25,000 scale topographic maps as well as aerial photographs and satellite images of the Study Area and surrounding landscape. A preliminary "bare-earth" ZVI based on the DEM was produced prior to the commencement of fieldwork in order to inform the maximum extent and nature of areas within the nominated 5 km viewshed of the Proposed Development.

It should be noted that bare-earth ZVI's are naturally very conservative as they do not take into account the screening effects of local features such as subtle variations in landform, vegetation cover or existing development and infrastructure. In addition, the following assumptions were made when generating the ZVI's:

- The solar array was assumed to cover the entire CWP Development Footprint (in reality, the final Trina Solar Development Footprint and final design constraints will confine built infrastructure to a subset of this area); and
- The solar array is assumed to be installed at a maximum height of 5 m above the natural surface area (however, this is likely to be lower).

Therefore, based on the ZVI modelling and the conservative assumptions underlying the model, it is considered that the bare-earth ZVI represents a 'worst-case' scenario, which provides a useful tool for assessing the maximum potential visual impacts associated with the Proposed Development.

2.4.3 Viewpoint assessment methodology

Potential viewpoints were identified based on site inspection and further desktop analyses. The site inspection involved:

- Assessment of the potential extent of visibility of the Proposed Development;
- Determination and confirmation of the various view locations from which the Proposed Development is potentially visible; and
- Preparation of a record for each viewpoint assessed.

The results of the site inspection were corroborated with the development of further ZVI scenarios based on potential visual screening associated with existing vegetation and other structures within the existing landscape (current-landscape ZVI) and agreed mitigation and visual screening commitments (proposed-development ZVI).

Once all potential viewpoints were identified, the following assessment approach for each viewpoint was adopted:

- An assessment of the visual sensitivity;
- A description of the likely visual change and an assessment of the magnitude of visual change;
- An overall assessment of the potential impact;

- The identification of any mitigation measures that would reduce the visual impact identified;
- An assessment of mitigation strategies to provide a final assessment of potential residual effects of the Proposed Development, using the same criteria outlined above.

A viewpoint analysis was prepared for potentially highly and moderately impacted residences using the Current condition surface model which incorporates the screening effects of existing vegetation and development. Similar to the preparation of ZVI maps, this modelling approach uses DEM data to consider what can be seen from each assessed residence. Viewpoint analyses for all assessed residences (i.e. all highly or moderately impacted) are provided in Appendix A and B to this report.

Visual Sensitivity Criteria

Sensitivity in relation to visual amenity is dependent on a combination of the location, context and the importance of the viewshed held by the viewer. The sensitivity level attributed to Visual Amenity is determined by considering the distance of a sensitive receptor from the Proposed Development, the potential for views, and whether it is a public or private viewpoint. Residential viewpoints are considered more sensitive than public viewpoints. The sensitivity of visual amenity receptors are evaluated according to the five point scale provided in Table 4 and based on guidance provided in GLVIA (2013).

Table 4: Visual sensitivity criteria used for Visual Amenity

Visual Sensitivity levels	Visual Amenity
Insignificant	Residential viewpoints within 5 km with no, or very limited potential views; or Public viewpoints within 2 km with limited potential views and a low number of viewers.
Low	Residential viewpoints over 2 km away with the potential for some views; or Public viewpoints over 3 km viewed by a high number of viewers; or Public viewpoints within 1 km viewed by a low number of viewers, or by transient viewers (such as road users).
Moderate	Residential viewpoints within 1-2 km with potential for some views of the Proposed Development; or Public viewpoints between 1-3 km viewed by a high number of viewers; or Public viewpoints within 1 km viewed by moderate number of viewers with potential extensive views of the Proposed Development; or by transient viewers (such as road users).
High	Residential viewpoints less than 1 km away with some views of the Proposed Development. Public viewpoints within 1 km viewed by a high number of viewers with views of the Proposed Development.
Very High	Residential viewpoints within 1 km with extensive or intrusive views of the Proposed Development; or Public viewpoints within 1 km, viewed by a high number of viewers with extensive views of the Proposed Development.

Magnitude of Change Criteria

The magnitude of visual change for visual amenity considers the degree of change, particularly with respect to changes from characteristically 'rural' views to those which contain infrastructure. The magnitude of visual change for each viewpoint is evaluated according to the five-point scale provided in Table 5.

Table 5: Magnitude of visual change definitions used for Visual Amenity

Magnitude of Visual Change	Visual Amenity
Insignificant	Minor scale of change, not significantly different in scale or type to existing views and/or landscape character.
Low	Low to moderate scale change, not significantly different in scale or type to existing views and/or landscape character.
Moderate	Moderate visual change to views as a result of landscape change and construction of infrastructure where it was previously a rural landscape.
High	High visual change to views as a result of landscape change and construction of infrastructure where it was previously a rural landscape
Very High	Significant visual change to views as a result of substantial landscape change within close proximity.

3 Context of Existing Environment

3.1 General context of the location

The Proposed Development would be located in southern New South Wales around 4 km north-east of Jindera, within the Greater Hume Shire LGA. This LGA occupies around 575,000 ha covering large tracts of the South West slopes of the Riverina Murray region. The general location of the Proposed Development is illustrated in Figure 1. The landscape within the vicinity of the Proposed Development is gently undulating and of a rural nature, mainly supporting agricultural landscapes and scattered rural residences on farms, with the small town of Jindera nearby which is fringed by rural-residential subdivision blocks. Nearby areas of public amenity include Table Top Mountain and Benambra National Park which are located within 16 km to the east and north-east of the Proposed Development. A number of historic buildings are located within 5 km of the Site including "Drumwood" homestead and outbuildings situated on the south side of Drumwood Road, and the nationally recognised Pioneer Museum and Wagners Store contained within the Pioneer Museum Group buildings, located approximately 2.3 km south west.

Jindera is a small rural town located 20 km north of Albury. Gazetted around 1869, it had a population of 2,222 people at the 2016 Census (ABS, 2018). Jindera contains several historic and diverse built structures, which are still largely connected by the original fabric of urban development that was established following European settlement in the area. The town is known for its award-winning Jindera Pioneer Museum on Urana Road which contains a complex of historic buildings.

The Proposed Development would be located approximately 20 km from Albury, a regional centre situated on the Hume Highway on the northern side of the Murray River. With a population of 51,076 people at the 2016 Census (ABS, 2018), the Albury district supports a relatively large regional population and economy. Due to distance and landscape screening, the Proposed Development would have no impact on the immediate visual qualities of Albury and therefore it is no longer discussed as part of this analysis.

There are a number of National Parks within the wider region. The more significant include the Benambra, Woomargama, Chiltern-Mt Pilot and Murray Valley National Parks. The closest National Park, Benambra National Park, covers an area of 1,400 ha and contains some of the state's best examples of box gum woodland. The park includes the Great Yambala Ridge which offers scenic views from 640 m above sea level; however, there are no formal walks or campgrounds within the park, only management trails, and their location combined with distance and vegetation screening would limit the opportunity for views toward the Proposed Development.

3.2 Landform, Geology & Soils

The Proposed Development is located in a predominantly flat landscape, with small elevation ranges between 200 - 220 m above sea level Australian Height Datum (AHD) and a small rise in the centre of the Site. The topography of the Site falls generally north and east at relatively flat grades. Shallow flat depressions meander through the Site, draining water to several farm dams. The gradient of the slopes on site are best described as gently undulating.

The Site lies within two geologic formations: a large area of intrusive Jindera Granite and associated sediments from the Silurian period, overlaid by an unconsolidated Quaternary alluvium (Geological Survey of New South Wales, 2009). Soils include Chromosols associated with the Yarra landscape in the south, and Sodosols associated with the Kindra landscape in the north. (OEH 2010).

3.3 Vegetation

Land within the Site and wider district has been historically cleared for grazing purposes and most has been sown with improved pastures. Cropping lands adjoin the Site to the north. Within the Site there are scattered patches of retained native woodland. Two plant community types (PCTs) occur within the Site:

- PCT 277: *Blakely's Red Gum - Yellow Box grassy tall woodland of the NSW South Western Slopes Bioregion* (present in three condition states: 'grazing/exotic pasture; planted; and low condition); and
- PCT 9: *River Red Gum - wallaby grass tall woodland wetland on the outer River Red Gum zone mainly in the Riverina Bioregion* (low condition).

3.4 Hydrology

Hydrology within the Site is characterised by ephemeral low order drainage lines. Several drainage lines intersect each other upstream of the Site to form Kilnacroft Creek which is classed as a third order stream (Strahler, 1952) as it passes through the Site. Dead Horse Creek, also a third order stream, passes through the northern most portion of the Site. Both streams flow into Bowna Creek downstream of the Site which drains to the Murray River upstream of Hume Weir.

Riparian areas within the Site have been almost completely cleared, reducing visual amenity and landscape sensitivity.

3.5 Landuse

The primary landuse within the region is agriculture including mixed grazing and cropping. Improvement of pastures is a common practice within the region, and the Site contains land predominantly used for grazing and has been historically improved. The township of Jindera is separate to, but near the Site, and provides residential and essential business services to the district.

3.6 Major Roads

No major roads are located within 5 km of the Proposed Development. Approximately 7 km east of the Site the Hume Highway (M31) and Olympic Highway (A41) pass through agricultural countryside with open vistas in places, as well as sections of densely vegetated native forest. The Hume Highway provides a major national route linking Sydney with Melbourne, while the Olympic Highway Links the major regional centres of Albury and Wagga Wagga.

Although average daily traffic numbers on the Hume Highway at Table Top north of Albury are high at 11,761 vehicles per day (RMS, 2018), the Proposed Development is not visible from either the Hume Highway or the Olympic Highway.

3.7 Minor Roads

Immediately adjoining the Proposed Development are a number of unsealed minor roads, including, Ortlipp Road, Lindner Road and Blight Road (East and West). These roads are subject to low volumes of local traffic (the latter, Blight Road are only used by the <5 total residences that are located on both ends of the road). Jindera town roads and sealed local collector roads including Walla-Walla-Jindera Road, Dights Forest Road, Urana Road, Glenellen Road, and Gerogery Road also support relatively low volumes of local and district traffic.

3.8 Residences and Villages

No residences are located within the Site itself. Residences within the majority of the Visual Impact Assessment Area comprise scattered rural residences, including the two owned by participating host landholders. The nearest locality is Glenellen, located approximately 1.2 km north of the Proposed Development. The Glenellen district had a population of 127 at the 2016 census (ABS, 2018).

The majority of Jindera also falls within the Visual Impact Assessment Area. Jindera district had a population of 2,222 people, with 1,293 people living in the town itself at the 2016 Census (ABS, 2018). This comprises a mixture of urban, peri-urban and rural residential development.

3.9 Landscape Character

The landscape character of the Site itself, and the majority of the surrounding area, is classified as one LCU, however the wider 2 km Landscape Character Assessment Area also contains a second LCU, each is described below;

- LCU1 is dominated by predominantly flat to gently undulating agricultural land. The LCU is rural, with dwellings scattered across the wider landscape, and includes the locality of Glenellen. The land is largely cleared and incorporates areas of improved pasture and cropping. Due to this historic clearing for agriculture, vegetation cover is generally low except for within road reserves, travelling stock reserves and isolated patches of undeveloped land and paddock trees.

  In reference to Table 2, the sensitivity of LCU1 is assessed as **Low**, for it is of a type that is widespread and common within the local area and does not have any notable landscape features or attributes that set it apart. A representative image of LCU1 is shown in Figure 3.

- LCU2 comprises the village of Jindera which lies in the south-west of the wider 5km visual impact investigation area. This LCU is a more urbanised area containing just over 400 private dwellings and businesses, including several local heritage listed places. Vegetation is retained along parts of Bowna Creek and cultivated in parks and gardens.

  In reference to Table 2, the sensitivity of LCU2 is assessed as **Moderate**. A representative image of LCU1 is shown in Figure 4.

3.10 General Visibility

The Proposed Development has a relatively confined area of visibility due to fairly level topography and areas of remaining woody vegetation along fence lines and road edges. The Site is generally most visible from the cleared paddocks to the north east and elevated areas to the south east. However, views from these locations are generally buffered by distance and/or vegetation screening.

The Proposed Development has a combined 3 km direct road frontage to Ortlipp Road and the Drumwood Road. Topography and vegetation in adjoining public areas, which includes Jindera Golf Course, naturally obscures potential views of the Proposed Development. More distant views and glimpses of the Site are possible from Blight Road East, Lindner Road, Walla-Walla-Jindera Road, Fielder Moll Road, Dights Forest Road, Urana Road, Glenellen Road, and Gerogery Road.

Figure 3: Typical views of LCU1, showing flat rural landscape and cleared vegetation across the Site.

Figure 4: Typical views of LCU2 viewed from Urana Road. Source: Google Street View.

4 Visual Impact Assessment

4.1 Landscape character impact assessment

The landscape impact assessment considers the direct and indirect impacts of the Proposed Development on LCUs associated with the Site.

An assessment, considering the relationship between 'visual sensitivity' (the ability of the LCU to absorb a development) and the 'magnitude of visual change' is used to determine the potential impact of the Proposed Development on each LCU.

4.1.1 Landscape Character Unit 1 (LCU1)

The visual sensitivity of LCU1 has been assessed as **low** (as described in Section 3.9), for although it is an attractive rural landscape, it is of a type and scale that is widespread in the local area, as well as landscapes within the wider context of the Murray NRM region, and which does not display particular defining qualities of note. LCU1 is not covered by a designated landscape classification such as a State Forest, National Park or a World Heritage Area.

The magnitude of visual change to LCU1 during the construction and operation of the Proposed Development is considered to be **moderate**, as the introduction of a commercial-scale solar farm involves a moderate scale landscape change and vegetation clearing in a landscape already impacted by widespread and landscape-modifying agriculture (Table 3).

Based on these findings, and with reference to Table 1, the overall impact on the landscape character within LCU1 is assessed as **low**.

Following decommissioning, all above-ground infrastructure would be removed and the Site would be returned to agricultural production. Thereafter, the magnitude of visual change is considered to be **insignificant** due to the very minor residual changes to landform and vegetation that would remain.

4.1.2 Landscape Character Unit 2 (LCU2)

The visual sensitivity of LCU2 is assessed as **moderate** (Section 3.9), as it comprises the township of Jindera. LCU2 is not covered by a designated landscape classification such as a State Forest, National Park or a World Heritage Area.

The magnitude of visual change to LCU2 during the construction is considered to be **insignificant** because the combination of distance and screening by topography and vegetation from the Proposed Development would reduce the visibility of GSF to where it would likely not be seen from the town at all. The magnitude of change during operation is considered to be **insignificant** as the Site will likely not be visible due to the combination of distance, a biodiversity retention area and potential screening options (Table 3). The overall impact on the landscape character within LCU2 is assessed as **insignificant** (Table 1).

Following decommissioning, all above-ground infrastructure would be removed and the Site would be returned to agricultural production, resulting in an **insignificant** visual change due to residual changes to landform.

4.2 Visual Amenity Impact Assessment: Viewshed Analysis

4.2.1 Viewshed analysis

ZVI mapping has been generated to understand the potential extent of visibility of the Proposed Development within the Visual Amenity Assessment Area (5 km).

Bare Earth Digital Terrain Model

A bare earth ZVI heat map for a 5 m high Indicative Solar Panel Area (CWP Development Footprint) based on the digital terrain model (DTM) is presented in Figure 5.

The ZVI clearly illustrates that within the gently undulating topography that characterises the landscape, theoretical visibility is high. Furthermore, the heat map, stratified by the percentage of the Indicative Solar Panel Area potentially visible from any given viewpoint, clearly demonstrates areas of increased theoretic visibility associated with elevated parts of the landscape, particularly to the north and south east of the Site.

The bare earth DTM significantly overstates potential visibility of the Site due as it considers only topographical features, not the screening effects of vegetation and built infrastructure. Furthermore, the heat map overstates potential visibility as it does not consider the effect of perspective from the viewpoint (i.e. it assumes you can see parts of the array obscured by other parts of the array).

Despite these limitations the bare earth DTM is useful to identify areas that are definitely not subject to visual impact from the Proposed Development. Of the 277 potential receptors identified within the 5 km Visual Amenity Assessment Area, 66 were identified as non-impacted (Table 6).

Surface Model

A surface model ZVI heat map for a 5 m high Indicative Solar Panel Area is presented in Figure 6. Unlike the DTM, the surface model includes above ground relief resulting from vegetation, buildings and other infrastructure. As such the surface model provides a more realistic indication of potential visibility than the DTM, however it may sightly underestimate visibility from nearby viewpoints as it does not incorporate partial visibility through buffers (such as through stands of vegetation).

Using the surface model, potential visibility of the Indicative Solar Panel Area is significantly reduced, with 52 potential visual receptors identified within the 5 km Visual Amenity Assessment Area as being able to see some part of the Indicative Solar Panel Area. Furthermore, average visibility of the site (the percentage of the Indicative Solar Panel Area potentially visible) decreased significantly when compared to the bare earth DTM, from an average site visibility per receptor of 46% of the Indicative Solar Panel Area to 12%. Again, it is noted that this figure is likely to overestimate visibility as the effect of perspective is not considered, for instance, not all houses face the Proposed Development.

Surface model with existing commitments

Through the extensive and ongoing consultation process, Glenellen Solar Farm Pty Ltd have identified a number of commitments developed in consultation with adjoining landholders aimed at reducing potential impacts on social amenity. With regard to visual impacts, these commitments include:

- The adoption of a residential setback for homes located along Lindner Road;
- The retention of existing vegetation around the periphery of the Site; and
- Establishment of vegetated buffer strips (vegetation screens) along parts of the Site boundary intended to grow densely and to height taller than the panel array.

The nature and effect of these commitments is shown in Figure 7. This approach has a small effect on overall visibility of the Proposed Development in the broader landscape but has a major effect of reducing visibility to the residents adjacent to the Proposed Development. It is also likely to significantly improve social amenity outcomes for adjoining and nearby residences. Incorporating these commitments reduces the number of potentially impacted residences within 5 km from 52 to 50 (Table 6) and is likely to improve the effectiveness of landscape screening associated with existing vegetation within the landscape.

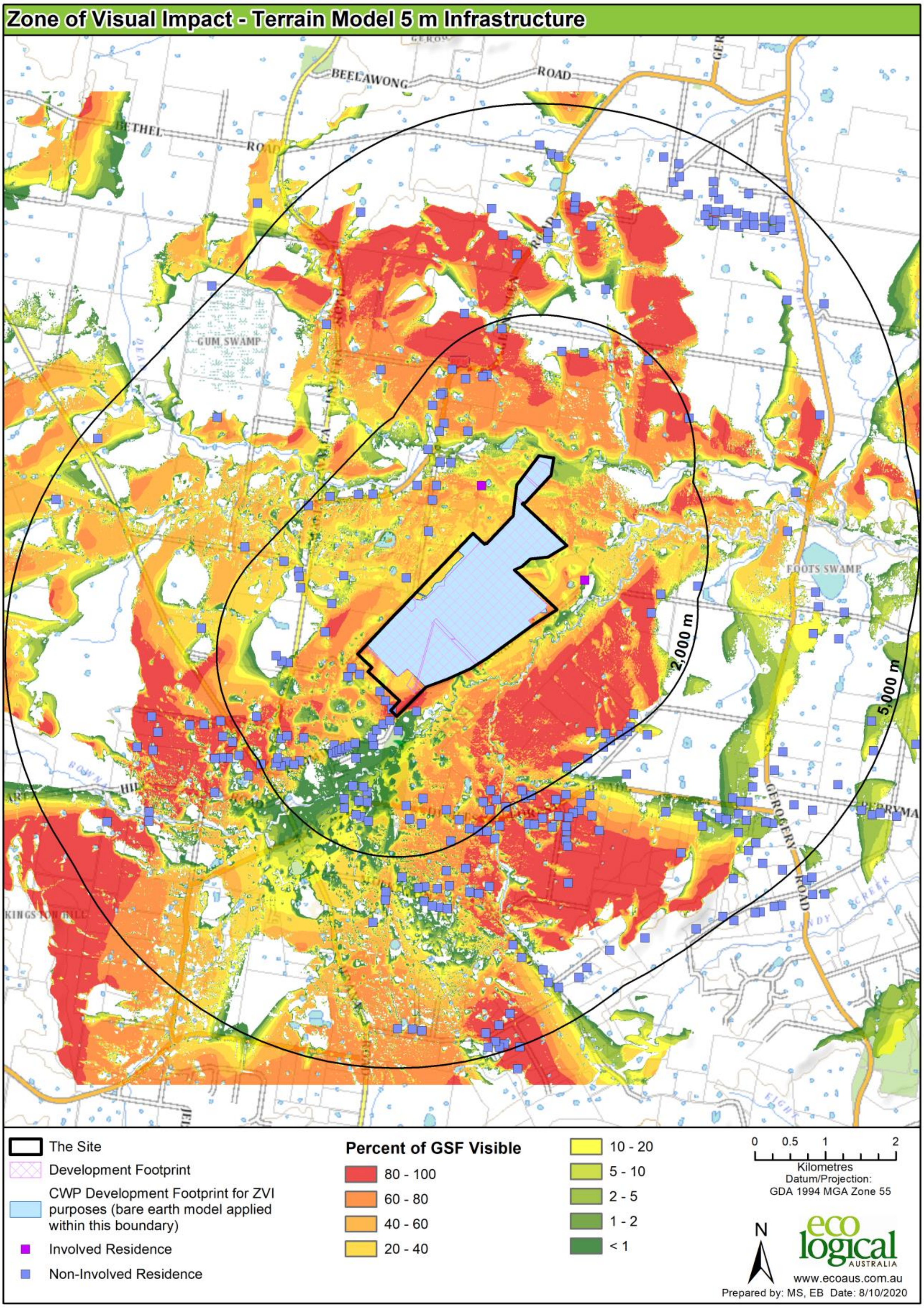

Figure 5. Bare earth ZVI for 5 m tall panel array

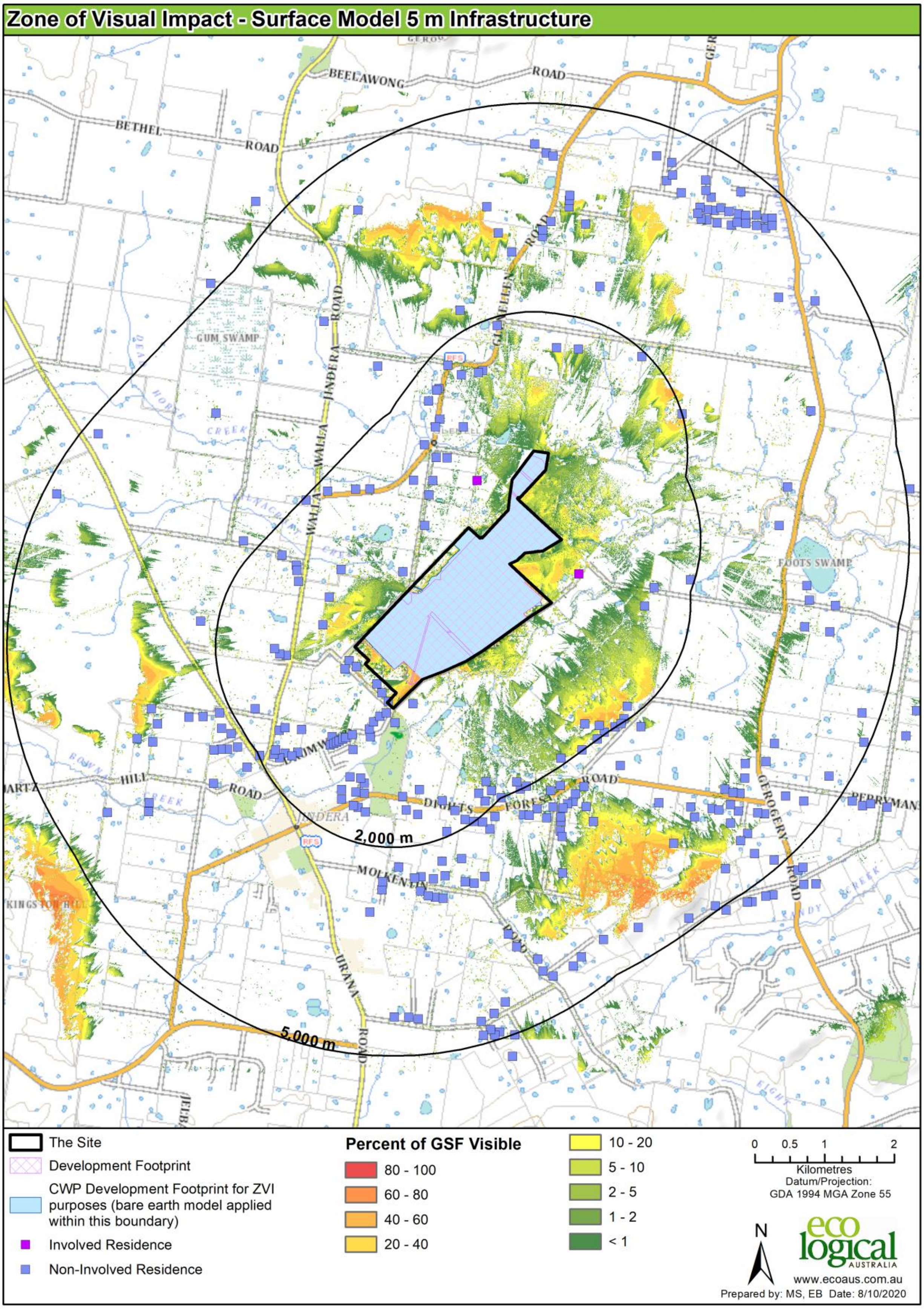

Figure 6. Current state surface layer ZVI for 5 m tall panel array

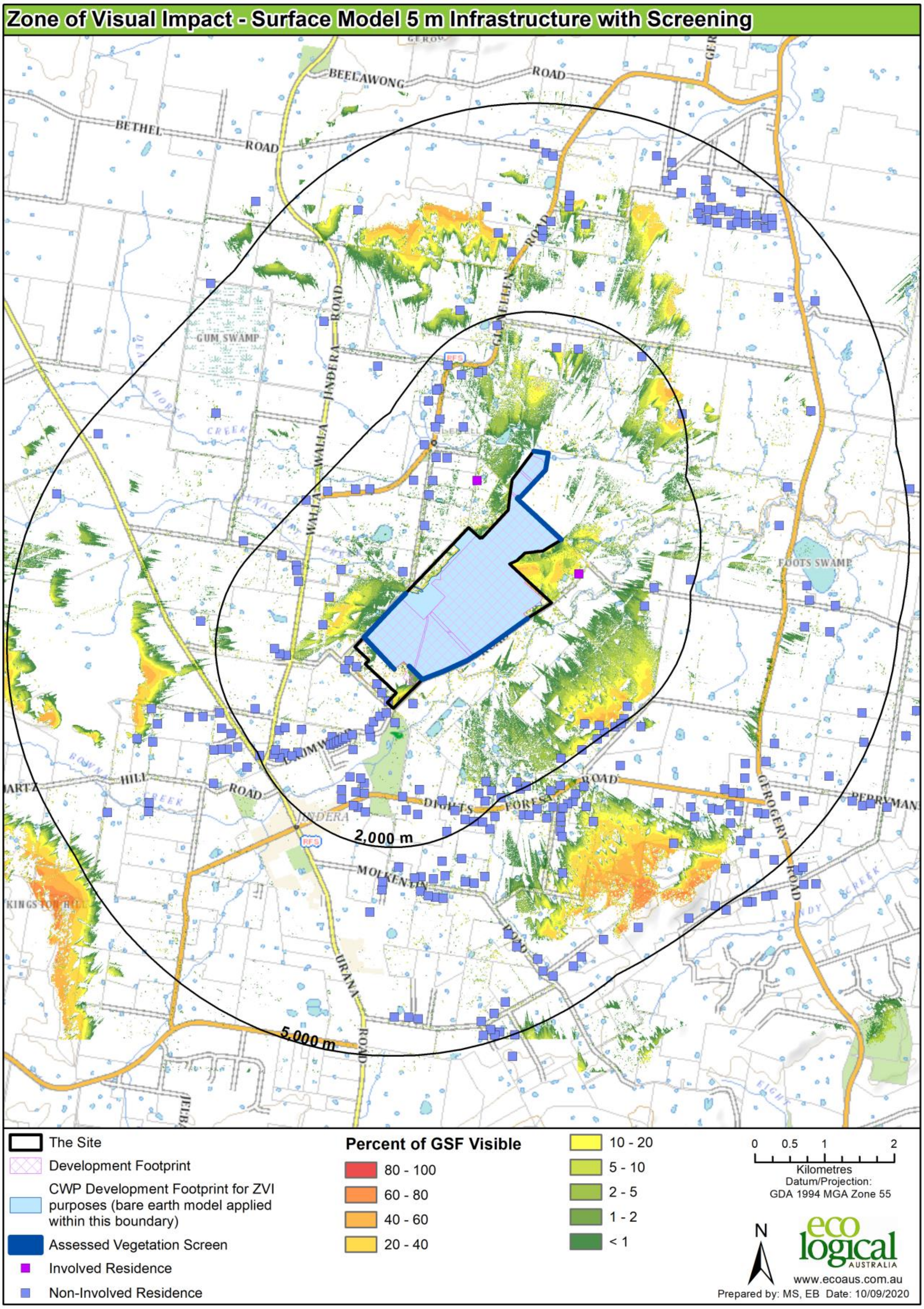

Figure 7: Surface layer ZVI for 5 m tall panel array with screening

4.3 Visual Amenity Impact Assessment: Viewpoints

Residential Viewpoints

Desktop spatial assessment identified 277 residences and/or potential dwellings within 5 km of the Site. Of these 97 were located within 2 km of the Site.

ZVI analysis using a bare earth DTM indicates that the Proposed Development is theoretically visible from 211 of these locations. The bare earth DTM represents a worst-case scenario as no allowance is made for potential visual screening associated with vegetation and existing built structures.

A digital surface model was developed that incorporated screening effects of both retained boundary vegetation within the Site, as well as vegetation and structures within the wider landscape. Under this modelled scenario the number of identified residences with potential views of the Proposed Development is reduced to 52, of which 7 are located within 2 km of the Proposed Development and 45 between 2 km and 5 km of the Proposed Development (Table 6).

In addition to significantly reducing the number of residences from which the Proposed Development is visible, existing vegetation and infrastructure also reduced the average extent of the solar farm visible decreasing the average proportion of the visible Indicative Solar Panel Area from a combined average of 46% to 12% (Table 6).

Table 6: Effect of existing landscape screening and proposed visual buffering within the Site

Distance from Site	Number of impacted dwellings			Average proportion visible (%)		
	No existing landscape screening (i.e. 'bare earth')	Existing landscape screening (i.e. 'surface model')	Existing landscape screening plus proposed vegetative screening	No existing landscape screening (i.e. 'bare earth')	Existing landscape screening (i.e. 'surface model')	Existing landscape screening plus proposed vegetative screening
0 - 2 km	84	7	7	43	18	18
2 - 5 km	127	45	43	48	11	11
Combined	211	52	50	46	12	12

Potential visual impacts to individual residences are assessed in Appendix A and Appendix B of this report. Potentially impacted residences are identified in Table 7. Generally, impacts to visual amenity associated with GSF are assessed as low or insignificant, however one residence is assessed as highly impacted and two properties are assessed as moderately impacted. In these cases, targeted consultation (integrated with other potential impacts to amenity, where relevant) with landholders regarding potential visual screening options has been undertaken to identify acceptable levels of impact and situation-specific mitigation strategies. General ongoing consultation with other impacted landholders has also been undertaken.

Table 7: Residential Visual Impact Assessment summary and recommendations

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual Amenity Impact	Comment
WWJ016	615	West	50	High	Targeted consultation
FMO001	1514	North	21	Moderate	Targeted consultation
NIK011	1853	South	49	Moderate	Targeted consultation
NIK010	1912	South	7	Low	
NIK004	2002	East	53	Low	
GLE014	2280	North	17	Low	
DFR036	2436	South	7	Insignificant	
DFR026	2442	South	1	Insignificant	
DFR037	2451	South	10	Low	
DFR028	2515	South	17	Low	
DFR027	2527	South	10	Low	
DFR024	2534	South	1	Insignificant	
DFR038	2688	South	19	Low	
DFR030	2797	South	3	Insignificant	
DFR033	2876	South	3	Insignificant	
DFR034	2925	South	29	Low	
GLE017	3087	North	6	Insignificant	
GLE027	3172	North	40	Low	
GLE018	3173	North	6	Insignificant	
URA012	3217	West	1	Insignificant	
URA013	3223	West	13	Insignificant	
LEM001	3335	North	27	Low	
DFR035	3346	South	12	Insignificant	
URA015	3571	West	12	Insignificant	
GLE023	3575	North	46	Low	
GLE021	3639	North	23	Low	
GRD009	3714	East	1	Insignificant	
DFR044	3734	South	1	Insignificant	
DFR045	3811	East	1	Insignificant	
GRD001	3821	East	2	Insignificant	
DFR039	3853	South	45	Low	

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual Amenity Impact	Comment
114	4015	North	20	Low	
113	4056	North	23	Low	
116	4060	North	22	Low	
DFR062	4143	East	4	Insignificant	
73	4179	North	21	Low	
202	4284	North	1	Insignificant	

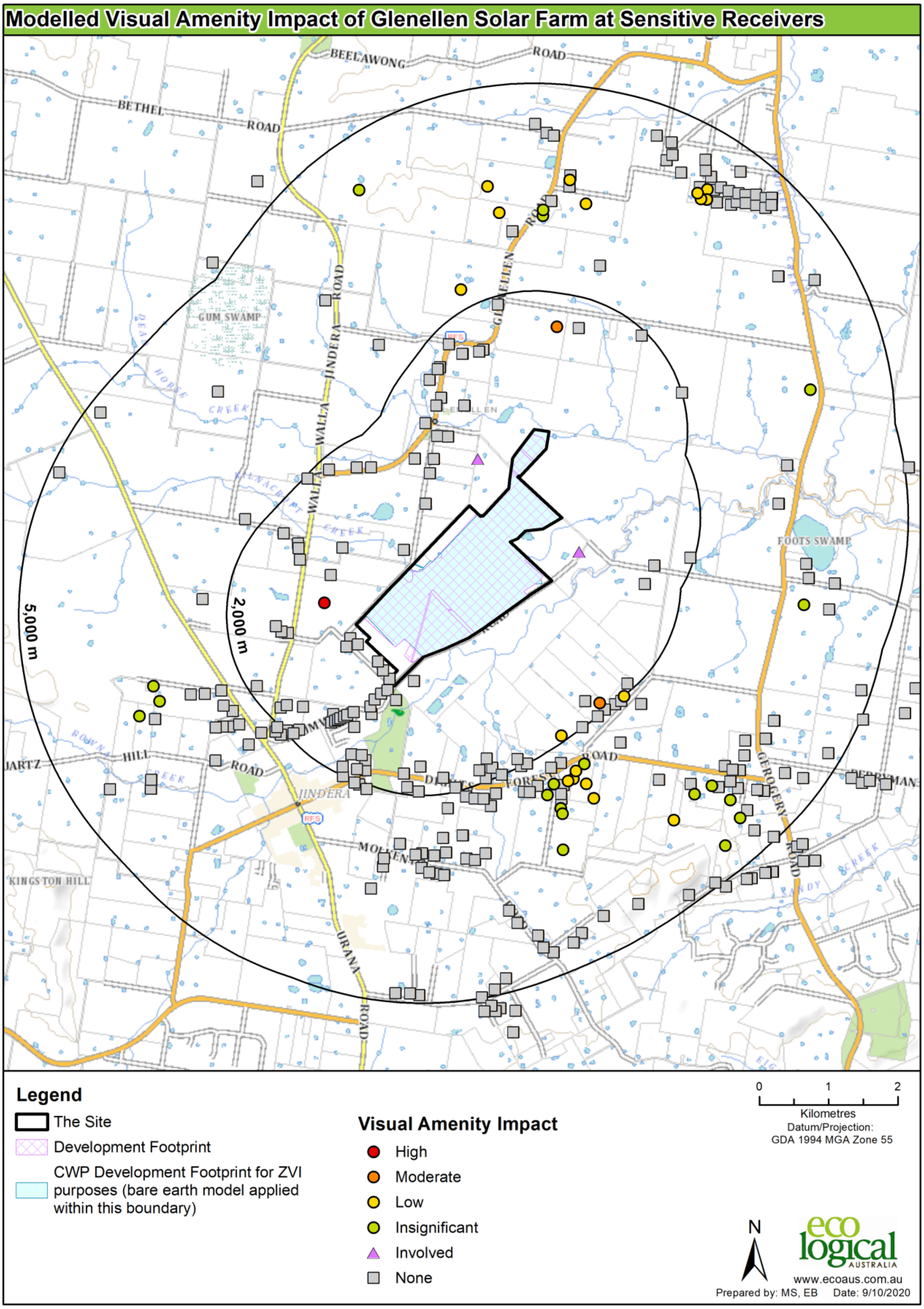

Figure 8: Visual amenity impact assessment on residential viewpoints.

Public Viewpoints

Public viewpoints within 5 km of the Development Footprint are restricted to public roads. During field investigations it was confirmed that the Project would be potentially visible from the following roads:

- Ortlipp Road;
- Lindner Road;
- Drumwood Road;
- Blight Road West;
- Blight Road East;
- Urana Road;
- Walla Walla Jindera Road;
- Glenellen Road
- Dights Forest Road; and
- Gerogery Road.

Surface model ZVI mapping (Figure 6) indicates that potential views from all roads are generally limited due to existing vegetation within the road corridor, and that this effect will be enhanced through existing commitments to vegetative buffer screen around the Site periphery (Figure 7). While it may be possible to catch glimpses of the solar array from other roads beyond 5 km from the Proposed Development, such glimpses are considered to be insignificant.

Appendix C provides an assessment from each public viewpoint and the assessed visual sensitivity. Visual impacts on public roads are shown to be low or insignificant (Table 8); therefore, additional mitigation strategies for public viewpoints are not recommended.

Table 8: Summary of potential impacts to visual amenity at public viewpoints

Viewpoint	Minimum distance to GSF	Road length impacted	Visual sensitivity	Magnitude of change	Visual Amenity Impact
Drumwood Road	0 m	1.15 km	Low	Moderate	Low
Ortlipp Road	0 m	1.53 km	Low	Moderate	Low
Blight Road West	0 m	1.35 km	Insignificant	Low	Insignificant
Lindner Road	200 m	0.15 km	Low	Low	Low
Walla Walla Jindera Road	1,000 m	0.73 km	Low	Low	Low
Blight Road East	1,100 m	0.28 km	Insignificant	Low	Insignificant
Glenellen Road	1,100 m	0.70 km	Insignificant	Insignificant	Insignificant
Dights Forest Road	1,600 m	0.23 km	Insignificant	Insignificant	Insignificant
Urana Road	2,300 m	0.35 km	Insignificant	Insignificant	Insignificant
Gerogery Road	3,400 m	0.45 km	Insignificant	Insignificant	Insignificant

4.4 Other considerations

4.4.1 Night lighting

There is no requirement to light the solar farm at night. The only facilities with provisions for night lighting will be associated with the operations and maintenance compound and existing substation. Lighting at this location will be predominantly on-demand only. Field based observations indicate that the existing substation is visible from a small number of potential sensitive receivers. As such, it is recommended that night lighting be developed to minimise light spill.

4.4.2 Glint, glare and reflections

When the sun is reflected off a smooth surface, it can result in a glint (a quick reflection) or glare (longer reflection). In both cases, the intensity of light will depend upon the reflectiveness of the surface from which the sun is being reflected.

Solar farms are not considered to be reflective, since PV panels are designed to absorb as much sunlight as possible and convert it into electricity. Solar panels feature low-iron glass that is designed to minimise reflection and maximise the transmission of light through the glass. Low-iron glass reflects between 4% and 7% of light (Spaven Consulting, 2011). SunPower, (2009), as referenced by Pager Power, (2018 – Appendix D of this report) established that the reflectivity of a PV solar panel is similar to or less than those of still water and significantly less than reflections from glass and steel. Additionally, NGH, (2010) reported that PV panels are no more reflective than areas of vegetation such as grasslands, crops and forested areas associated with rural landscapes, and far less reflective than standing water such as water in dams, rivers and lakes.

Assessment of potential glint, glare and reflections is provided in Pager Power (2018 – Appendix D of this report). It is noted that glint and glare modelling is based on a bare-earth DEM, however in reality glint and glare impacts are only possible at receptors from which GSF is visible according to surface modelling that considers vegetation and visual screening mitigation measures. The modelling also had assumed the entire Site would contain PV panels, not just the Development Footprint.

Residential receptors

Based on Pager Power's expertise, initial, high-level glint and glare modelling of anticipated likely impacts was undertaken for residences located within 1 km of the Site. The study concludes that:

- Reflections are possible towards three of the assessed surrounding dwelling receptors: one to the west and two the south of the Site. Based on the modelling, Pager Power advise that approximately 10 dwellings could experience effects;
- At these dwellings, the solar reflections generally occurred immediately following sunrise until no later than 8 am AEST (GMT+10), when the sun is at a low angle of incidence and would typically last not more than 15 minutes on any given day potentially all year round;
- In all cases, a clear view of the reflecting solar panels at the particular time of day when a solar reflection was geometrically possible would be required. In addition, the weather would also have to be clear and sunny;
- In all scenarios where a solar reflection is geometrically possible towards the surrounding dwellings, direct sunlight would coincide with the solar reflection, such that the observer looking towards a reflecting panel would also be looking towards the sun. Direct sunlight is significantly more intense than reflections from solar panels;

These residences were cross checked with the visual impact assessment prepared using the 5 m surface model to assess likely visibility. Visual impact assessment for these residences indicates that WWJ016 (Dwelling 2 in Appendix D of this report) which has a high assessed visual impact could receive solar reflections from various sections within the panel area, most often from the western portion. The other residences with potential solar reflections are completely screened from the Proposed Development, therefore, no impact is anticipated.

Road users

Reflected light from the solar farm is theoretically possible immediately following sunrise until no later than 8 am AEST (GMT+10) towards approximately 400 m of Walla Walla Jindera Road which has a moderate density of traffic expected. A solar reflection to that part of the road would be in the early morning from a bearing of more than 50 degrees beyond the direction of travel. This means a driver looking directly ahead would not be looking towards a reflecting panel. Theoretically this reflection could last for up to 10 minutes, however in reality road users would be expected to be travelling at (up to) 100 km/h and so effects would be fleeting for an observer in a vehicle travelling through the solar reflection zone.

Solar reflections would only occur on days when the weather is clear and sunny and in scenarios where a solar reflection towards the road user is possible, the Sun and the solar reflection would originate from a similar location

The overall expected impact upon road users with respect to safety is conservatively classified as low where the reflecting solar panels are visible. Where the solar panels are not visible, (which is the majority of the 400 m potentially affected stretch of road) there is no impact.

Air traffic

Searches of the Civil Aviation Safety Authority website identified no specific advice regarding the assessment of solar farm development at or near to Australian aerodromes, however, the Australian Department of Defence's External Land Use Assessment Guidance for Extraneous Lighting and Reflective Surfaces (Department of Defence, nd) indicate that "large expanses of reflective building materials are of concern to Defence with regard to glare and aviation safety" and consider that further assessment is required if the Proposed Development is located within 6 km of an airfield.

The nearest public aerodrome is Albury Airport, located approximately 15 km south of the Site. Its runway is aligned approximately east-west, such that an approaching pilot would not be looking towards the development area. The United States of America's Federal Aviation Administration guidance (as referenced in Appendix D of this report) stipulates that reflections from more than 50 degrees (horizontally) outside a pilot's view are not significant. Based on the separation distance, significant effects are not predicted.

A commercial helicopter business, Forest Air, is situated in proximity to the Site. ORT009 (984 m north) marks the hangar, with the landing pads right in front of it on the northern side, and ORT001 (1133 m north) is the home/office building. Forest Air operate a training school and provide "a broad range of services from charter and scenic flights to aerial agriculture, fire fighting and survey work" (Forest Air, 2018, http://www.forestair.com.au/). Communication with Forest Air revealed the helicopters generally use the 330 kV lines as a navigation routing aide and fly in/out to the east heading through 100-500 ft (approximately 30-150 m) to avoid houses noise impacts to houses.

Neither ORT009 nor ORT001 were assessed as likely to receive potential solar reflections, nor were they assessed as having their visual amenity impacted. Once airborne, it is anticipated that potential glare impacts can be adaptively managed through adjustments to flight paths and direction. Consultation with Forest Air has commenced during the preparation of this EIS and will continue during the design phase will assist to identify and manage potential concerns.

Generally speaking, concerns regarding glare from solar farms has focussed on solar facilities on, or adjacent to airfields. Spaven Consulting (2011) concluded that off-airfield ("*en route*") facilities are unlikely to present glare problems to pilots, for the following reasons:

- glare is likely to present a hazard only during critical phases of flight, especially approach and landing, the *en route* phase is not normally a critical phase;
- glare occurs almost exclusively at low angles of elevation, aircraft in the *en route* phase of flight will be at higher angles of elevation;
- pilots in the *en route* phase are already subjected to glare from a number of existing sources such as large assemblies of parked cars, major glasshouse facilities and large bodies of water, etc; and
- the pilot view from most cockpits, is severely limited in the downward direction by the aircraft structure, thus blocking the line of sight to any source of glare on the ground.

The presence of the Proposed Development is anticipated to have an insignificant visual impact on air traffic. As discussed above, PV panels are similarly or less reflective than standing water such as water in dams, rivers and lakes, all features which pilots regularly fly over or adjacent to.

Further evidence of the limited risks posed by reflections from PV panels is the increasing installation of large solar arrays within airports in order to take advantage of large open areas and high local day-time electricity demand. Australian examples include Darwin Airport, Adelaide Airport, Alice Springs Airport, Newman (WA) Airport and Ballarat Airport (Solar Choice, 2013).

4.4.3 Decommissioning

At the conclusion of the operational phase of the project, all above ground infrastructure associated with the solar farm shall be removed from Site and the Site rehabilitated to a condition to allow the resumption of agricultural activities. As such, all visual impacts post decommissioning are considered to be insignificant.

4.5 Cumulative visual impacts

A cumulative landscape or visual impact could result from the Proposed Development being constructed in conjunction with other existing or Proposed Developments, and may be either associated with, or separate to it. A search of the NSW Major Projects Register, VicPlan, and LGA websites (NSW and Victoria) was undertaken on 12 June 2020 to identify other large or major projects which may contribute to cumulative impacts on the local community. Other major and renewable energy projects within 70 km of the Proposed Development include:

- Jindera Solar Farm (130 MW) – NSW DIPE decision pending;
- Walla Walla Solar Farm (300 MW) – NSW DIPE decision pending;
- Hume Battery Energy Storage System (20 MW / 40 MWh) – NSW DIPE decision pending;
- Howlong Sand and Quarry Expansion – Response to Submissions;
- Wodonga Solar Farm, Victoria (54 MW) – approved;
- Culcairn Solar Farm (400 MW) – NSW DIPE decision pending;
- Corowa Solar Farm (27 MW) – approved; and
- Wangaratta Solar Farm, Victoria (20 MW) – approved.

Based on topography and separation distances it is anticipated that there is limited potential for significant views of GSF and any other solar farm developments other than the proposed Jindera Solar Farm (JSF). The JSF proposal comprises a commercial scale PV solar farm located immediately to the north east of GSF (Figure 9). The JSF proposes to connect to the Jindera Substation.

During construction and operation, there may be a cumulative visual impact of GSF from JSF for private and public receivers. Visual impact assessment for JSF is not available at the time of preparation of this assessment, however, the PEA for JSF identifies potentially impacted sensitive receptors within a 1 km buffer from the site boundary (Figure 9). Of these, only one residence (WWJ016) is identified as potentially impacted by GSF.

Given the generally low levels of visual impact associated with GSF and the proponent's ongoing commitment to consult with significantly impacted landholders, it can be anticipated that there is limited capacity for potential direct cumulative visual impacts within the general study area.

Public viewpoints located within close proximity to both GSF and JSF include:

- Ortlipp Road;
- Lindner Road;
- Blight Road West;
- Walla Walla Jindera Road; and
- Glenellen Road.

Potential visual impacts to these public viewpoints associated with the proposed GSF are shown to be either low or insignificant (Table 8) and further reference to ZVI analyse indicates that only occasional momentary glimpses are likely from all roads within the assessment area (Figure 6). On this basis, potential direct cumulative visual impacts to public areas associated with GSF and PSF are considered to be low and manageable.

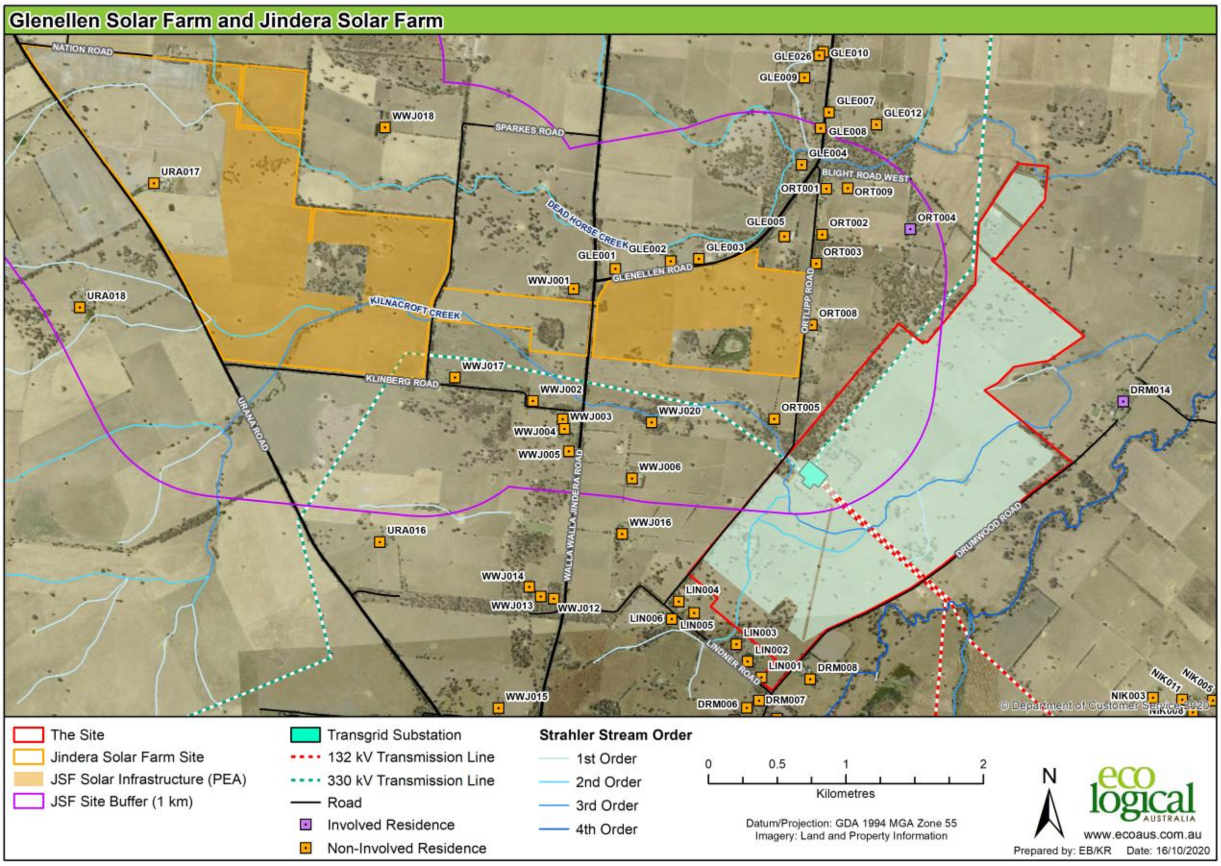

Figure 9: Location of Jindera Solar Farm (PEA) and GSF. Source NGH, 2018

5 Mitigation Measures

5.1 Proposed Mitigation Measures

The following mitigation measures will be implemented over the life of the project:

- Minimise vegetation clearing and earthworks, and rehabilitate bare earth progressively;
- Implement existing commitment to establish perimeter vegetation screening:
- Continue to consult with potentially impacted landholders to identify, where necessary, the location of additional mutually agreeable vegetation screening both pre and post construction;
- Continue to consult with Forest Air;
- Where practicable use muted, low contrast colours for supporting infrastructure, so that they blend into the landscape as far as possible;
- Where practicable select infrastructure to minimise potential for reflectivity and glare; and
- Minimise night lighting.

Visual impact mitigation measures will be offered to owners of non-involved neighbouring residences where there is opportunity to significantly reduce potential visual impacts from the proposal. Visual impact mitigation measures may include landscaping, screen plantings, which can be located on the owner's land to minimise visual impacts of the Project at the residence and its curtilage. Mitigation measures will be determined through consultation with the owner, be reasonable and feasible, and directed towards reducing the visual impacts of the Project on the residences, commensurate with the level of visual impact.

5.2 Draft Landscaping Plan

A draft landscaping plan has been developed by the proponent in consultation with potentially impacted adjoining landholders (Figure 10). The proposed vegetation buffers will augment existing vegetation retained within the buffer zone as well as that within the adjoin road reserve/landholding. Where appropriate, endemic native species shall be selected if they are deemed suitable to meet the agreed screening performance criteria (to be finalised in the Landscape Management Plan) so that complementary biodiversity outcomes can be achieved.

Additional observer point vegetation screening has been developed through ongoing consultation with impacted landholdings.

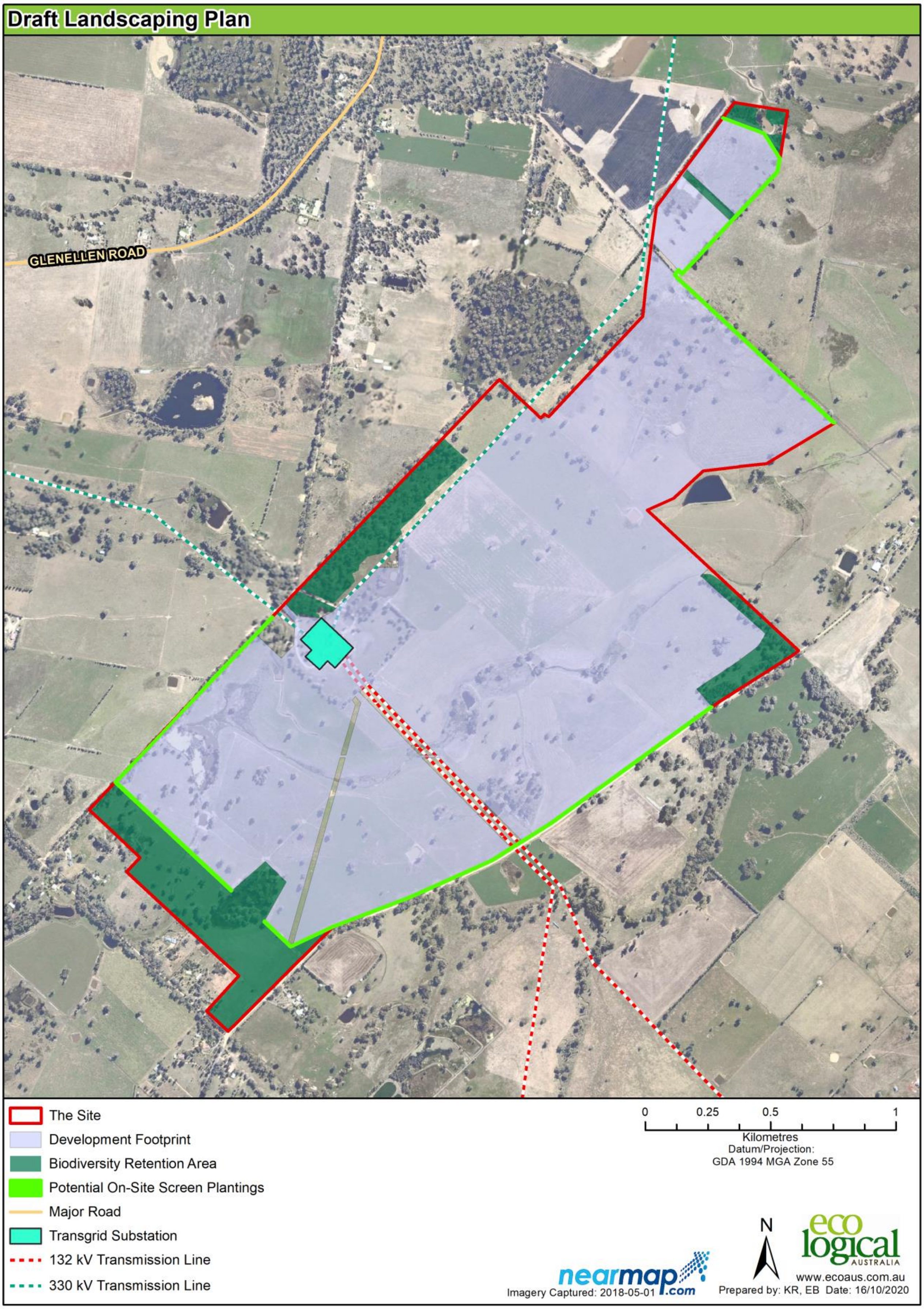

Figure 10: Draft landscaping plan for Proposed Development

6 Conclusion

The Proposed Development requires the installation of solar panels within a potential Development Footprint area of approximately 320.2 ha, which is currently land used for agricultural purposes.

Solar farms do not generally result in excessive visual impacts due to their low-lying nature. Accordingly, the overall potential for impacts as a consequence of the introduction of the Proposed Development is low due to the interacting influences of:

- Design principles that move infrastructure away from public and private viewpoints;
- A location that benefits from screening from existing vegetation; and
- The use of visual screening techniques as a mitigation strategy.

The objective of the visual impact assessment is to determine how the Proposed Development would impact landscape character and visual amenity at the Site and within the surrounding landscape. The parameters which influence visual impacts associated with the Proposed Development include:

- The visible extent of the Proposed Development;
- The visual appearance of the solar panels and associated infrastructure;
- The sensitivity of the viewing location; and
- The sensitivity of the viewer (residential, public, permanent or transient).

The landscape at the proposed Site and in the surrounding area is characterised as a gently undulating rural landscape. Due to historic clearing for agriculture, vegetation cover is generally low except in road reserves, private and public land and isolated low-lying areas.

Broadly, the Proposed Development, by its very nature, would introduce a new element into a largely rural landscape. With regard to landscape character, the Proposed Development would not greatly change the underlying characteristics of the local or wider landscape, as the landscape is of a type and scale that is widespread and common within the local area.

Despite its scale, the Proposed Development would not be visible from most public or private viewpoints outside the Site. This is largely due to natural visual screening inherent within the landscape and the generally low to rolling topography within the study area. Due to the effect of existing vegetation the main extent of visibility is from elevated areas some distance away from the Site, however, visual impacts at viewpoints beyond 2 km are considered to be low and if visible, the Proposed Development is likely to appear as a grey line or band in the background of broader landscape views.

The proponent has developed a mitigation strategy aimed at minimising potential visual impacts of the Proposed Development. This includes ongoing consultation regarding visual screening options aimed at minimising visibility from impacted landholdings and public roads. The proponent’s setbacks and visual screening commitments are modelled to greatly reduce visual impacts to the receptors adjacent to the Proposed Development by using locally native vegetation plantings. These commitments are likely to significantly improve social amenity outcomes for adjoining and nearby residents.

In conclusion, the Proposed Development will generally have a low visual impact on the landscape character of the local area. Visual amenity impacts are generally low with only a small number of residences potentially affected; however, through ongoing consultation with landholders, measures to mitigate these impacts using vegetation screening have be developed. These screenings will effectively mitigate potential residual impacts and, consequently, the overall visual impact of the GSF will be low.

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Appendix A – Residential Visual Impact Assessment

Summary of impacts to residential visual amenity and recommendations (based on existing 5m Surface Model)

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
ORT005	244	West	0	Nil			
LIN003	324	South	0	Nil			
LIN005	369	West	0	Nil			
DRM008	374	South	0	Nil			
LIN002	381	South	0	Nil			
LIN004	385	West	0	Nil			
LIN001	467	South	0	Nil			
ORT004	494	North	0	Nil			Involved
LIN006	512	West	0	Nil			
DRM014	551	East	0	Nil			Involved
WWJ016	615	West	50	High	High	High	Possible views to NE, some existing screening
DRM007	636	South	0	Nil			
ORT008	651	West	0	Nil			
DRM006	703	South	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DRM015	735	South	0	Nil			
WWJ006	754	West	0	Nil			
DRM005	814	South	0	Nil			
WWJ020	904	West	0	Nil			
ORT003	914	North	0	Nil			
DRM004	931	South	0	Nil			
ORT009	984	North	0	Nil			
GLE012	1014	North	0	Nil			
ORT002	1026	North	0	Nil			
DRM002	1028	South	0	Nil			
DRM001	1116	South	0	Nil			
ORT001	1133	North	0	Nil			
WWJ012	1143	West	0	Nil			
DRM021	1203	South	0	Nil			
GLE005	1216	North	0	Nil			
WWJ013	1231	West	0	Nil			
WWJ005	1232	West	0	Nil			
DRM020	1247	South	0	Nil			
WWJ014	1296	West	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DRM003	1296	South	0	Nil			
DRM019	1299	South	0	Nil			
DRM013	1318	South	0	Nil			
DRM018	1335	South	0	Nil			
GLE008	1338	North	0	Nil			
GLE007	1349	North	0	Nil			
GLE004	1354	North	0	Nil			
WWJ004	1358	West	0	Nil			
GLE006	1365	North	0	Nil			
DRM017	1375	South	0	Nil			
GLE024	1376	North	0	Nil			
WWJ003	1413	West	0	Nil			
DRM016	1428	South	0	Nil			
BRE001	1476	East	0	Nil			
BRE002	1502	East	0	Nil			
GLE011	1506	North	0	Nil			
FMO001	1514	North	21	Moderate	Moderate	Moderate	Views likely mitigated by distance, topography and screening
GLE003	1520	West	0	Nil			
FMO002	1555	North	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
WWJ021	1562	West	0	Nil			
DFR015	1584	South	0	Nil			
GLE002	1611	West	0	Nil			
GLE010	1625	North	0	Nil			
GLE026	1635	North	0	Nil			
GLE009	1636	North	0	Nil			
DFR005	1637	South	0	Nil			
WWJ002	1663	West	0	Nil			
DFR004	1674	South	0	Nil			
DFR002	1692	South	0	Nil			
DFR021	1696	South	0	Nil			
DFR016	1707	South	0	Nil			
NIK003	1710	South	0	Nil			
WWJ011	1716	West	0	Nil			
GLE025	1738	North	0	Nil			
DFR014	1770	South	0	Nil			
WWJ010	1805	West	0	Nil			
DFR013	1816	South	0	Nil			
GLE001	1828	West	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DRM009	1830	South	0	Nil			
DFR001	1831	South	0	Nil			
DFR003	1847	South	0	Nil			
DFR012	1852	South	0	Nil			
NIK011	1853	South	49	Moderate	Moderate	Moderate	Elevated views of Site mitigated by distance
WWJ015	1871	West	0	Nil			
GLE015	1875	North	0	Nil			
DFR054	1883	South	0	Nil			
DFR018	1889	South	0	Nil			
DFR006	1891	South	0	Nil			
NIK002	1899	East	0	Nil			
NIK010	1912	South	7	Moderate	Low	Low	Views likely mitigated by distance and screening
DRM011	1926	West	0	Nil			
FMO003	1929	North	0	Nil			
BRE003	1942	East	0	Nil			
DFR007	1944	South	0	Nil			
DFR040	1945	South	0	Nil			
DFR008	1955	South	0	Nil			
WWJ001	1959	West	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DRM010	1967	West	0	Nil			
NIK008	1975	South	0	Nil			
NIK009	1993	South	0	Nil			
NIK001	1993	South	0	Nil			
DFR022	1997	South	0	Nil			
DFR011	1998	South	0	Nil			
DFR020	1998	South	0	Nil			
NIK004	2002	East	53	Low	Moderate	Low	Views likely mitigated by distance and screening
FMO004	2002	North	0	Nil			
NIK005	2004	South	0	Nil			
DFR017	2014	South	0	Nil			
NIK006	2025	East	0	Nil			
WWJ008	2034	West	0	Nil			
DFR065	2045	South	0	Nil			
DFR019	2053	South	0	Nil			
DRM012	2071	West	0	Nil			
DFR064	2073	South	0	Nil			
WWJ007	2095	West	0	Nil			
DFR048	2106	South	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DFR049	2174	South	0	Nil			
DFR041	2213	South	0	Nil			
DFR051	2214	South	0	Nil			
WWJ017	2215	West	0	Nil			
DFR010	2222	South	0	Nil			
DFR052	2224	South	0	Nil			
DFR009	2239	South	0	Nil			
NIK007	2250	East	0	Nil			
URA001	2259	West	0	Nil			
GLE014	2280	North	17	Low	Low	Low	View to SE, but vegetation screening and distance mitigation
URA011	2344	West	0	Nil			
DFR023	2353	South	0	Nil			
URA016	2356	West	0	Nil			
DFR025	2359	South	0	Nil			
DFR050	2359	South	0	Nil			
URA007	2360	West	0	Nil			
DFR053	2393	South	0	Nil			
URA004	2406	West	0	Nil			
URA008	2428	West	0	Nil			

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DFR036	2436	South	7	Insignificant	Insignificant	Insignificant	Vegetation screening and distance, possible glimpses
DFR026	2442	South	1	Insignificant	Insignificant	Insignificant	Vegetation screening and distance, possible glimpses
DFR037	2451	South	10	Low	Low	Low	Vegetation screening and distance, possible glimpses
DFR042	2496	South	0	Nil			
URA002	2505	West	0	Nil			
FMO005	2506	North	0	Nil			
DFR028	2515	South	17	Low	Low	Low	Vegetation screening and distance, possible glimpses
GLE013	2524	North	0	Nil			
DFR027	2527	South	10	Low	Low	Low	Vegetation screening and distance, possible glimpses
DFR029	2530	South	0	Nil			
DFR024	2534	South	1	Insignificant	Insignificant	Insignificant	Vegetation screening and distance, possible glimpses
URA003	2540	West	0	Nil			
URA009	2577	West	0	Nil			
URA005	2611	West	0	Nil			
DFR032	2623	South	0	Nil			
7	2628	South	0	Nil			
16	2639	South	0	Nil			
DFR031	2683	South	0	Nil			
DFR038	2688	South	19	Low	Low	Low	Vegetation screening and distance, possible glimpses

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
URA006	2698	West	0	Nil			
32	2721	South	0	Nil			
URA010	2764	West	0	Nil			
DFR030	2797	South	3	Insignificant	Insignificant	Insignificant	Vegetation screening and distance, possible glimpses
9	2837	South	0	Nil			
6	2842	South	0	Nil			
11	2856	South	0	Nil			
8	2871	South	0	Nil			
DFR033	2876	South	3	Insignificant	Insignificant	Insignificant	Vegetation screening and distance, possible glimpses
GLE016	2876	North	0	Nil			
DFR034	2925	South	29	Low	Moderate	Low	Vegetation screening and distance, possible glimpses
31	2963	South	0	Nil			
15	2975	South	0	Nil			
4	2976	South	0	Nil			
34	3014	West	0	Nil			
5	3025	South	0	Nil			
10	3044	South	0	Nil			
30	3079	South	0	Nil			
GLE017	3087	North	6	Insignificant	Insignificant	Insignificant	Vegetation screening and distance, possible glimpses

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
13	3113	South	0	Nil			
GRD002	3136	East	0	Nil			
12	3136	South	0	Nil			
14	3164	South	0	Nil			
GLE027	3172	North	40	Low	Moderate	Low	Distance and landscape screening
GLE018	3173	North	6	Insignificant	Insignificant	Insignificant	Distance and landscape screening
URA012	3217	West	1	Insignificant	Insignificant	Insignificant	Distance and landscape screening
URA013	3223	West	13	Low	Insignificant	Insignificant	Distance and landscape screening
DFR043	3258	South	0	Nil			
GLE019	3304	North	0	Nil			
LEM001	3335	North	27	Low	Low	Low	Distance and landscape screening
GRD003	3337	East	0	Nil			
DFR035	3346	South	12	Low	Insignificant	Insignificant	Distance and landscape screening
URA014	3386	West	0	Nil			
29	3429	South	0	Nil			
WWJ019	3525	North	0	Nil			
GLE020	3541	North	0	Nil			
URA015	3571	West	12	Low	Insignificant	Insignificant	Distance and landscape screening
GLE023	3575	North	46	Low	Moderate	Low	Distance and landscape screening

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DFR046	3586	South	0	Nil			
GRD007	3590	East	0	Nil			
GLE021	3639	North	23	Low	Low	Low	Distance and landscape screening
GRD006	3671	East	0	Nil			
GLE022	3706	North	0	Nil			
GRD013	3707	East	0	Nil			
GRD009	3714	East	1	Insignificant	Insignificant	Insignificant	Distance and landscape screening
DFR056	3729	East	0	Nil			
DFR044	3734	South	1	Insignificant	Insignificant	Insignificant	Distance and landscape screening
WWJ018	3759	West	0	Nil			
DFR045	3811	East	1	Insignificant	Insignificant	Insignificant	Distance and landscape screening
GRD001	3821	East	2	Insignificant	Insignificant	Insignificant	Distance and landscape screening
GRD014	3832	East	0	Nil			
DFR057	3848	East	0	Nil			
DFR039	3853	South	45	Low	Moderate	Low	Possible views, but distant and vegetation screening
90	3865	South	0	Nil			
GRD011	3889	East	0	Nil			
DFR047	3890	East	0	Nil			
49	3900	West	0	Nil			

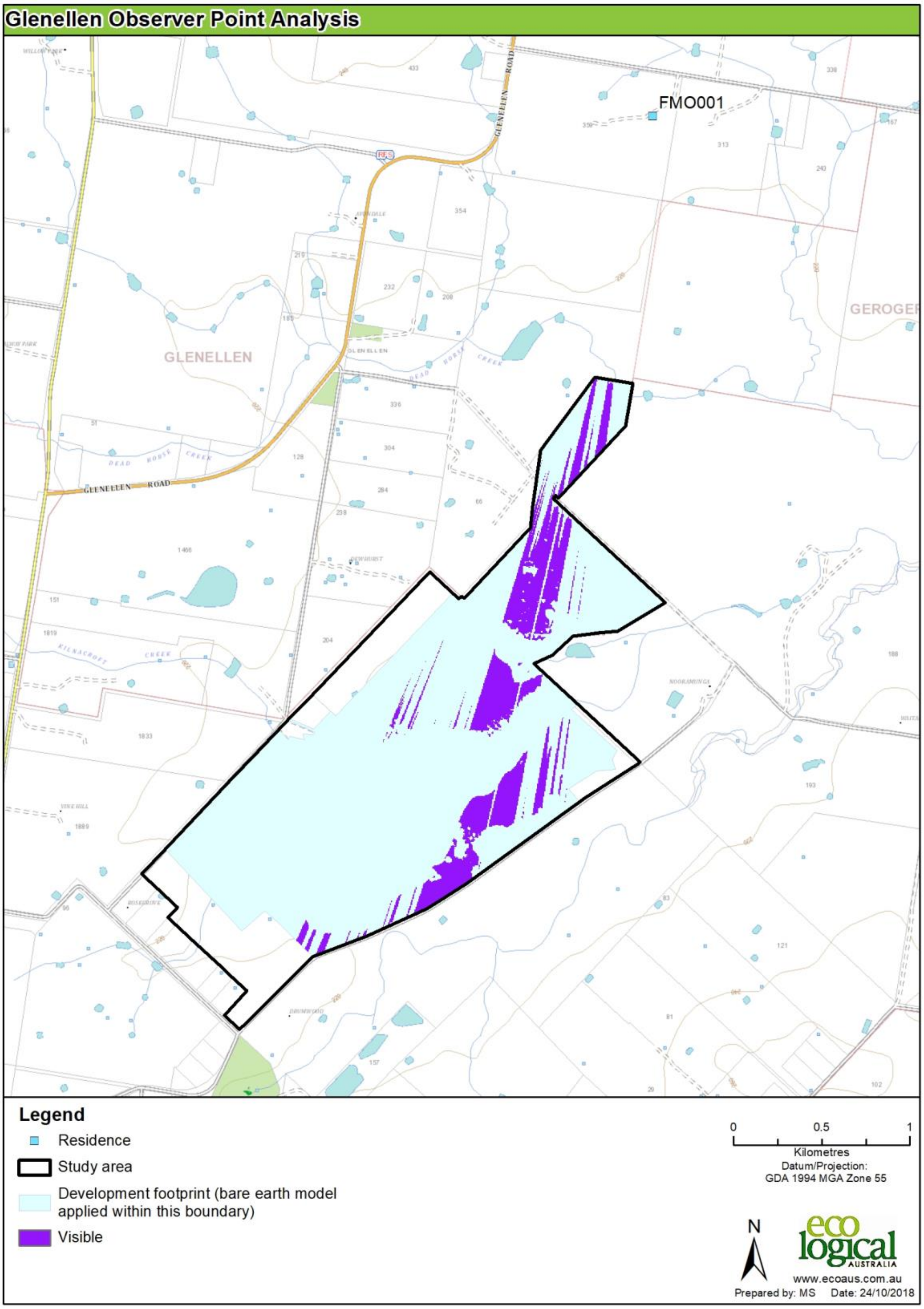
ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
DFR055	3925	East	0	Nil			
GRD012	3929	East	0	Nil			
DFR061	3945	East	0	Nil			
48	3985	West	0	Nil			
GRD004	3996	North	0	Nil			
114	4015	North	20	Low	Low	Low	Not assessed
GRD008	4051	East	0	Nil			
113	4056	North	23	Low	Low	Low	Not assessed
116	4060	North	22	Low	Low	Low	Not assessed
91	4076	South	0	Nil			
GRD010	4080	East	0	Nil			
DFR060	4090	East	0	Nil			
115	4102	North	0	Nil			
DFR062	4143	East	4	Insignificant	Insignificant	Insignificant	Distance and landscape screening
74	4150	North	0	Nil			
73	4179	North	21	Low	Low	Low	Not assessed
119	4199	North	0	Nil			
132	4201	North	0	Nil			
72	4227	North	0	Nil			

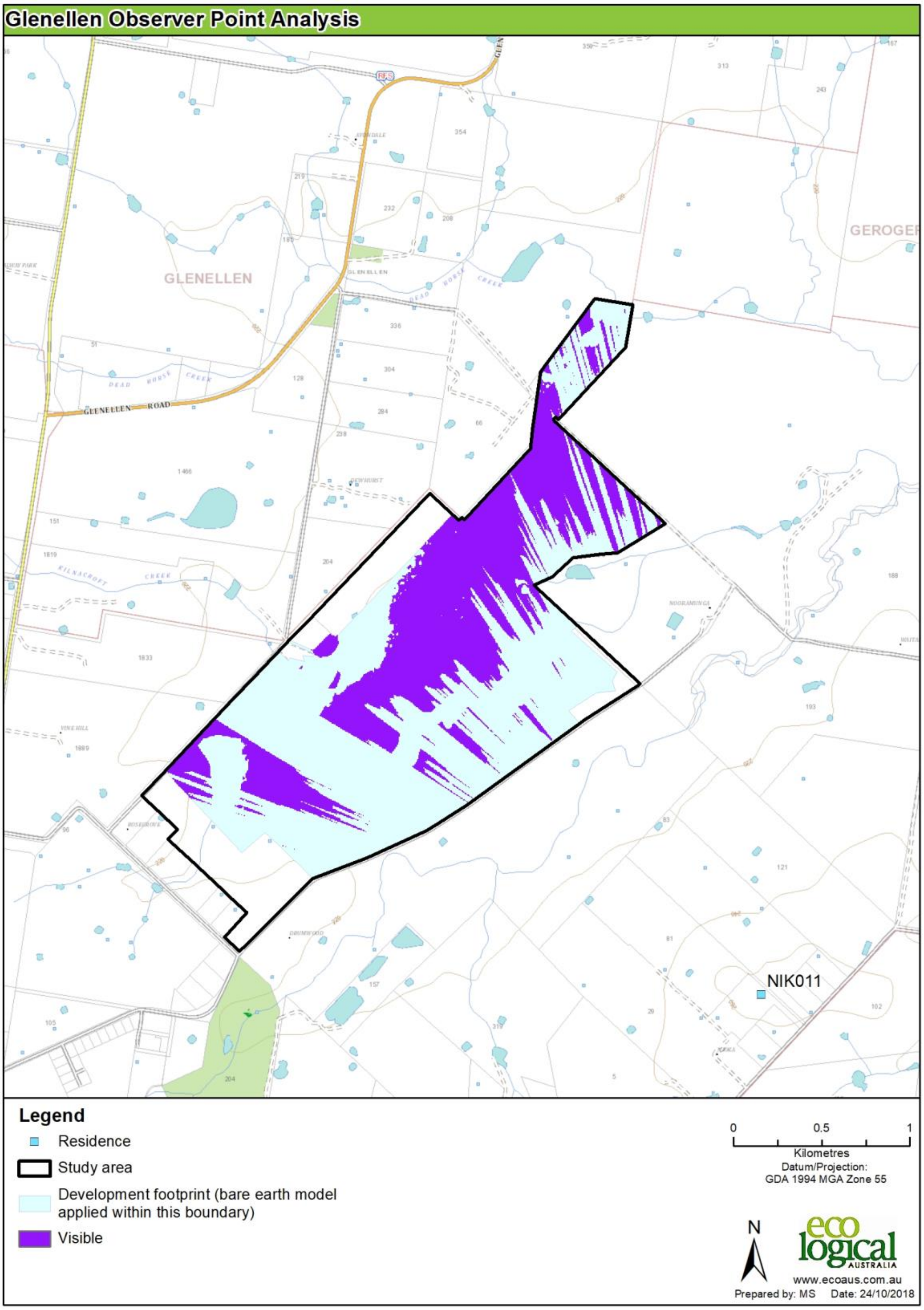
ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
204	4248	North	0	Nil			
134	4270	North	0	Nil			
202	4284	North	1	Insignificant	Insignificant	Insignificant	Not assessed
203	4284	North	0	Nil			
120	4286	North	0	Nil			
DFR059	4304	East	0	Nil			
117	4312	North	0	Nil			
118	4336	North	0	Nil			
92	4349	South	0	Nil			
123	4355	North	0	Nil			
130	4361	North	0	Nil			
135	4377	North	0	Nil			
DFR058	4387	East	0	Nil			
121	4396	North	0	Nil			
131	4401	North	0	Nil			
70	4410	North	0	Nil			
GRD005	4414	North	0	Nil			
GRD015	4416	East	0	Nil			
DFR063	4430	East	1	Insignificant	Insignificant	Insignificant	Distance and landscape screening

ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
124	4434	North	0	Nil			
122	4442	North	0	Nil			
PRY006	4448	East	0	Nil			
187	4462	South	0	Nil			
50	4463	West	0	Nil			
127	4494	North	0	Nil			
136	4530	North	0	Nil			
138	4537	North	0	Nil			
191	4539	South	0	Nil			
125	4545	North	0	Nil			
137	4549	North	0	Nil			
188	4556	South	0	Nil			
186	4557	South	0	Nil			
129	4588	North	0	Nil			
1	4591	South	2	Insignificant	Insignificant	Insignificant	Not assessed
126	4601	North	0	Nil			
189	4632	South	0	Nil			
190	4656	South	0	Nil			
205	4663	North	0	Nil			

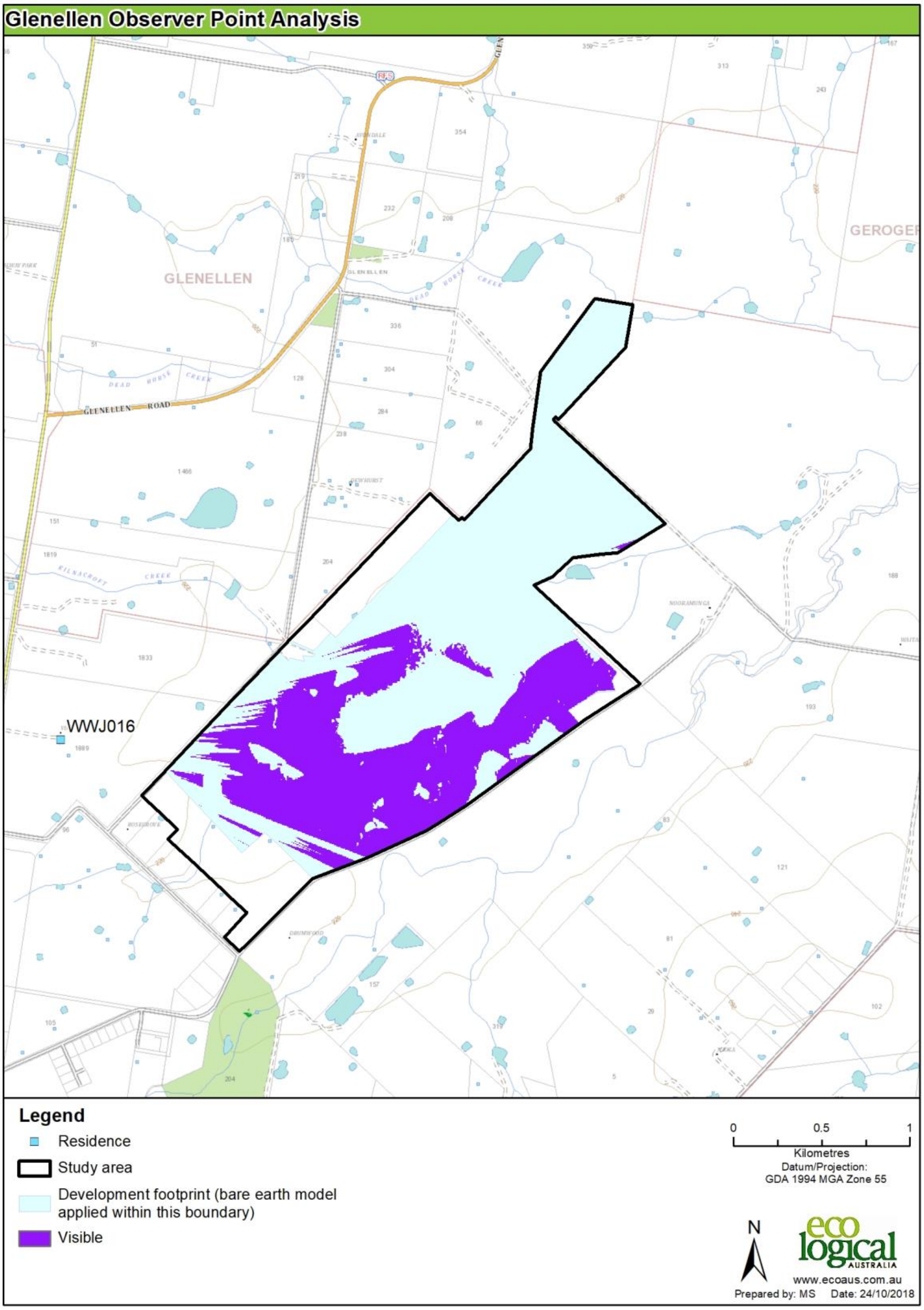
ID code	Distance to GSF (m)	Direction from GSF	Percent of GSF visible	Visual sensitivity	Magnitude of change	Visual Amenity Impact	Site investigation comments
128	4664	North	0	Nil			
GRD016	4701	East	0	Nil			
PRY007	4702	East	0	Nil			
19	4791	South	0	Nil			
PRY001	4803	East	0	Nil			
URA017	4809	West	0	Nil			
185	4855	South	0	Nil			
SAR004	4857	East	0	Nil			
27	4862	South	0	Nil			
URA018	4867	West	0	Nil			
28	4870	South	0	Nil			
26	4883	South	0	Nil			
17	4913	South	0	Nil			
184	4935	South	0	Nil			
GRD019	4956	East	0	Nil			
18	4990	South	0	Nil			

Appendix B – Development visibility from selected viewpoints





Glenellen Observer Point Analysis
GLENELLEN
GEROGERY
GLENELLEN ROAD
DEAD HORSE CREEK
NIK011
Legend
Residence
Study area
Development footprint (bare earth model applied within this boundary)
Visible
0
0.5
1
Kilometres
Datum/Projection:
GDA 1994 MGA Zone 55
N
eco logical AUSTRALIA
www.ecoaus.com.au
Prepared by: MS
Date: 24/10/2018


Glenellen Observer Point Analysis
GLENELLEN
GEROGERY
GLENELLEN ROAD
DEAD HORSE CREEK
KILNACROFT CREEK
WWJ016
Legend
Residence
Study area
Development footprint (bare earth model applied within this boundary)
Visible
0
0.5
1
Kilometres
Datum/Projection:
GDA 1994 MGA Zone 55
N
www.ecoaus.com.au
Prepared by: MS
Date: 24/10/2018

Appendix C – Public Viewpoint Sensitivity Assessment

The road length within 5 km with potential views of the Proposed Development is based on the bare earth ZVI (the surface model ZVI results are in brackets). The % amount of the farm visible will differ along the road. Any visibility (> 0) has been included.

Viewpoint	Distance from Site	Viewpoint description and potential visibility of the Proposed Development	Viewpoint sensitivity assessment
Drumwood Road	0 m	• Passes immediately alongside PV array areas. • Proximate views of PV array in south.	• Number of viewers – Very low • Road length within 5 km with potential views – 4900 m (1146 m) • Period of view – Short term • Viewpoint sensitivity - **Low**
Ortlipp Road	0 m	• Passes immediately alongside PV array areas. • Passes Substation and main Site entrance. • Proximate views of northern PV arrays.	• Number of viewers – Low • Road length within 5 km with potential views – 3332 m (1529 m) • Period of view – Short term • Viewpoint sensitivity – **Low**
Blight Road West	0 m	• Paper road passes immediately alongside PV array areas in the north.	• Number of viewers – Very low • Road length within 5 km with potential views – 2499 m (1353 m) • Period of view – Short term • Viewpoint sensitivity - **Insignificant**
Lindner Road	200 m	• Proximate views of southern PV arrays.	• Number of viewers – Low • Road length within 5 km with potential views – 1862 m (145 m) • Period of view – Short term • Viewpoint sensitivity – **Low**
Walla Walla Jindera Road	1,000 m	• Proximate views of western PV arrays.	• Number of viewers – Medium • Road length within 5 km with potential views – 6665 m (727 m) • Period of view – Short term • Viewpoint sensitivity – **Low**
Blight Road East	1,100 m	• Distant glimpses may be possible from higher points of Blight Road East to arrays.	• Number of viewers – Very low • Road length within 5 km with potential views – 1941 m (284 m) • Period of view – Short term • Viewpoint sensitivity - **Insignificant**

Glenellen Road	1,100 m	• Distant glimpses may be possible from higher points of Glenellen Road to arrays.	• Number of viewers – Low • Road length within 5 km with potential views – 5055 m (695 m) • Period of view – Short term • Viewpoint sensitivity - **Insignificant**
Dights Forest Road	1,600 m	• Distant glimpses may be possible from higher points of Dights Forest Road to arrays.	• Number of viewers – Low • Road length within 5 km with potential views – 4764 m (229 m) • Period of view – Short term • Viewpoint sensitivity – **Insignificant**
Urana Road	2,300 m	• Distant glimpses may be possible from higher points of Urana Road to southern arrays.	• Number of viewers – Medium • Road length within 5 km with potential views – 7826 m (348 m) • Period of view – Short term • Viewpoint sensitivity – **Insignificant**
Gerogery Road	3,400 m	• Distant glimpses may be possible from higher points of Gerogery Road to arrays.	• Number of viewers – Low • Road length within 5 km with potential views – 2925 m (445 m) • Period of view – Short term • Viewpoint sensitivity - **Insignificant**

Appendix D – Glint and Glare Assessment

PAGERPOWER
Urban & Renewables

Solar Photovoltaic Glint and Glare Study

Eco Logical Australia
Glenellen Solar Farm

November, 2018

ADMINISTRATION PAGE

Job Reference:	9283A
Date:	August, 2018
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Reviewer:	Mike Watson
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Issue	Date	Detail of Changes
1	August, 2018	Initial issue
2	September, 2018	Second issue – inclusion of aviation discussion
3	November, 2018	Third issue – further revisions

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EXECUTIVE SUMMARY

Report Purpose

Pager Power has been retained to assess the possible effects of glint and glare from the proposed Glenellen Solar Farm to be located near Jindera in New South Wales, Australia. This assessment pertains to the possible impact upon of glint and glare upon surrounding roads and dwellings. The impacts upon aviation have also been considered at a high-level.The modelling[1] has considered a single axis tracker. Various configurations have been considered within the overall assessment.

Pager Power

Pager Power has undertaken over 300 glint and glare assessments in locations such as Australia, India and Europe. The company's own glint and glare guidance is based on industry experience and extensive consultation with industry stakeholders including airports and aviation regulators.

Guidance

There is limited glint and glare guidance for the assessment of proposed solar photovoltaic (PV) developments. Pager Power's methodology is based on independent studies, consultation with stakeholders and experience.

Glint and Glare

The definition of glint and glare used by Pager Power is as follows:

- Glint – a momentary flash of bright light;
- Glare – a continuous source of bright light.

The reflections produced by solar panels are of intensity similar to or less than those produced from still water and significantly less than reflections from glass and steel[2].

Results

The predicted impacts are not significant. Reflections towards observers within the surrounding dwellings or the nearby main road (Walla Walla Jindera road) are judged to be acceptable based on the technical modelling and the recommended approach for determining impact significance (see Section 6 and the report appendices).

[1] Pager Power has utilised its own proprietary software and external modelling software for the analysis, see Section 3.

[2] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

Technical Findings – Surrounding Main Roads

Solar reflections are theoretically possible towards approximately 0.4km of Walla Walla Jindera Road[3]. The impact is not significant because:

- Reflections would occur from a bearing more than 50 degrees beyond the direction of travel. This means a driver looking straight ahead would not be looking towards a reflecting panel. Reflections under these conditions are considered acceptable for pilots landing aircraft based on the most applicable guidance (see Section 3).
- Effects would be fleeting for an observer in a moving vehicle.
- Views of the solar panels are likely to be partially obscured by intervening vegetation and buildings.

The above conclusions are applicable to any layout or choice of tracker system that utilises flat panels within the assessed footprint. The modelling results do not change significantly for alterations in azimuth angle within approximately 10 degrees[4].

Technical Findings – Surrounding Dwellings

Visible solar reflections are predicted towards one dwelling to the east of the proposed development, and another two to the southwest of the development. In reality reflections could be observed from other dwellings adjacent to the development area because at close range, small changes in terrain elevation can impact the likelihood of a visible reflection occurring. Furthermore, if the panel configuration, elevation or tracker system details were changed significantly, the modelling results would be likely to change. It is likely that approximately 10 dwellings could experience effects. The impact is not significant because:

- The predicted effects would typically last for no more than 15 minutes on any individual day.
- Effects would largely coincide with direct sunlight, such that an observer looking towards a reflecting panel would also be looking towards the Sun. Direct sunlight is significantly more intense than a reflection from a solar panel.
- Views of the reflecting panels are likely to be partially obscured by vegetation between the observer and the panel area.

The above conclusions are applicable to any layout or choice of tracker system that utilises flat panels within the assessed footprint. The modelling results do not change significantly for alterations in azimuth angle within approximately 10 degrees.

---

[3] The assessment methodology considers main roads within 1 km of the panel boundaries. It is understood that roadside vegetation is generally providing good screening around the site.

[4] Azimuth angle is the direction the panels are 'facing'. A panel that is pointing directly north has an azimuth angle of 0 degrees. A panel that is pointing directly east has an azimuth angle of 90 degrees.

Aviation

The nearest aerodrome to the proposed development is Albury. It is more than 15 km south of the panel area. Its runway is aligned approximately east-west, such that an approaching pilot would not be looking towards the development area. Based on the separation distance, significant effects are not predicted. Consultation with the aerodrome could be undertaken for completeness.

Aviation concerns are most common with reference to aircraft approaching or departing an aerodrome (or helipad) because this is the most critical phase of flight. Aircraft overflying the development area in general are significantly less likely to be adversely affected. This is predominantly due to restricted views of a development directly beneath an aircraft and the fact that reflections from solar panels are of similar intensity to common outdoor reflectors such as water and windows.

Mitigation

No mitigation requirement has been identified due to the low ranking of impact significance. Any potential impacts could be reduced or removed by the provision of screening that shields the panel area from a receptor's view. Typically this would be in the form of planting at the site boundary with a height that is greater than that of the adjacent panels.

The developer is committed to creating vegetation buffers that will alleviate visual impacts on all roads. Where no visibility of the panels is available, there can be no glint and glare impacts.

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ABOUT PAGER POWER

Pager Power is a dedicated consultancy company based in Suffolk, UK. The company has undertaken projects in 44 countries within Europe, Africa, America, Asia and Australia.

The company comprises a team of experts to provide technical expertise and guidance on a range of planning issues for large and small developments.

Pager Power was established in 1997. Initially the company focus was on modelling the impact of wind turbines on radar systems. Over the years, the company has expanded into numerous fields including:

- Renewable energy projects.
- Building developments.
- Aviation and telecommunication systems.

Pager Power prides itself on providing comprehensive, understandable and accurate assessments of complex issues in line with national and international standards. This is underpinned by its custom software, longstanding relationships with stakeholders and active role in conferences and research efforts around the world.

Pager Power's assessments withstand legal scrutiny and the company can provide support for a project at any stage.

1 INTRODUCTION

1.1 Overview

Pager Power has been retained to assess the possible effects of glint and glare from the proposed Glennellen Solar Farm near Jindera located in New South Wales, Australia.

This assessment pertains to the possible effects upon surrounding roads and dwellings. This report contains the following:

- Solar farm details.
- Explanation of glint and glare.
- Overview of relevant guidance.
- Overview of relevant studies.
- Overview of Sun movement.
- Assessment methodology.
- Identification of receptors.
- Glint and glare assessment for identified receptors.
- Results discussion.
- Mitigation options.

Following this a summary of findings and overall conclusions and recommendations is presented.

1.2 Pager Power's Experience

Pager Power has undertaken over 300 Glint and Glare assessments internationally. The studies have included assessment of civil and military aerodromes, railway infrastructure and other ground-based receptors including roads and dwellings.

1.3 Understanding Glint and Glare – General Overview and Definition

When sunlight illuminates an object, an amount of the incident light is reflected. This reflected light, when directed towards the eye of an observer, can become noticeable and cause a distraction or a nuisance. The definition of glint and glare can vary. The definition used by Pager Power is as follows:

- Glint – a momentary flash of bright light.
- Glare – a continuous source of bright light.

In context, glint will be witnessed by moderate to fast moving receptors whilst glare would be encountered by static or slow-moving receptors with respect to a solar farm. The term 'solar reflection' is used in this report to refer to both reflection types i.e. glint and glare. Where reflected sunlight may be visible to a receptor, it can be concluded that glint and glare effects are possible.

2 PROPOSED SOLAR FARM LOCATION AND DETAILS

2.1 Photovoltaic Panel Mounting Arrangements and Orientation

The solar panels will be mounted to the ground and fitted to a single-axis tracking system that tilts the panels from east to west throughout the day. A single-axis tracking system has been modelled in this report, based on typical parameters set out in the following sub-section. High-level consideration of alternative configurations has been included to incorporate a level of flexibility in the site design.

2.2 Tracking System

The modelling has assumed that

- The azimuth angle of the panels will be 90 degrees in the morning and 270 degrees in the evening. During solar noon, when the Sun is directly overhead, the panels will be flat, directed immediately upwards.
- The tilt of the panels throughout the day is programmed, based on the known path of the Sun and shading considerations i.e. the tilt angle is optimised to avoid having one row of panels cast a shadow on another row.
- The range of elevation angles will be ±60°.

The system type is illustrated in Figure 1 below.

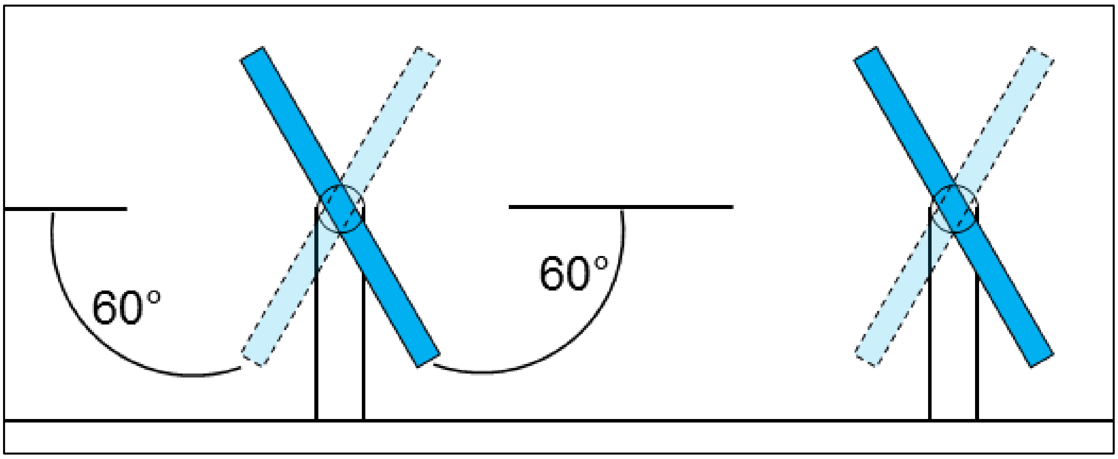


Figure 1 *Panel tracking details*

Shading considerations could also dictate the panel tilt. This is affected by:

- The elevation angle of the Sun.
- The vertical tilt of the panels.
- The spacing between the panel rows.

This means that early in the morning and late in the evening, the panels may not be directed exactly towards the Sun. Figure 2 below illustrates this.

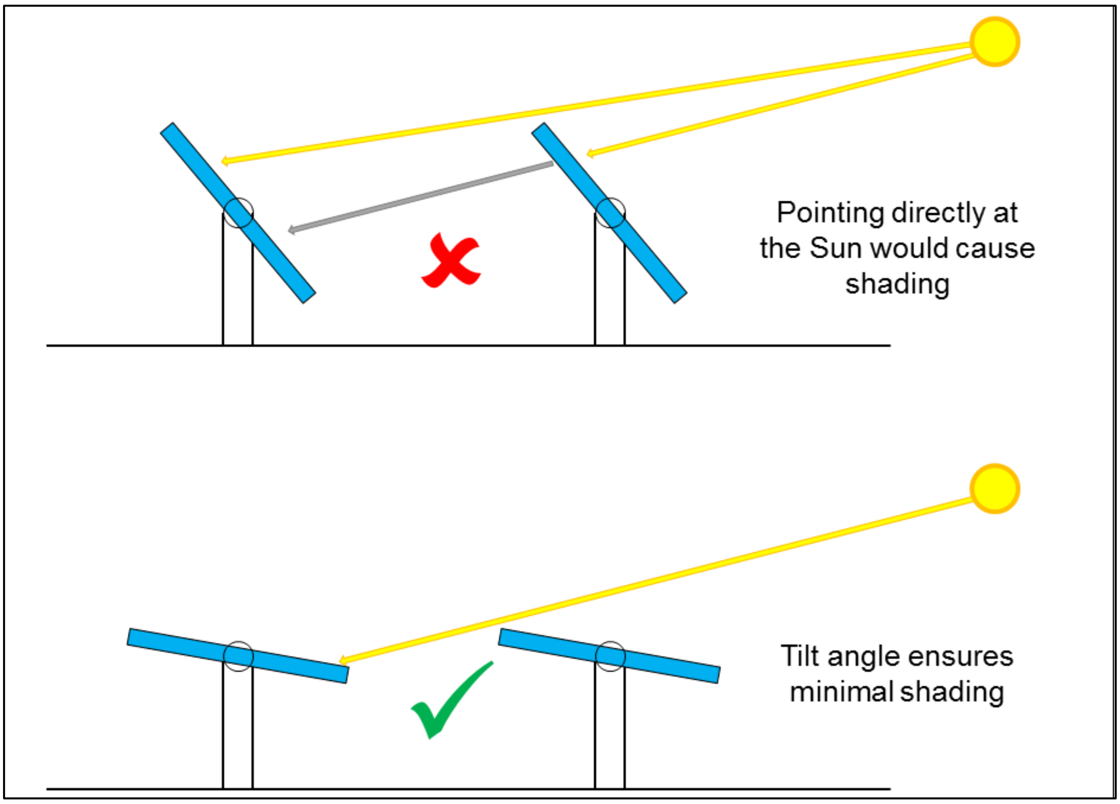


Figure 2 *Shading considerations*

Later in the day, the panels can be directed towards the Sun without any shading issues. This is illustrated in Figure 3 below.

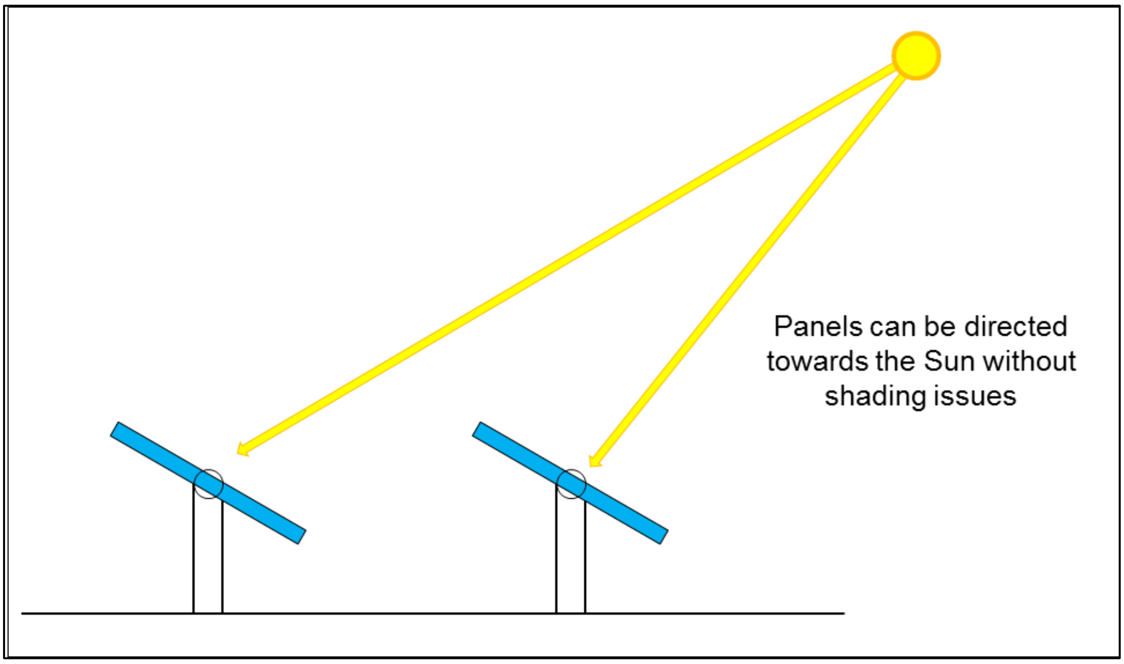


Figure 3 *Panel alignment at high solar angles*

In reality the lines from the Sun to each panel would be effectively parallel due to the large separation distance. The previous figures are for illustrative purposes only.

2.3 Proposed Solar Farm Panel Area

Figure 4 below[5] shows the proposed Solar Farm area (blue polygon).

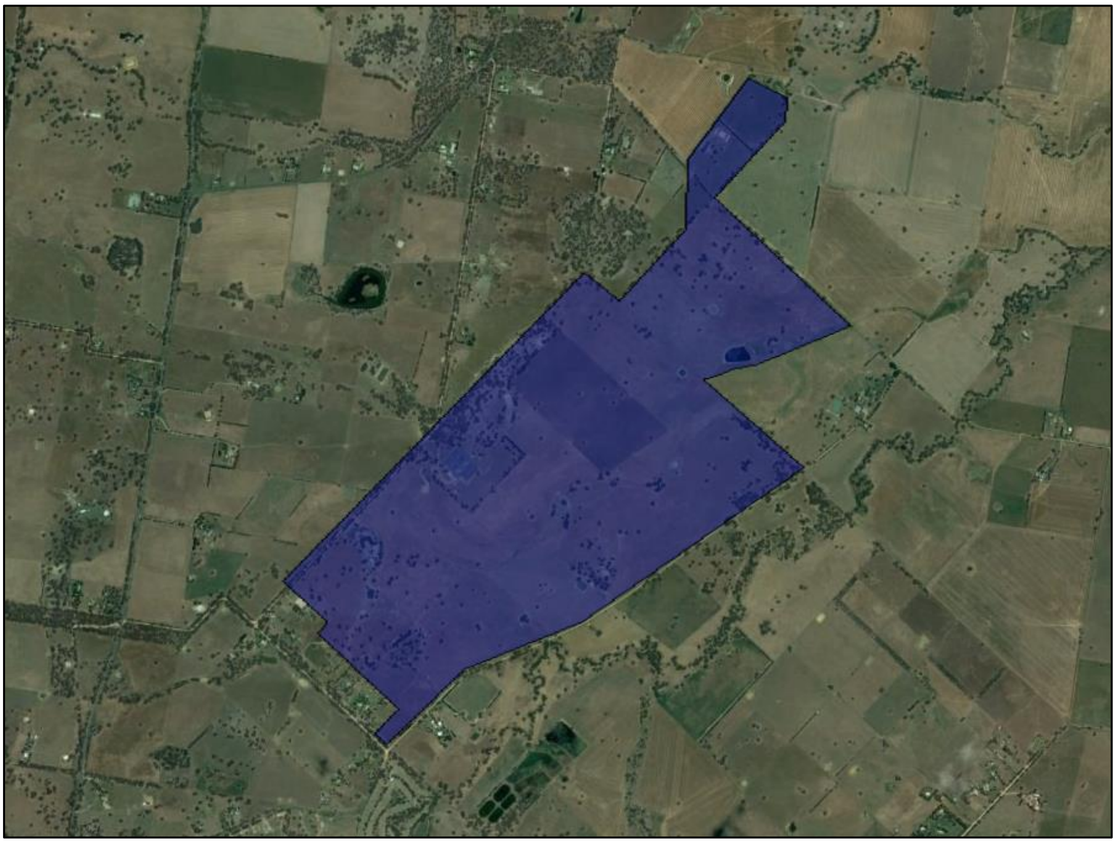


Figure 4 *Solar Farm Development Area*

The assessment has assumed that the entire area would contain panels, which will not be the case for the Proposed Development. In practice, the final design will only involve placing solar panels within the Development Footprint, an area smaller and within this Site. The assessment approach is intended to be conservative by presenting a worst-case scenario in the context of glare.

[5] © 2018 Google

3 GLINT AND GLARE ASSESSMENT METHODOLOGY

3.1 Guideline and Studies Overview

To the author's knowledge, there are no formal guidelines for examining the effect of solar reflections from solar panels with respect to residential amenity or road safety in Australia.

Established guidelines exist internationally, including in the UK (produced by the CAA[6]) and in the USA (produced by the FAA[7]) with respect to solar developments and aviation activity. Generic advice has also been provided within various local planning policies.

Pager Power's approach is informed by the available literature, stakeholder consultation and industry experience[8]. The approach is to identify receptors, undertake geometric reflection calculations using Pager Power's own bespoke glint and glare model, and then to compare against available solar panel reflection studies.

The available studies have measured the intensity of reflections from solar panels with respect to other naturally occurring and manmade surfaces. The overall conclusions from the available independent studies with regard to glint and glare issues from solar panels are as follows:

- Specular reflections of the Sun from solar panels are possible;
- The measured intensity of a reflection from solar panels can vary from 2% to 30% depending on the angle of incidence; and
- Published guidance shows that the intensity of reflections from solar panels are equal to or less than those from water. It also shows that reflections from solar panels are significantly less intense than many other reflective surfaces which are common in an outdoor environment such as those produced from glass and steel[9].

Appendix A and Appendix B present a review of relevant guidance and independent studies.

---

[6] Civil Aviation Authority.
[7] Federal Aviation Administration.
[8] Pager Power's assessment approach is detailed in full within a guidance document first published in 2017, available free of charge from the company website or on request.
[9] SunPower, 2009, SunPower Solar Module Glare and Reflectance (appendix to Solargen Energy, 2010).

3.2 Methodology

The overall approach to the assessment is presented below:

- Identify receptors in the area surrounding the proposed solar farm.
- Consider direct solar reflections from the proposed solar farm towards the identified receptors by undertaking geometric calculations – accounting for the tracker system.
- Consider the visibility of the panels from the receptor's location. If the panels are not visible from the receptor then no reflection can occur.
- Based on the results of the geometric calculations, determine whether a reflection can occur, and if so, at what time it will occur.
- Consider both the solar reflection from the proposed solar farm and the location of the direct sunlight with respect to the receptor's position.
- Consider the solar reflection with respect to the published studies and guidance.
- Determine whether a significant detrimental impact is expected.

Modelling has been undertaken using Pager Power's own software and a third-party modelling tool[10].

Further technical details relating to the methodology of the geometric calculations can be found in Appendix C whilst the impact significance criteria can be found in Appendix D.

3.3 Assessment Limitations

The list of assumptions and limitations are presented in Appendix E.

[10] Developed by ForgeSolar, designed to test solar farms for FAA compliance in the USA.

4 IDENTIFICATION OF RECEPTORS

4.1 Ground Level Receptors – Overview

There is no legal or formal guidance with regard to the maximum distance at which glint and glare should be assessed. There is also no technical limit to the distance at which reflections could occur.

However, the significance of a reflection decreases with distance. This is because the proportion of an observer's field of vision that is taken up by the reflecting area diminishes as the separation distance increases.

Terrain and shielding by vegetation are also more likely to obstruct an observer's view at longer distances.

A 1km buffer is therefore considered appropriate for glint and glare effects on ground-based receptors. This buffer zone has been determined and deemed appropriate considering existing studies, guidance and Pager Power's assessment experience.

All terrain elevations are based on interpolated SRTM[11] data.

4.2 Modelling Overview

Figure 5 on the following page[12] shows the assessed solar panel areas that have been used for modelling purposes within the Pager Power model. Coordinate data for the boundary points is shown in Appendix F.

Only solar panels within 1.5km have been modelled for each individual receptor. The number of assessed panel locations is appropriate for providing a reliable result. An increased resolution would not change the overall results significantly. Use of the third-party model for comparison provides further reliability to the overall results.

---

[11] Shuttle Radar Topography Mission – this was an international research project that has provided almost worldwide digital elevation data using radar signals from space.

[12]© 2018 Google

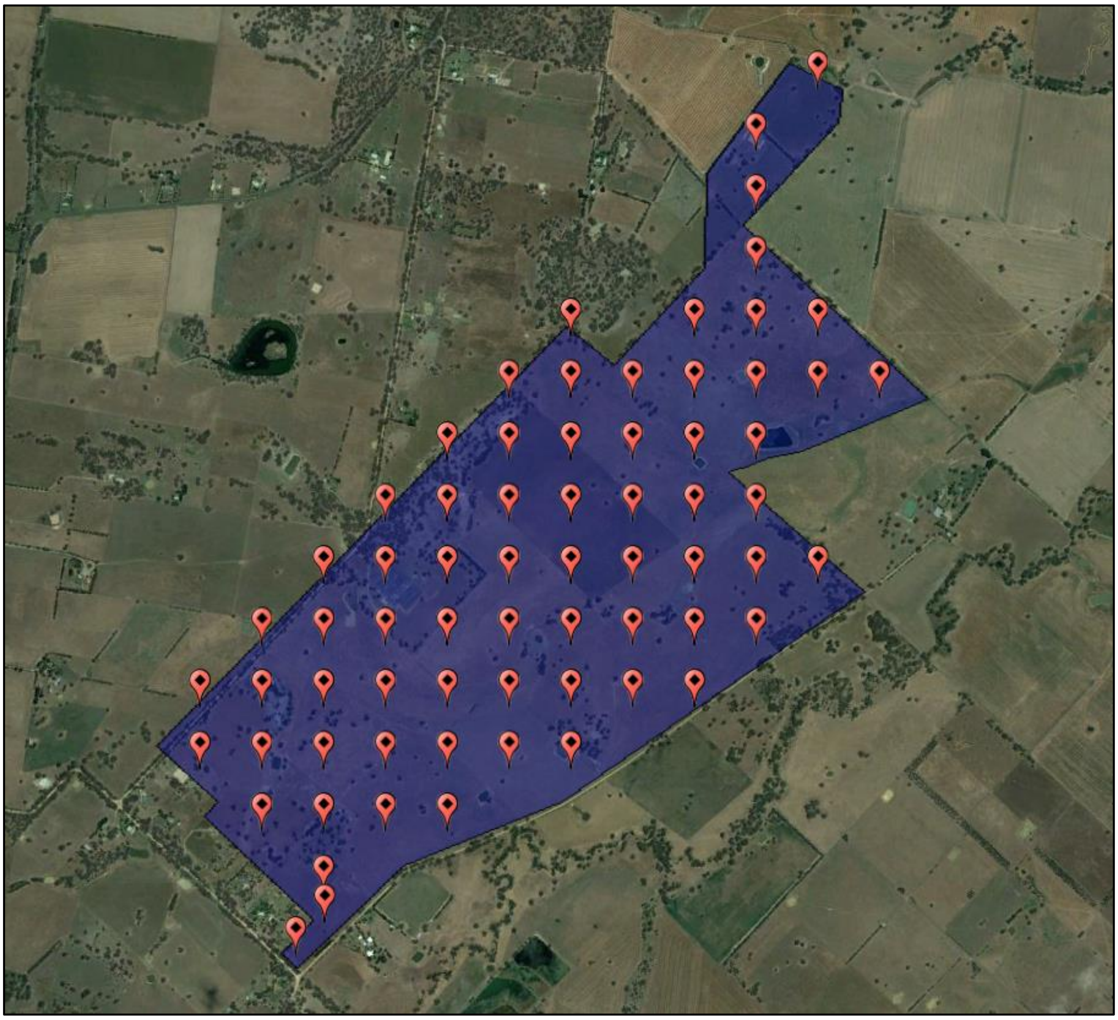


Figure 5 *Modelled points within the solar farm (Pager Power model)*

4.3 Main Road Receptors

The most significant road that passes within 1 km of the site boundary is the Walla Walla Jindera road. The other roads in the area are considered 'local'. Reflections towards local roads are not considered significant because traffic volumes and speeds would be generally low.

Receptor points for the stretch of road within 1 km of the site boundary have been spaced at 100 metre intervals. Figure 6 below[13] shows the assessed points relative to the site.

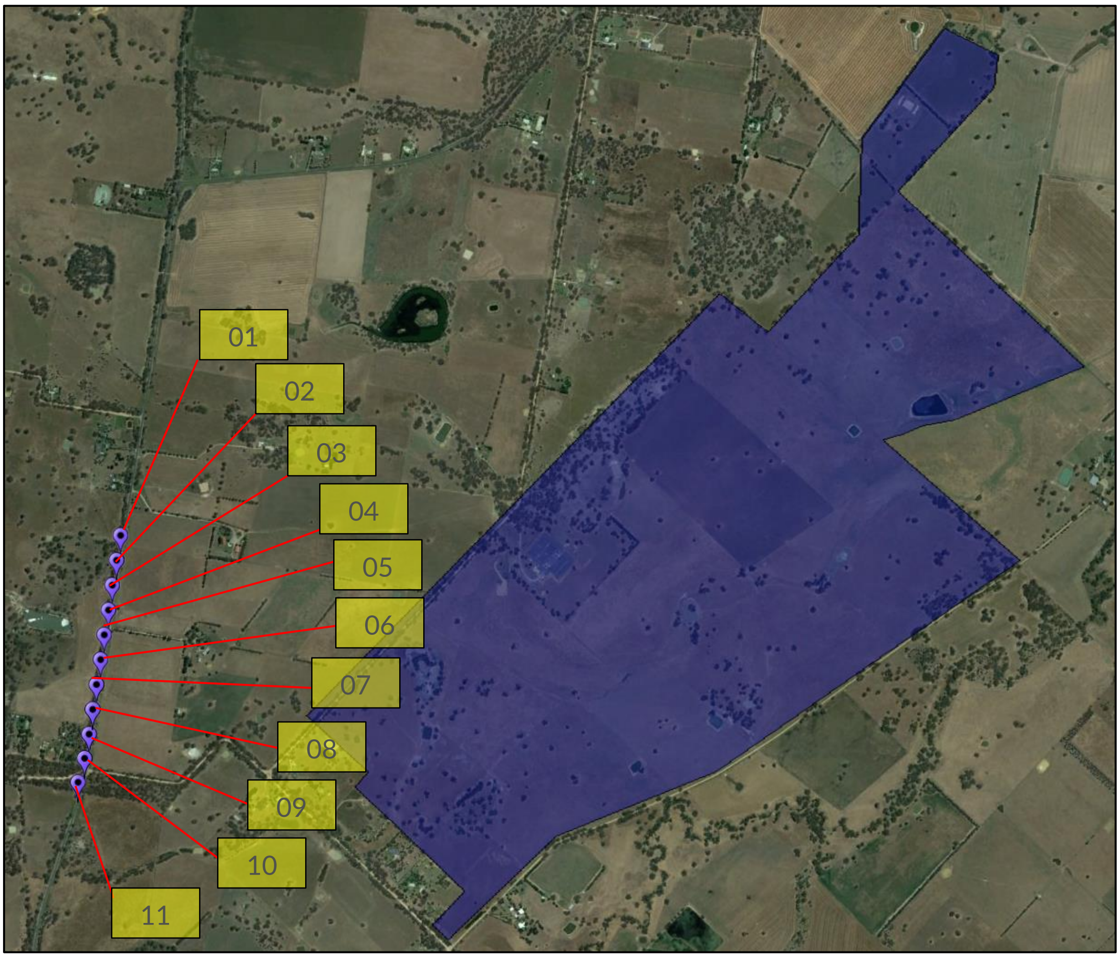


Figure 6 *Road receptors*

The co-ordinates of the assessed roads are presented in Appendix F.

[13] © 2018 Google

4.4 Dwelling Receptors

Potential dwelling receptors have been identified[14] within one kilometre of the proposed solar farm. These dwellings are shown in the Figure 7 below[15].

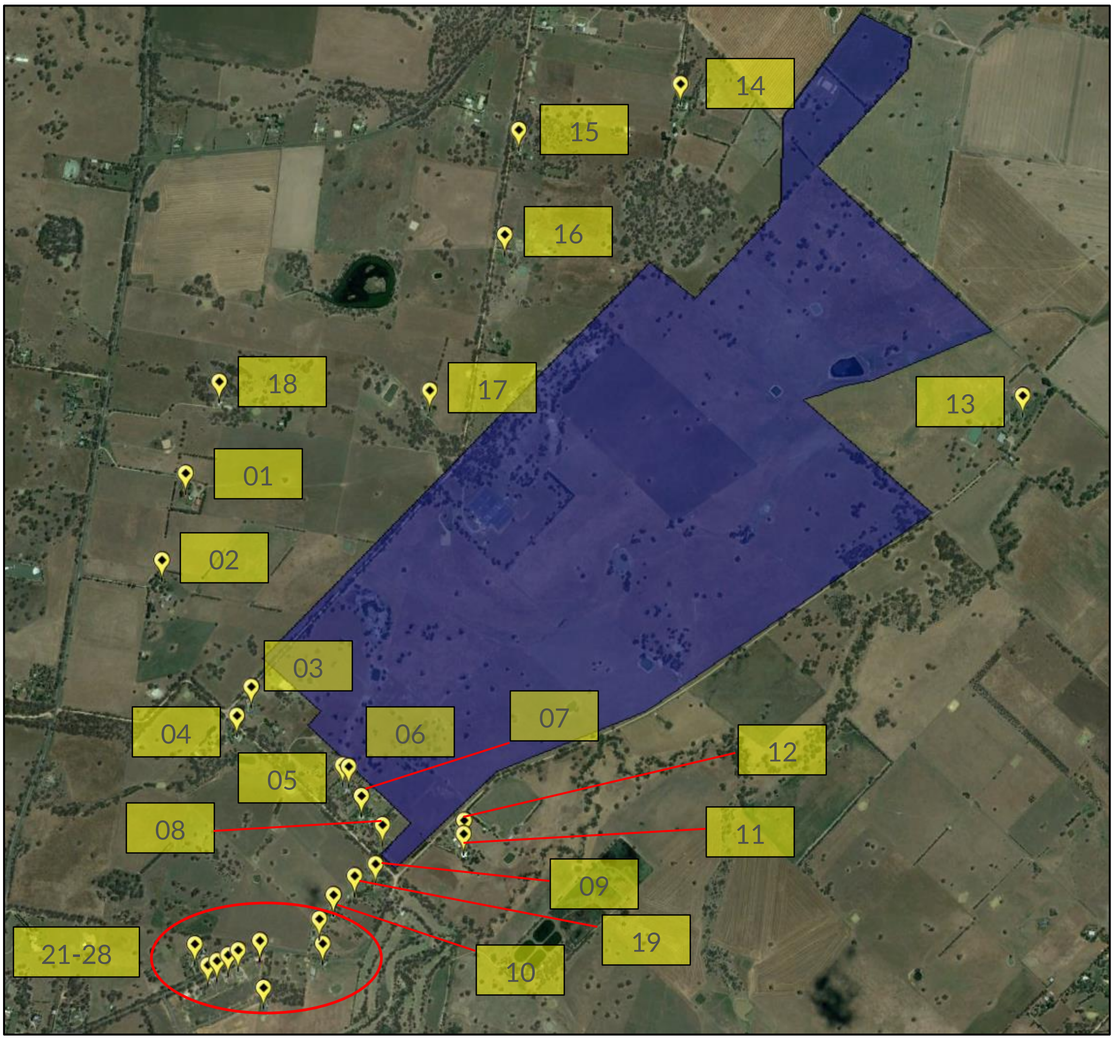


Figure 7 *Dwelling receptors*

The co-ordinates of the assessed dwellings are presented in Appendix F.

[14] Identified based on available imagery. Where the function of the building could not be determined it was assessed as a dwelling to remain conservative.

[15] ©2018 Google

4.5 Aviation Receptors

The nearest aerodrome to the proposed development is Albury. It is more than 15 km south of the panel area.

Its runway is aligned approximately east-west, such that an approaching pilot would not be looking towards the development area. This is significant because the FAA guidance stipulates that reflections from more than 50 degrees (horizontally) outside a pilots view are not significant.

Based on the separation distance, significant effects are not predicted. Detailed modelling of reflections towards aviation receptors is not considered a requirement and has not been undertaken.

Consultation with the aerodrome could be undertaken for completeness.

Aviation concerns are most common with reference to aircraft approaching or departing an aerodrome (or helipad) because this is the most critical phase of flight. Aircraft overflying the development area in general are significantly less likely to be adversely affected. This is predominantly due to restricted views of a development directly beneath an aircraft and the fact that reflections from solar panels are of similar intensity to common outdoor reflectors such as water and windows.

4.6 Evaluating Potential Changes

The Pager Power model calculates the angular separation between a reflection and the line from the observer to the reflecting panel. This is illustrated in Figure 8 below.

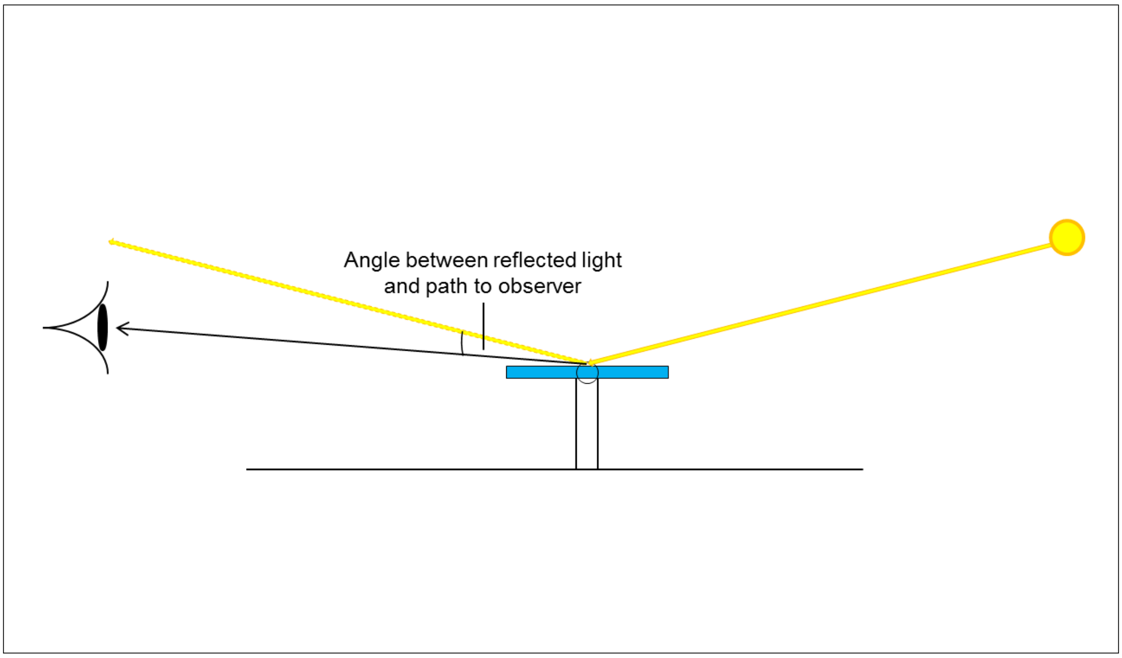


Figure 8 *Calculating reflections*

It can be seen that if the angle is zero, the observer will experience a direct reflection. Angles above zero indicate that the reflection will pass over the observer, and no reflection would be experienced.

It is important to remember that:

- The Sun is not a point source, but has an angular size of approximately 0.5 degrees as seen from Earth.
- The receptor height above ground level is based on a typical value (1.5 metres for road users and 1.8 metres for dwellings). In practice this may vary by, typically[16], one or two metres.
- The terrain height above mean sea level is based on a database, and may vary in practice by a few metres.
- The modelling considers the representative panel locations only (approximately 250 metres separation).

To accommodate for the above, the model identifies scenarios where the separation angle illustrated in Figure 8 is up to 10 degrees (in some cases higher). This is done to better understand the extent to which elevation differences may affect the results.

[16] e.g. due to an observer on an upper floor.

5 GLINT AND GLARE ASSESSMENT

5.1 Results

Tables 1 and 2 in the following subsections summarise the months and times during which a solar reflection is predicted for a receptor.

Times are in GMT+10 which is the local time at the development location.

All results are based on SRTM elevations, a fixed height above ground for each observer and the tracker system parameters defined in Section 2. Further commentary regarding the effect of possible variations is presented in Section 6.

Appendix G presents the detailed modelling output in cases where effects are possible – the charts displayed are from the third-party model.

5.2 Results – Roads

The results of the geometric calculations for the road users are presented in Table 1 below.

Receptor	Results		Screening remarks
	Approximate reflections times (GMT+10)		
	am	pm	
1-3	None.	None.	N/A
4-8	Between 04:50 and 08:00 throughout the year for up to 10 minutes per day.	None.	The reflections would be predominantly from the southwestern portion of the panel area but also from other panels throughout the site. It is likely that views of the panels would be partially obscured from view by terrain undulations and existing vegetation.
9-11	None.	None.	N/A

Table 1 *Analysis results for road users*

5.3 Results – Dwellings

The result of the geometric calculations for the dwelling receptors are presented in Table 2 below.

Receptor	Pager Power Results		Comment
	Approximate reflections times (GMT+10)		
	am	am	
1	None.	None.	N/A
2	Between 04:50 and 08:00 throughout the year for up to 15 minutes per day.	None.	The reflections would be from various sections within the panel area, most often from the western portion. It is possible that terrain undulations and existing vegetation would significantly restrict the view of the panel area from this location. This cannot be conclusively determined based on the available imagery.
3-8	None.	None.	N/A
9	Between 07:00 and 08:00 for parts of May-July for up to 10 minutes per day.	None.	The reflections would be from the extreme southern portion of the development area. It is likely that views of the panels would be partially obscured by trees to the north of the dwelling.
10-18	None.	None.	N/A

Receptor	Pager Power Results		Comment
	Approximate reflections times (GMT+10)		
	am	am	
19	Between 07:00 and 08:00 for parts of May-July for up to 5 minutes per day.	None.	The reflections would be from the extreme southern portion of the development area. It is likely that views of the panels would be partially obscured by trees to the northeast of the dwelling.
20-28	None.	None.	N/A

Table 2 *Analysis results for dwellings*

6 RESULTS AND DISCUSSION

6.1 Road Results

Effects are predicted for approximately 400 metres of Walla Walla Jindera road. The potentially affected stretch of road is shown in Figure 9 below[17] (orange line).

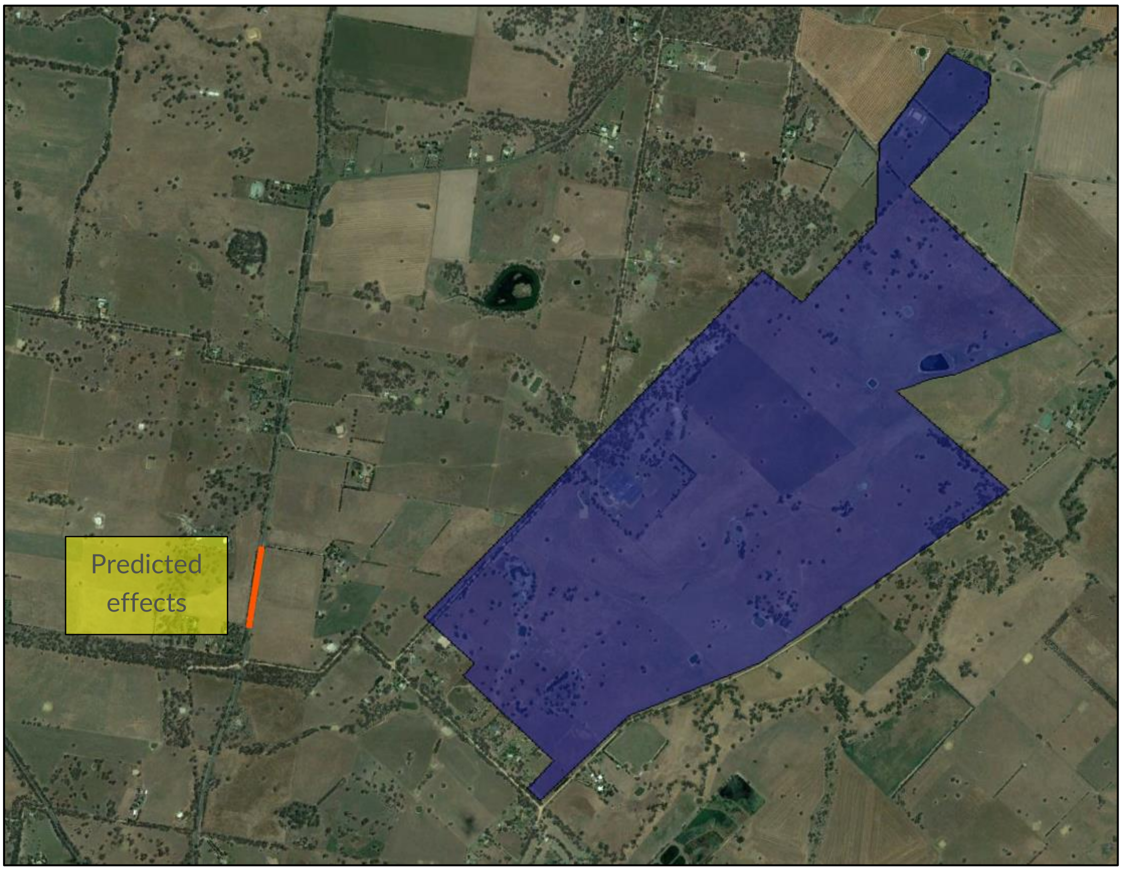


Figure 9 *Potentially affected stretch of road*

When evaluating the significance of a reflection towards a road user it is important to consider:

1. The duration of the effect.
2. The type of road – which affects the levels of traffic and vehicle speeds that can be reasonably expected.
3. The location of the reflection relative to the direction of travel.

[17] ©2018 Google

In the case of the proposed development:

i) Any reflection would be fleeting for a moving receptor.

ii) Walla Walla Jindera Road is a main road connecting the towns of Walla Walla and Jindera. Traffic speeds are limited to 100 km/h and traffic volumes are likely to be relatively low.

iii) Reflections would occur from the east – at a bearing outside the direction of travel by more than 50 degrees. For context purposes, it is relevant that the FAA in the USA deems reflections from beyond 50 degrees to be acceptable for pilots on final approach to a runway.

The potential impact on the Walla Walla Jindera Road is considered moderate because reflections are possible towards a national road, but do not occur under worst case conditions (due to the fleeting nature and the position of the reflector off to one side. Consequently, mitigation is not a requirement but could be considered.

6.2 Mitigation – Roads

The most appropriate mitigation option would be the provision of planting that removes or reduces the visibility of the panels from the potentially affected stretch of road. Mitigation is considered an unlikely requirement in practice, predominantly due to the relative position of the solar development and observers on the road.

The developer is committed to creating vegetation buffers that will alleviate visual impacts on all roads.

6.3 Dwelling Results

The analysis has identified potential reflections towards three dwelling locations. These are shown in Figure 10 below[18].

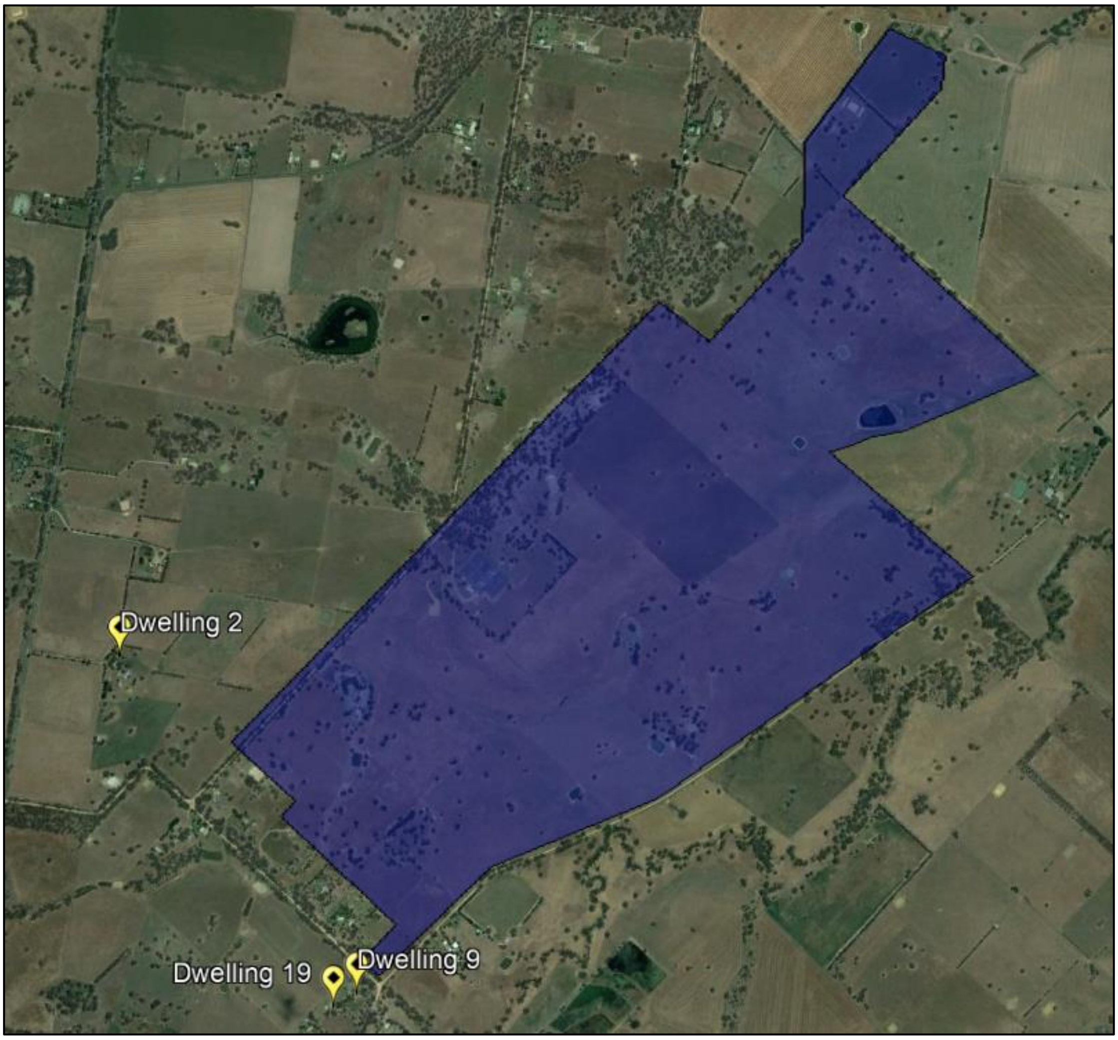


Figure 10 *Dwellings with predicted reflections*

It is generally the case that dwellings that are adjacent to one another stand to experience similar effects from a given development. The modelling results do not show impacts for dwellings adjacent to those identified in Figure 10 predominantly because:

- Small differences in elevation, for the panel or the receptor location, can cause significant differences for observers that are close to the reflectors.
- The terrain elevation in general varies quite significantly around the site (Dwelling 1 and Dwelling 2 are separated by less than 400 metres horizontally, however the terrain elevation changes by more than 9 metres).

[18] ©2018 Google

There are inherent accuracy limitations for desk-based analysis, including the values of terrain elevation. In addition, changes to the array azimuth and/or choice of tracker system could affect the results. The level of backtracking to avoid shading, for example, affects how 'flat' the panels are when the Sun is low in the sky.

Overall, it is considered that the dwellings nearest the site boundary (e.g. Dwellings 3-8, 11 and 12) could experience effects, due to their proximity and the level of uncertainty around some parameters[19].

Overall, it is likely the number of affected dwellings would be less than 10. Effects at the surrounding dwellings would likely be similar to those predicted for Dwellings 9 and 2.

Unmitigated, solar reflections are predicted to last for up to 15 minutes on any one day at any one location and only from windows with a clear view of the reflecting solar panels. Solar reflections would only occur on days when the weather is clear and sunny.

The potential reflections would last for more than three months a year but less than 60 minutes per day. In accordance with the methodology set out in Appendix D (for dwellings), the resulting impact significance is low to moderate. Consequently, mitigation is not a requirement but could be considered.

6.4 Mitigation – Dwellings

The most appropriate mitigation option would be the provision of planting that removes or reduces the visibility of the panels from the potentially affected dwellings. This is potentially relevant for the dwellings nearest the southern boundary of the panel area.

6.5 Changes in Azimuth

Sample crosschecks were carried out for potentially affected receptors considering a change in array azimuth angle of 10 degrees (either direction).

The change in azimuth angle does not lead to significant changes in the modelling output. Consequently, adjustments of this scale are not considered material with regard to the conclusions of this analysis.

[19] In particular potential variations in terrain elevation, height of existing vegetation and presence of first floor windows.

7 OVERALL CONCLUSIONS

7.1 Road Impacts

Solar reflections are theoretically possible towards approximately 0.4km of Walla Walla Jindera Road. The impact is not significant because:

- Reflections would occur from a bearing more than 50 degrees beyond the direction of travel. This means a driver looking straight ahead would not be looking towards a reflecting panel.
- Effects would be fleeting for an observer in a moving vehicle.
- Views of the solar panels are likely to be partially obscured by intervening vegetation and built structures.

The above conclusions are applicable to any layout or choice of tracker system that utilises flat panels within the assessed footprint.

The developer is committed to creating vegetation buffers that will alleviate visual impacts on all roads.

7.2 Dwelling Impacts

Visible solar reflections are predicted towards one dwelling to the east of the proposed development, and another two to the southwest of the development. In reality reflections could be observed from other dwellings adjacent to the development area because at close range, small changes in terrain elevation can impact the likelihood of a visible reflection occurring. Furthermore, if the panel configuration, elevation or tracker system details were changed significantly, the modelling results could be altered. It is likely that approximately 10 dwellings could experience effects. The impact is not significant because:

- The predicted effects would typically last for no more than 15 minutes on any individual day.
- Effects would largely coincide with direct sunlight, such that an observer looking towards a reflecting panel would also be looking towards the Sun.
- Views of the reflecting panels are likely to be partially obscured by vegetation between the observer and the panel area.

The above conclusions are applicable to any layout or choice of tracker system that utilises flat panels within the assessed footprint.

APPENDIX A – OVERVIEW OF GLINT AND GLARE GUIDANCE

Overview

This section presents details of some international guidance and studies with respect to the considerations and effects of solar reflections from solar panels, known as 'Glint and Glare'.

This is not a comprehensive review of the data sources, rather it is intended to give an overview of the important parameters and considerations that have informed this assessment.

The UK planning policy is included for reference purposes due to the absence of formal policy in Australia.

UK Planning Policy

UK National Planning Practice Guidance dictates that in some instances a glint and glare assessment is required however, there is no specific guidance with respect to the methodology for assessing the impact of glint and glare.

The planning policy from the Department for Communities and Local Government (paragraph 27[20]) states:

'Particular factors a local planning authority will need to consider include… the effect on landscape of glint and glare and on ***neighbouring uses and aircraft safety***.*'*

The National Planning Policy Framework for Renewable and Low Carbon Energy[21] (specifically regarding the consideration of solar farms) states:

'What are the particular planning considerations that relate to large scale ground-mounted solar photovoltaic Farms?

The deployment of large-scale solar farms can have a negative impact on the rural environment, particularly in undulating landscapes. However, the visual impact of a well-planned and well-screened solar farm can be properly addressed within the landscape if planned sensitively.

Particular factors a local planning authority will need to consider include:

- *the proposal's visual impact, the effect on landscape of glint and glare (see guidance on landscape assessment) and on* ***neighbouring uses and aircraft safety****;*
- *the extent to which there may be additional impacts if solar arrays follow the daily movement of the sun;*

[20] http://planningguidance.planningportal.gov.uk/blog/guidance/renewable-and-low-carbon-energy/
[21] Reference ID: 5-013-20140306, paragraph 13-13,http://planningguidance.planningportal.gov.uk/blog/guidance/renewable-and-low-carbon-energy/particular-planning-considerations-for-hydropower-active-solar-technology-solar-farms-and-wind-turbines/

The approach to assessing cumulative landscape and visual impact of large scale solar farms is likely to be the same as assessing the impact of wind turbines. However, in the case of ground-mounted solar panels it should be noted that with effective screening and appropriate land topography the area of a zone of visual influence could be zero.'

Assessment Process

No process for determining and contextualising the effects of glint and glare are, however, provided. Therefore, the Pager Power approach is to determine whether a reflection from the proposed solar development is geometrically possible and then to compare the results against the relevant guidance/studies to determine whether the reflection is significant.

Ground Based Assessment Guidelines – Roads and Dwellings

There are no specific guidelines for assessing the impact of solar reflections upon surrounding roads and dwellings. Therefore, the Pager Power approach has been informed by the policy presented above, current studies (presented in Appendix B) and stakeholder consultation.

APPENDIX B – OVERVIEW OF GLINT AND GLARE STUDIES

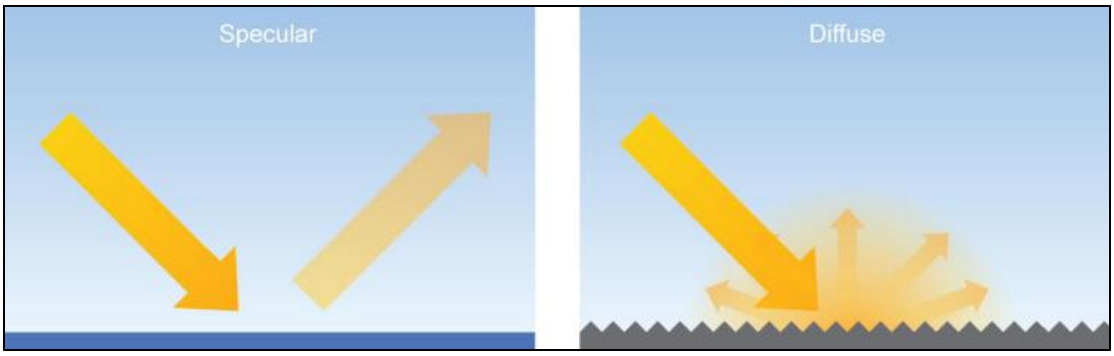
Overview

Studies have been undertaken assessing the type and intensity of solar reflections from various surfaces including solar panels. An overview of these studies is presented below.

There are no specific studies for determining the effect of reflections from solar panels with respect to roads and dwellings. The guidelines presented are related to aviation safety. The results are applicable for the purpose of this analysis.

Reflection Type from Solar Panels

Based on the surface conditions reflections from light can be specular and diffuse. A specular reflection has a reflection characteristic similar to that of a mirror; a diffuse will reflect the incoming light and scatter it in many directions. The figure below[22], taken from the FAA guidance, illustrates the difference between the two types of reflections. Because solar panels are flat and have a smooth surface most of the light reflected is specular, which means that incident light from a specific direction is reradiated in a specific direction.



Specular and diffuse reflections

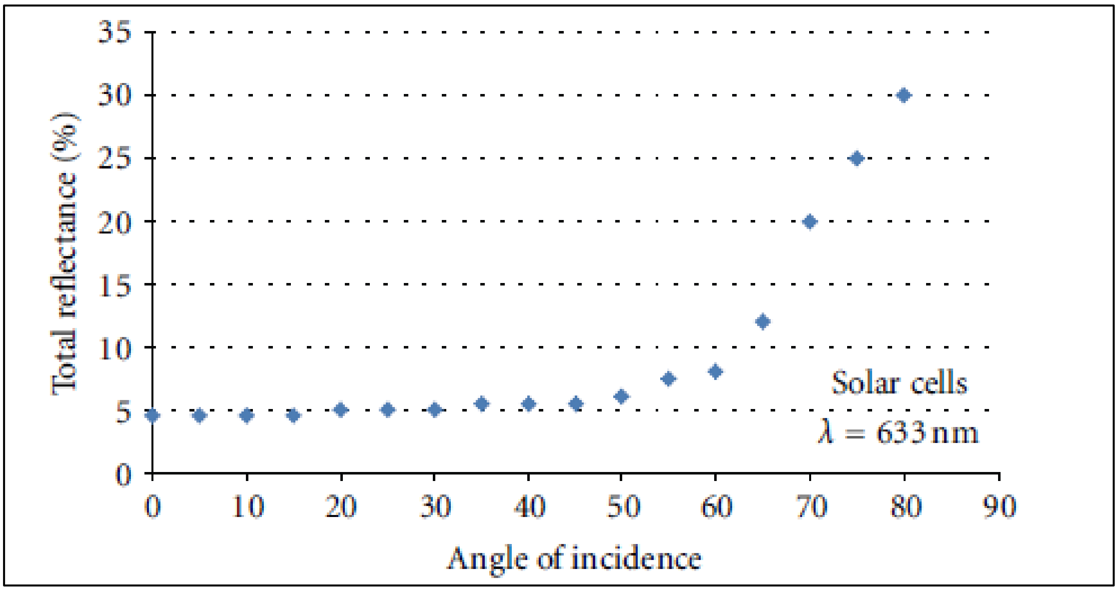
[22] http://www.faa.gov/airports/environmental/policy_guidance/media/airport_solar_guide_print.pdf

Solar Reflection Studies

An overview of content from identified solar panel reflectivity studies is presented in the subsections below.

Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems"

Evan Riley and Scott Olson published in 2011 their study titled: *A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems*[23]". They researched the potential glare that a pilot could experience from a 25 degree fixed tilt PV system located outside of Las Vegas, Nevada. The theoretical glare was estimated using published ocular safety metrics which quantify the potential for a postflash glare after-image. This was then compared to the postflash glare after-image caused by smooth water. The study demonstrated that the reflectance of the solar cell varied with angle of incidence, with maximum values occurring at angles close to 90 degrees. The reflectance values varied from approximately 5% to 30%. This is shown on the figure below.



Total reflectance % when compared to angle of incidence

The conclusions of the research study were:

- The potential for hazardous glare from flat-plate PV systems is similar to that of smooth water;
- Portland white cement concrete (which is a common concrete for runways), snow, and structural glass all have a reflectivity greater than water and flat plate PV modules.

[23] Evan Riley and Scott Olson, "A Study of the Hazardous Glare Potential to Aviators from Utility-Scale Flat-Plate Photovoltaic Systems," ISRN Renewable Energy, vol. 2011, Article ID 651857, 6 pages, 2011. doi:10.5402/2011/651857

FAA Guidance- "Technical Guidance for Evaluating Selected Solar Technologies on Airports"[24]

The 2010 FAA Guidance included a diagram which illustrates the relative reflectance of solar panels compared to other surfaces. The figure shows the relative reflectance of solar panels compared to other surfaces. Surfaces in this figure produce reflections which are specular and diffuse. A specular reflection (those made by most solar panels) has a reflection characteristic similar to that of a mirror. A diffuse reflection will reflect the incoming light and scatter it in many directions. A table of reflectivity values, sourced from the figure[25] within the FAA guidance, is presented below.

Surface	Approximate Percentage of Light Reflected[26]
Snow	80
White Concrete	77
Bare Aluminium	74
Vegetation	50
Bare Soil	30
Wood Shingle	17
Water	5
Solar Panels	5
Black Asphalt	2

Relative reflectivity of various surfaces

Note that the data above does not appear to consider the reflection type (specular or diffuse).

An important comparison in this table is the reflectivity compared to water which will produce a reflection of very similar intensity when compared to that from a solar panel. The study by Riley and Olsen study (2011) also concludes that still water has a very similar reflectivity to solar panels.

[24] FAA, November (2010): *Technical Guidance for Evaluating Selected Solar Technologies on Airports.*
[25] http://www.faa.gov/airports/environmental/policy_guidance/media/airport_solar_guide_print.pdf
[26] Extrapolated data, baseline of 1,000 W/m^2 for incoming sunlight.

SunPower Technical Notification (2009)

SunPower published a technical notification[27] to '*increase awareness concerning the possible glare and reflectance impact of PV Systems on their surrounding environment*'. The study revealed that the reflectivity of a solar panel is considerably lower than that of '*standard glass and other common reflective surfaces*'. With respect to aviation and solar reflections observed from the air, SunPower has developed several large installations near airports or on Air Force bases. It is stated that these developments have all passed FAA or Air Force standards with all developments considered "No Hazard to Air Navigation". The note suggests that developers discuss any possible concerns with stakeholders near proposed solar farms.

Figures within the document show the relative reflectivity of solar panels compared to other natural and manmade materials including smooth water, standard glass and steel. The results, similarly to those from Riley and Olsen study (2011) and the FAA (2010), show that solar panels produce a reflection that is less intense than those produced from these surfaces.

[27] Technical Support, 2009. SunPower Technical Notification- Solar Module Glare and Reflectance.

APPENDIX C – PAGER POWER'S REFLECTION CALCULATIONS METHODOLOGY

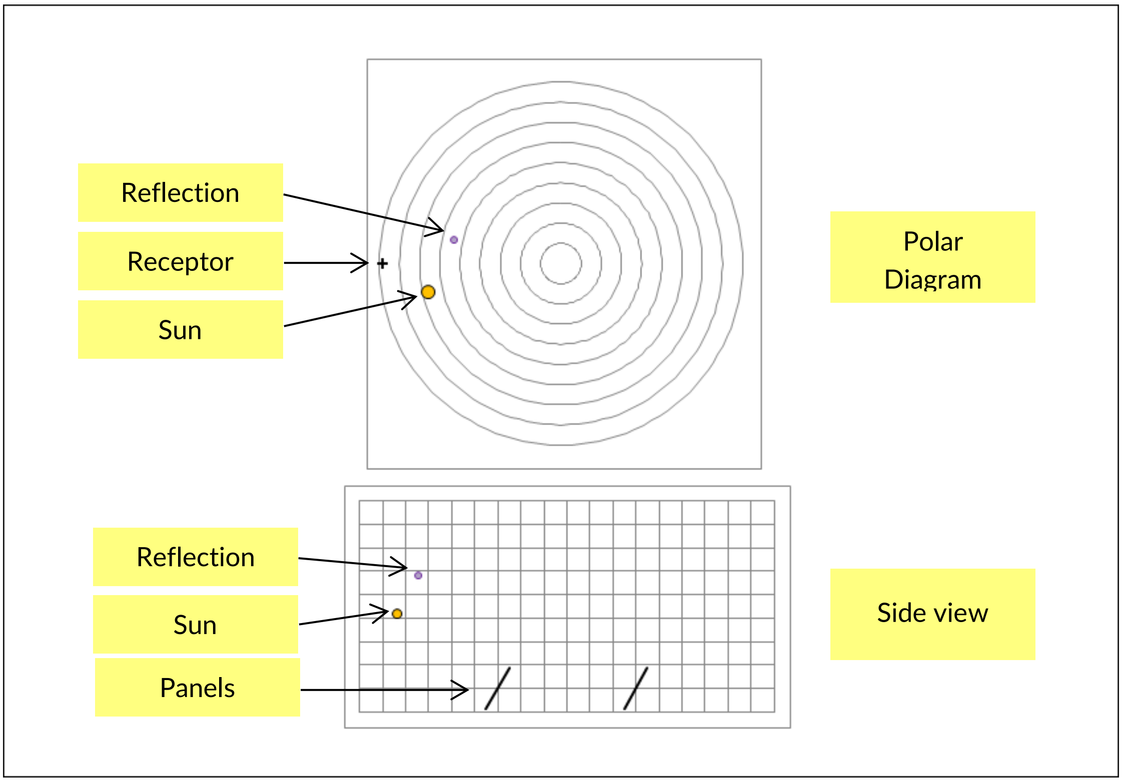
The calculations are three dimensional and complex, accounting for:

- The Earth's orbit around the Sun;
- The Earth's rotation;
- The Earth's orientation;
- The reflector's location;
- The reflector's 3D Orientation – including consideration of the tracking mechanism.

Reflections from a flat reflector are calculated by considering the normal which is an imaginary line that is perpendicular to the reflective surface and originates from it.

A single axis system such as Sun Power rotates panels from east to west so that they face the Sun as it passes through the sky during the day. At very low solar altitudes the panels flatten so that one row of panels does not cast a shadow on the next. Pager Power's computer algorithm determines the amount of panel tilt based on (1) the predicted position of the Sun; (2) how far the panel can actually tilt - determined by the physical characteristics of the tilting mechanism and (3) the shadow that will be cast on the neighbouring row of panels.

The diagram below illustrates one step in the iterative modelling process, showing the position of the Sun, the angle of the panels and the direction of the reflection at a single point in time.



APPENDIX D – GLINT AND GLARE IMPACT SIGNIFICANCE

Overview

The significance of glint and glare will vary for different receptors. The following section presents a general overview of the significance criteria with respect to experiencing a solar reflection.

Impact significance definition

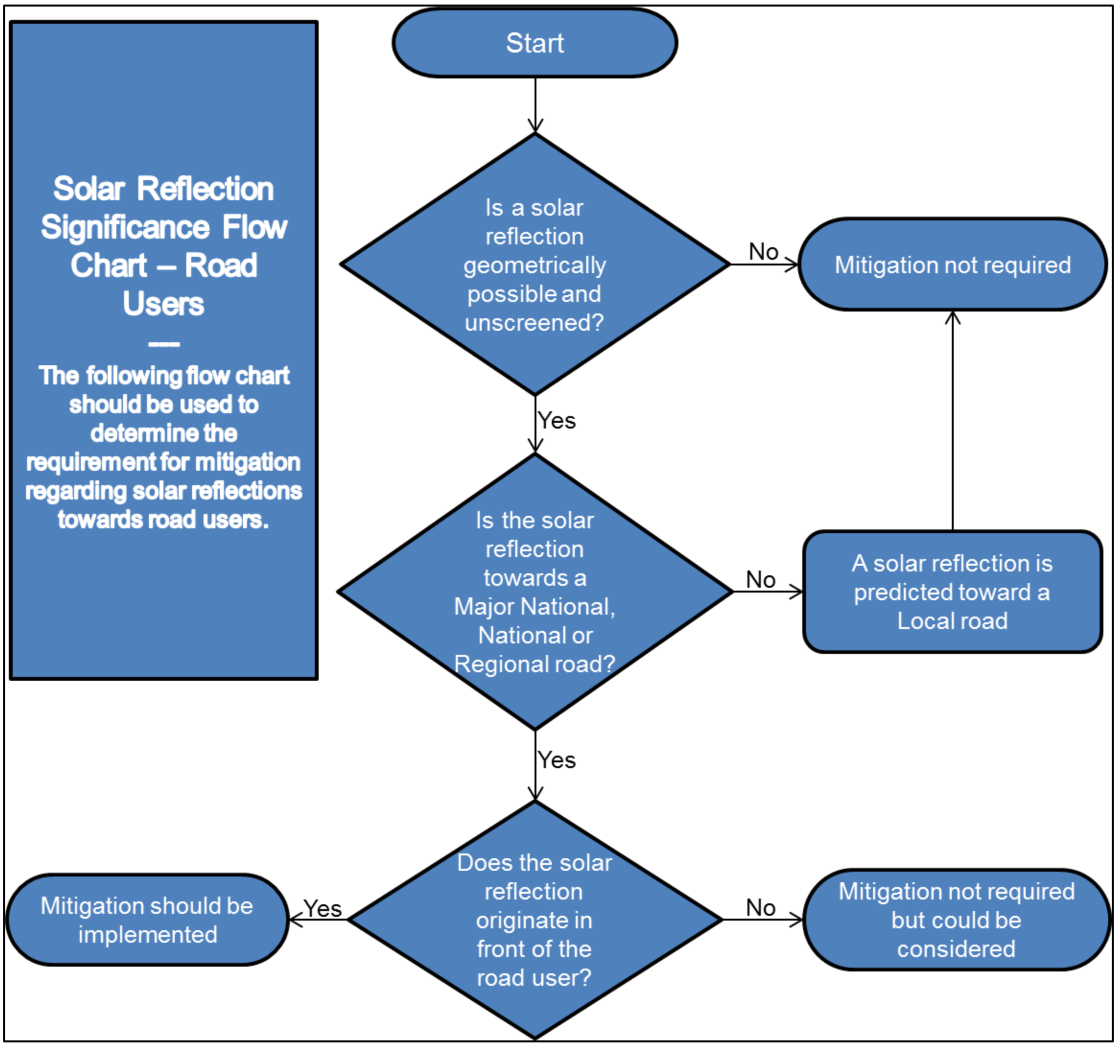
The table below presents the recommended definition of 'impact significance' in glint and glare terms and the requirement for mitigation under each.

Impact Significance	Definition	Mitigation Requirement
No Impact	A solar reflection is not geometrically possible or will not be visible from the assessed receptor.	No mitigation required.
Low	A solar reflection is geometrically possible however any impact is considered to be small such that mitigation is not required e.g. intervening screening will limit the view of the reflecting solar panels.	No mitigation required.
Moderate	A solar reflection is geometrically possible and visible however it occurs under conditions that do not represent a worst-case.	Whilst the impact may be acceptable, consultation and/or further analysis should be undertaken to determine the requirement for mitigation.
Major	A solar reflection is geometrically possible and visible under conditions that will produce a significant impact. Mitigation and consultation is recommended.	Mitigation will be required if the proposed solar development is to proceed.

Impact significance definition

Assessment process for road receptors

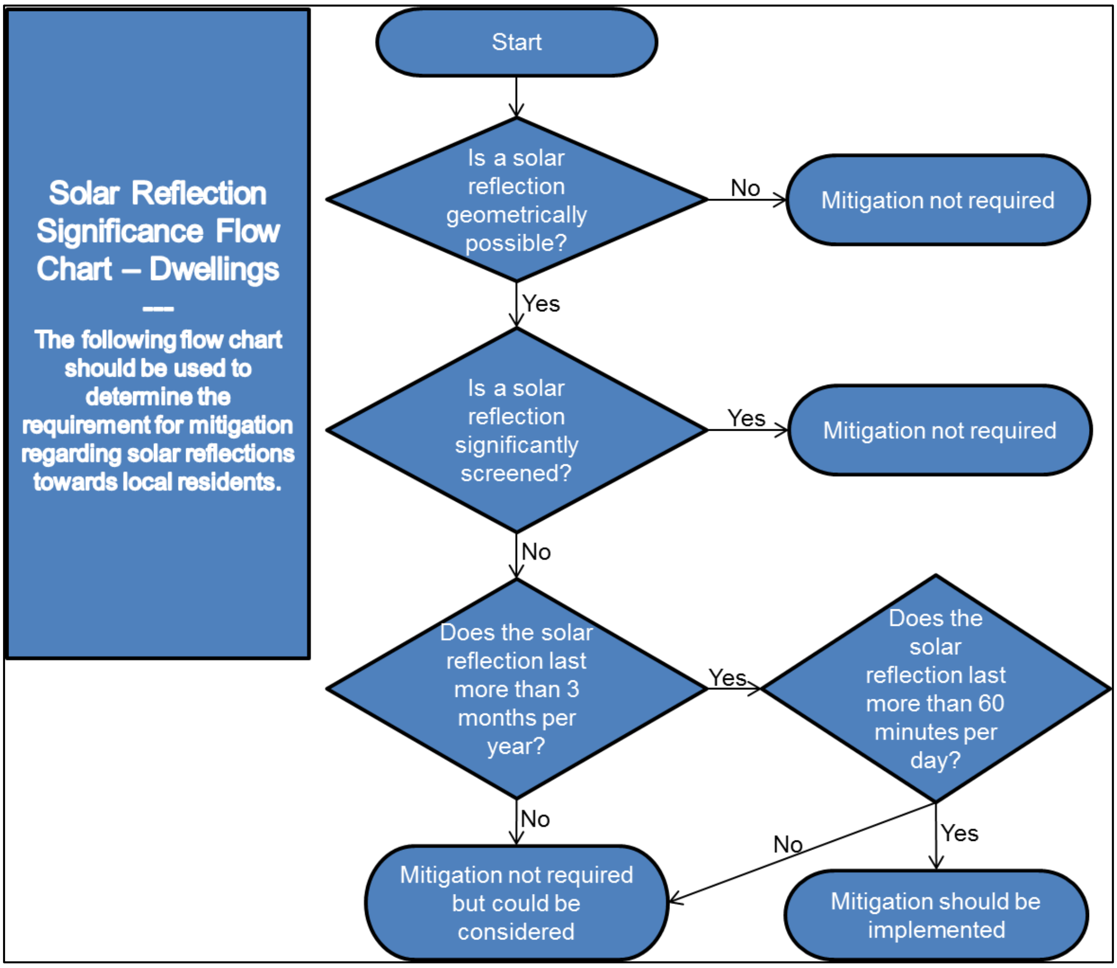
The flow chart presented below has been followed when determining the mitigation requirement for road receptors.



Road receptor mitigation requirement flow chart

Assessment process for dwelling receptors

The flow chart presented below has been followed when determining the mitigation requirement for dwelling receptors.



Dwelling receptor mitigation requirement flow chart

APPENDIX E – ASSESSMENT LIMITATIONS AND ASSUMPTIONS

Calculations have been undertaken for panel locations throughout the site. The resolution is sufficiently high that all potential development areas are captured.

Only a reflection from the face of the panel has been considered. The frame or the reverse of the solar panel has not been considered.

The model assumes that a receptor can view the face of every panel within the proposed solar farm area whilst in reality this, in the majority of cases, will not occur.

Therefore any predicted reflection from the face of a solar panel that is not visible to a receptor will not occur.

A finite number of points within the proposed solar farm are chosen in order to build a comprehensive understanding of the entire solar farm. This determines whether a reflection could ever occur at a chosen receptor. The calculations do not incorporate all of the possible panel locations within the solar farm outline – however the resolution is sufficiently high to capture the predicted effects of the site as a whole. Modelling of additional or intermediate panel locations would not significantly alter the predicted reflections as a whole.

A single reflection point on the panel has been chosen for the geometric calculations. This will suitably determine whether a reflection can be experienced at a location and the general time of year and duration of this reflection. Increased accuracy could be achieved by increasing the number of heights assessed however this would only marginally change the results and is not considered significant.

Whilst line of sight to the solar farm from receptors has been considered, only available street view imagery and satellite mapping has been used. In some cases this imagery may not be up to date and may not give the full perspective of the installation from the location of the assessed receptor.

Any screening in the form of trees, buildings etc. that may obstruct the Sun from view of the solar panels is not considered unless stated.

APPENDIX F – COORDINATE DATA

Receptor Data - Roads

Number	Longitude (°)	Latitude (°)
01	146.889320	-35.925513
02	146.889150	-35.926407
03	146.888971	-35.927306
04	146.888807	-35.928200
05	146.888621	-35.929091
06	146.888455	-35.929984
07	146.888278	-35.930880
08	146.888108	-35.931776
09	146.887934	-35.932671
10	146.887729	-35.933543
11	146.887413	-35.934416

Road receptor details

Receptor Data - Dwellings

Number	Longitude (°)	Latitude (°)	Number	Longitude (°)	Latitude (°)
01	146.893947	-35.924999	12	146.907149	-35.938848
02	146.892859	-35.928333	13	146.933721	-35.922000
03	146.897043	-35.933206	14	146.917435	-35.910017
04	146.896356	-35.934317	15	146.909749	-35.911789
05	146.901374	-35.936227	16	146.909079	-35.915818
06	146.901664	-35.936278	17	146.905515	-35.921808
07	146.902282	-35.937399	18	146.895518	-35.921474
08	146.903299	-35.938501	19	146.901981	-35.940455
09	146.902980	-35.939995	20	146.900297	-35.942116
10	146.900976	-35.941188	21	146.900441	-35.943075
11	146.907171	-35.938330	22	146.897473	-35.942950

Dwelling receptor details

Modelled Reflector Points (Pager Power Model)

Number	Longitude (°)	Latitude (°)	Number	Longitude (°)	Latitude (°)
01	146.905075	-35.936632	36	146.918965	-35.925383
02	146.902296	-35.934382	37	146.921743	-35.925383
03	146.905074	-35.934382	38	146.924521	-35.925383
04	146.907853	-35.934382	39	146.927300	-35.925383
05	146.910632	-35.934382	40	146.907851	-35.923133
06	146.899517	-35.932133	41	146.910629	-35.923133
07	146.902296	-35.932133	42	146.913408	-35.923133
08	146.905074	-35.932133	43	146.916186	-35.923133
09	146.907853	-35.932133	44	146.918964	-35.923133
10	146.910631	-35.932133	45	146.921742	-35.923133
11	146.913410	-35.932133	46	146.924520	-35.923133
12	146.916188	-35.932133	47	146.910629	-35.920883
13	146.899517	-35.929883	48	146.913407	-35.920883
14	146.902295	-35.929883	49	146.916185	-35.920883
15	146.905074	-35.929883	50	146.918963	-35.920883
16	146.907852	-35.929883	51	146.921741	-35.920883
17	146.910631	-35.929883	52	146.924520	-35.920883
18	146.913409	-35.929883	53	146.913406	-35.918634
19	146.916188	-35.929883	54	146.916185	-35.918634
20	146.918966	-35.929883	55	146.918963	-35.918634
21	146.921745	-35.929883	56	146.921741	-35.918634
22	146.902295	-35.927633	57	146.924519	-35.918634
23	146.905074	-35.927633	58	146.927297	-35.918634
24	146.907852	-35.927633	59	146.930075	-35.918634
25	146.910630	-35.927633	60	146.916184	-35.916384
26	146.913409	-35.927633	61	146.921740	-35.916384
27	146.916187	-35.927633	62	146.924518	-35.916384
28	146.918965	-35.927633	63	146.927296	-35.916384
29	146.921744	-35.927633	64	146.924517	-35.914134
30	146.924522	-35.927633	65	146.924516	-35.911884
31	146.905073	-35.925383	66	146.924515	-35.909634
32	146.907852	-35.925383	67	146.927292	-35.907385
33	146.910630	-35.925383	68	146.905131	-35.937690
34	146.913408	-35.925383	69	146.903838	-35.938854
35	146.916186	-35.925383	70	146.926829	-35.909753

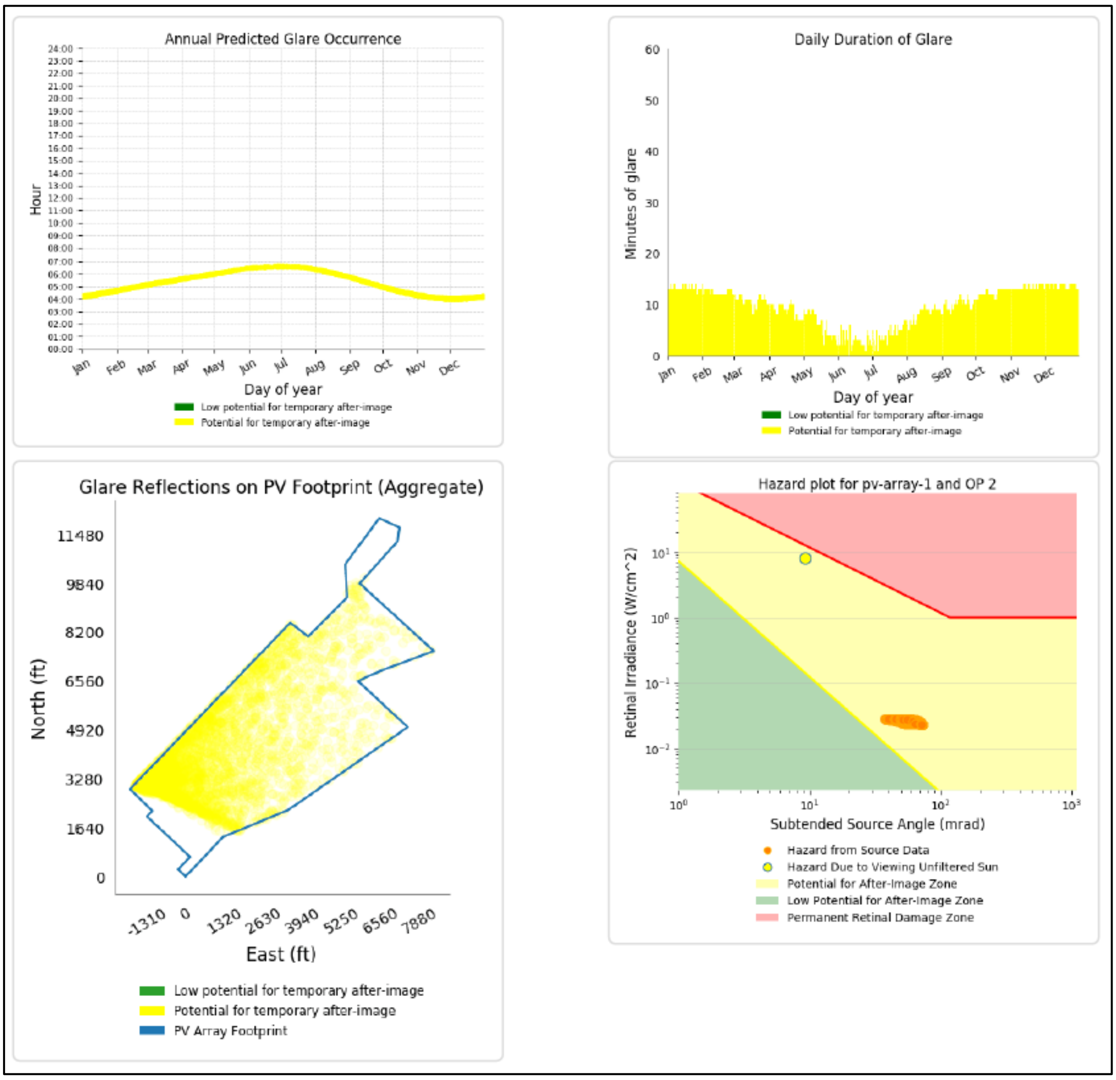
Modelled reflector points

APPENDIX G – GEOMETRIC CALCULATION RESULTS

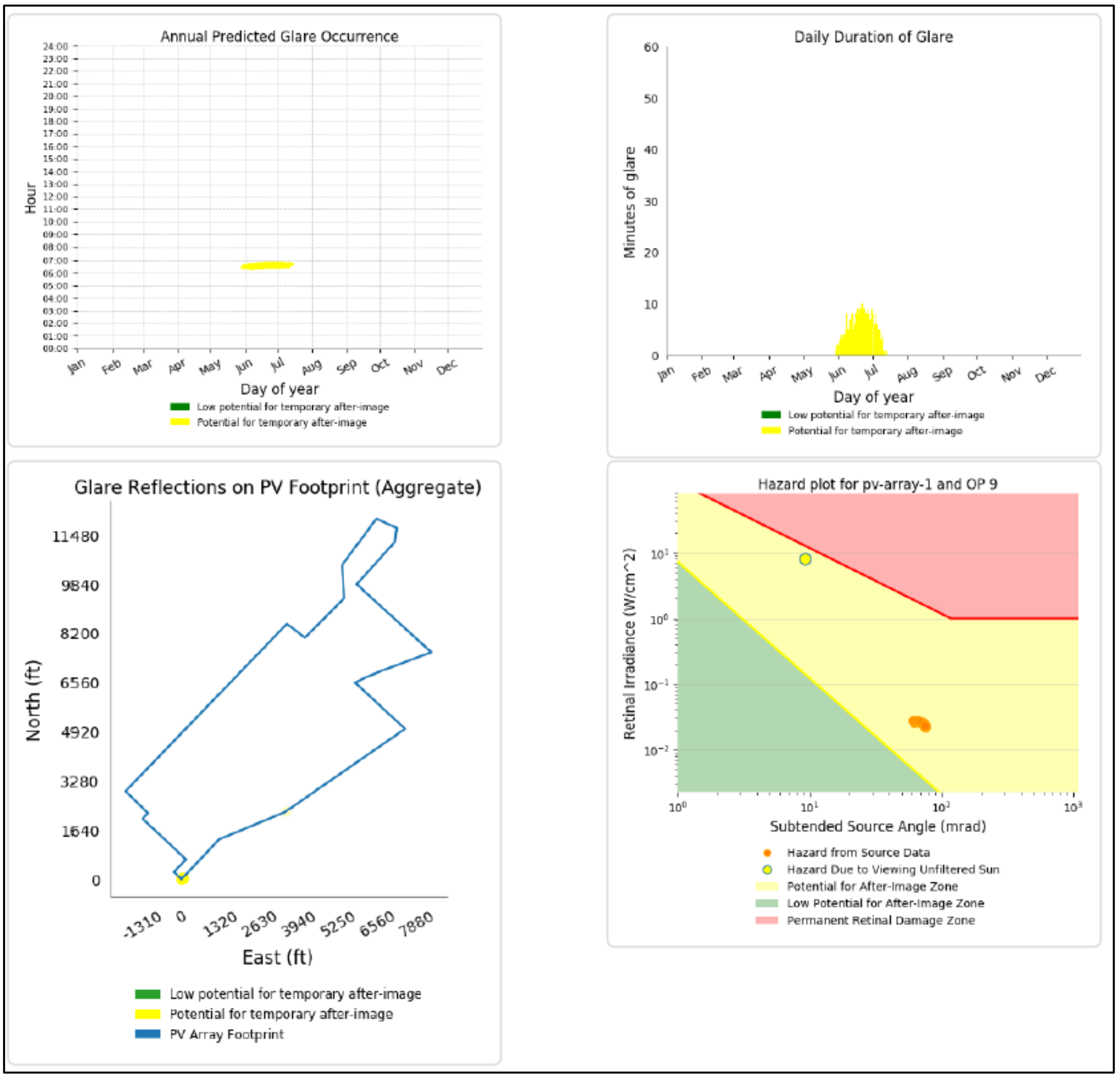
Overview

The charts for the receptors are shown on the following pages (3rd party modelling output). Each chart shows the reflection date/time graph. The 'heat map' shows the areas within the site boundary that would produce the reflection. The time per day and the intensity of the reflection are also shown. There are no regulations for intensity limits pertaining to road users or private residents – however the worst-case result in any modelled scenario is 'potential for a temporary after-image'.

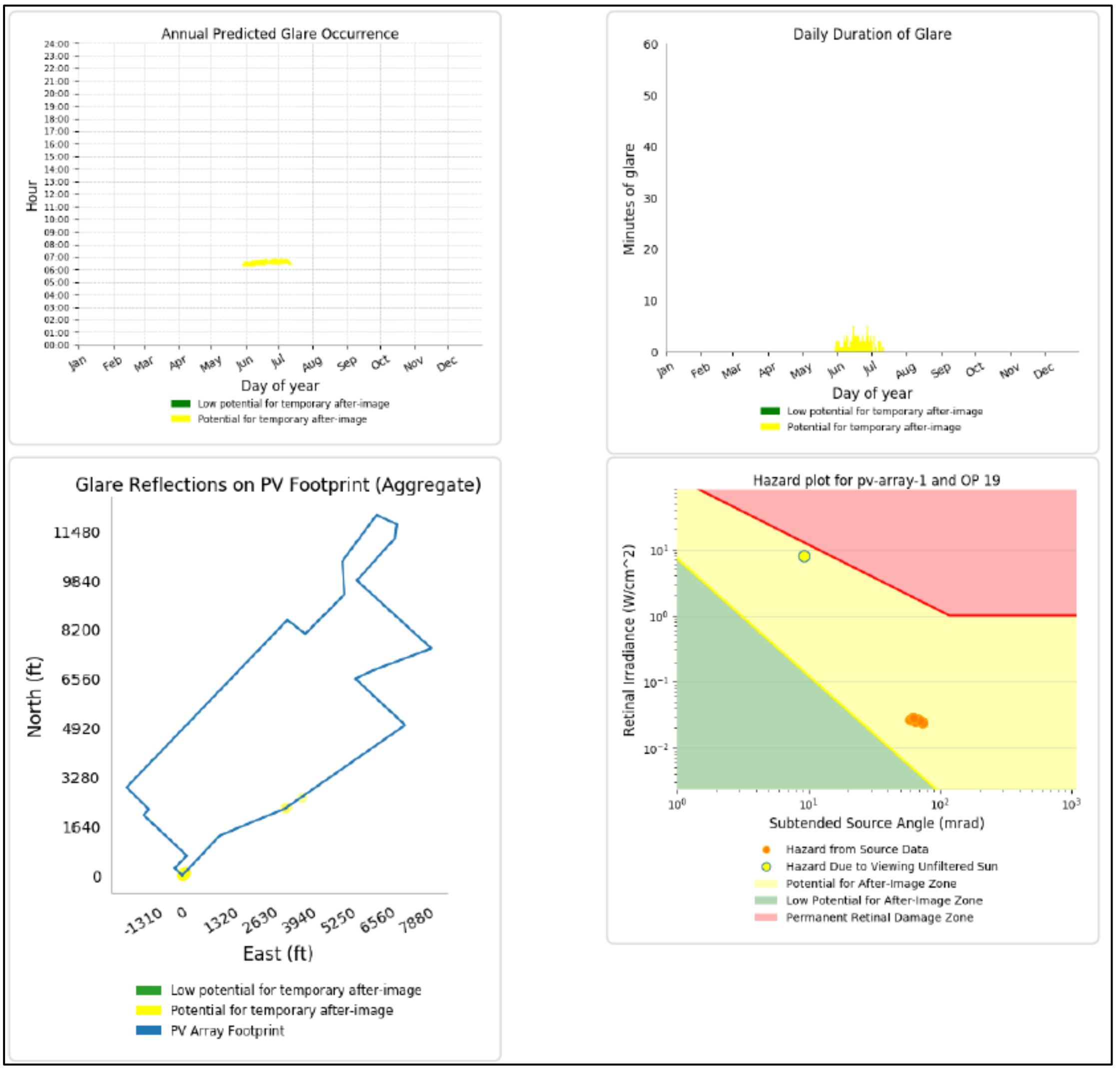
Dwelling 2



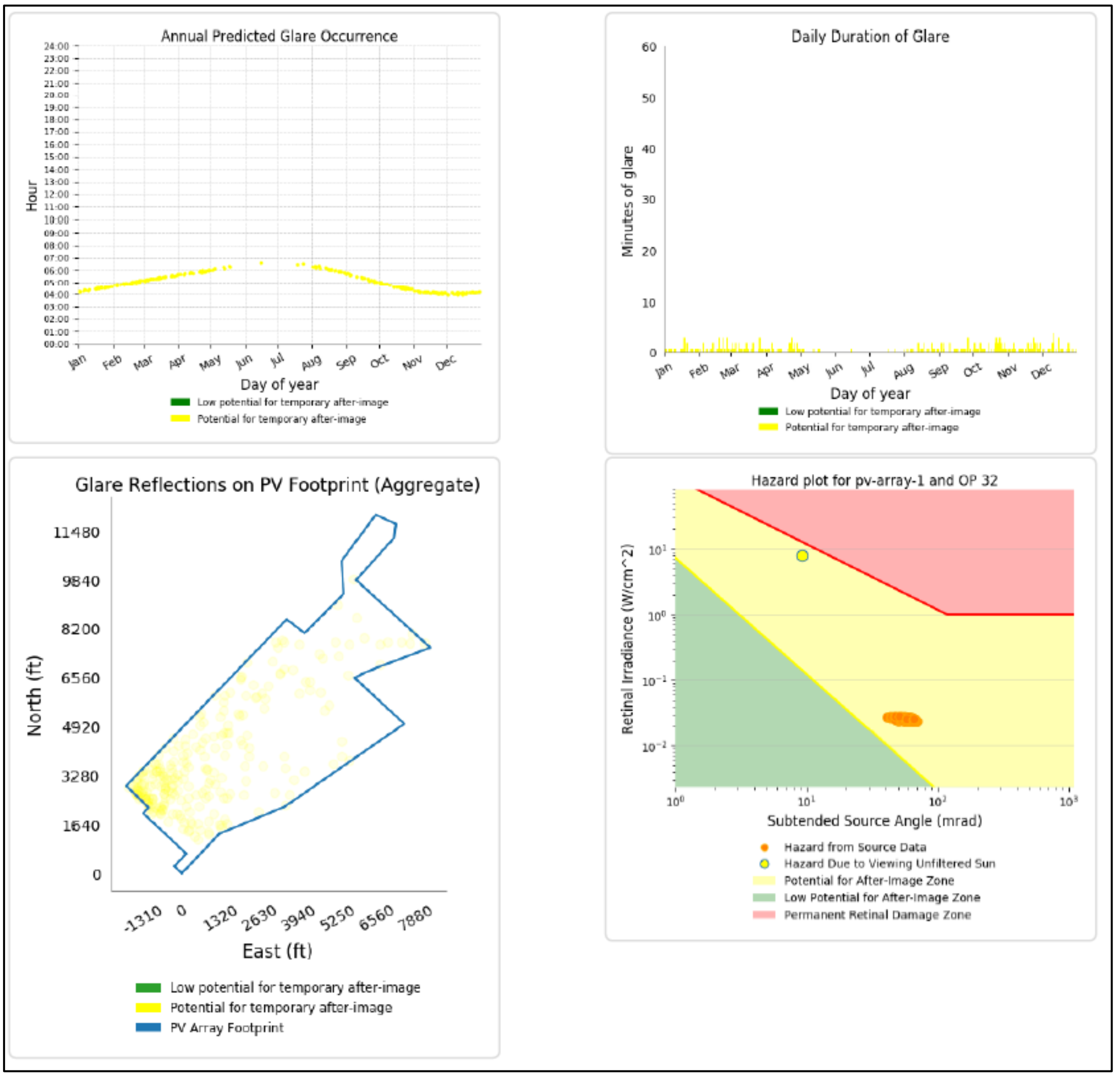
Dwelling 9


Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 9
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

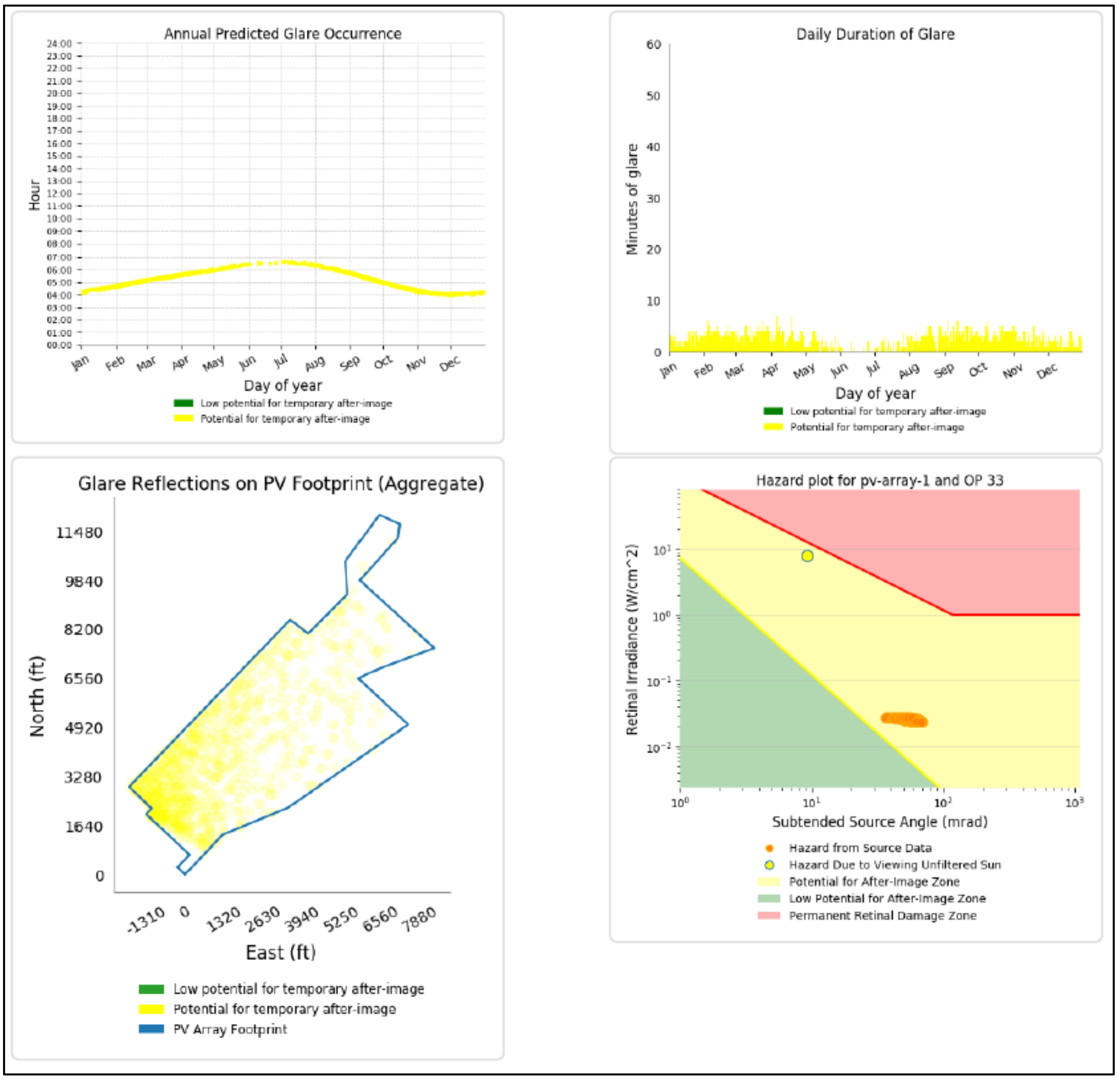
Dwelling 19


Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 19
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

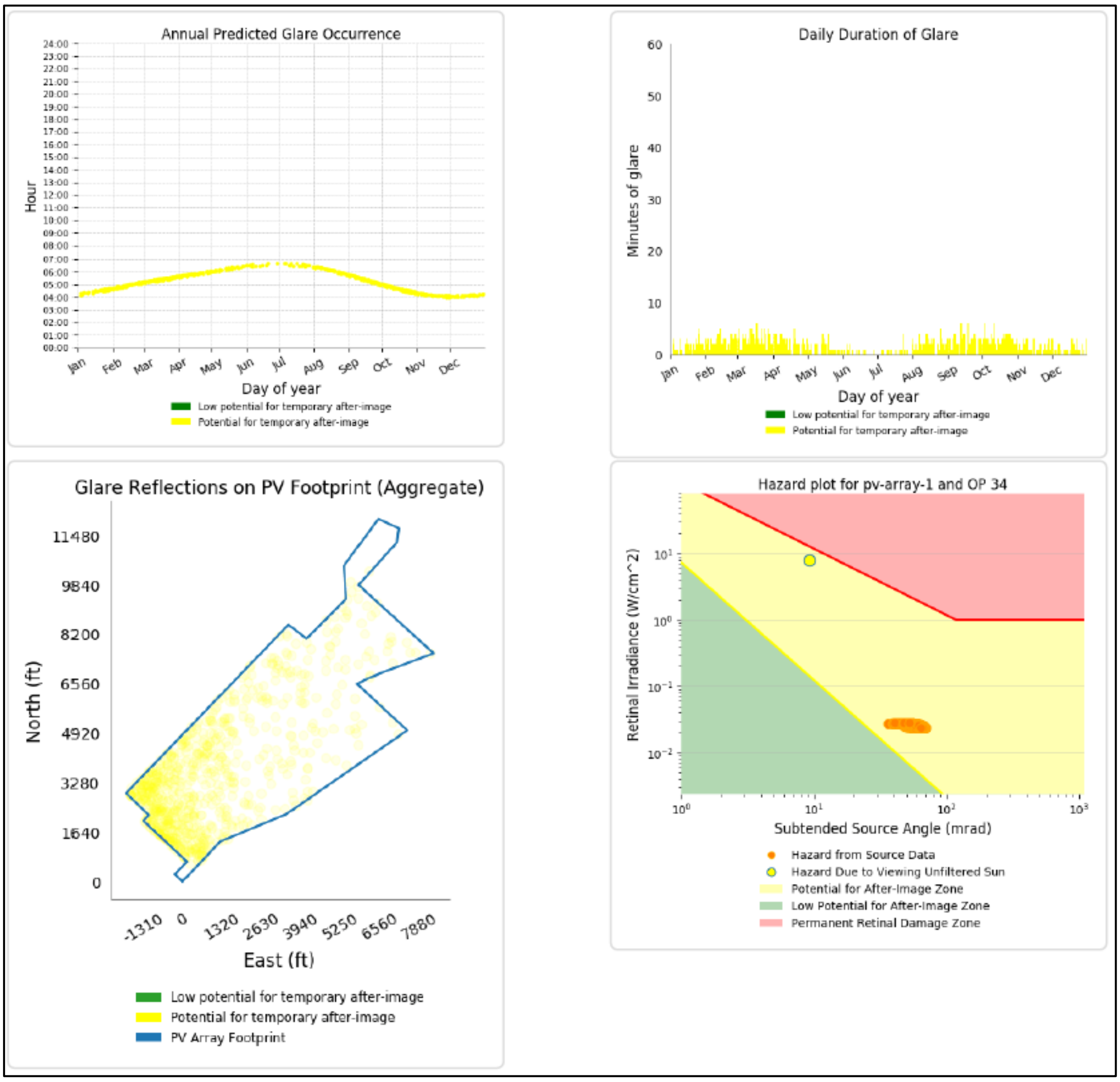
Road 4


Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 32
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

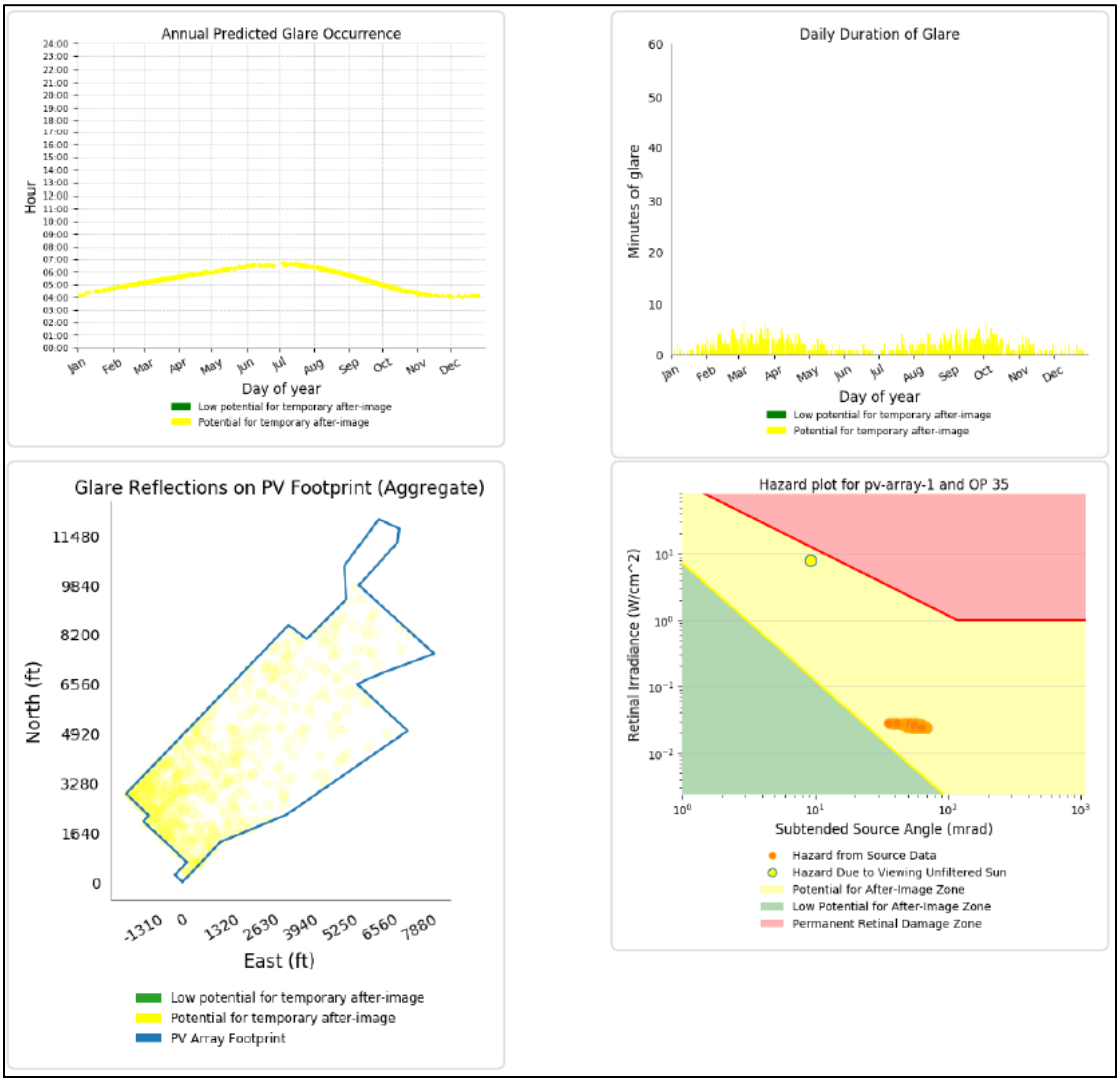
Road 5


Annual Predicted Glare Occurrence
Hour
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 33
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

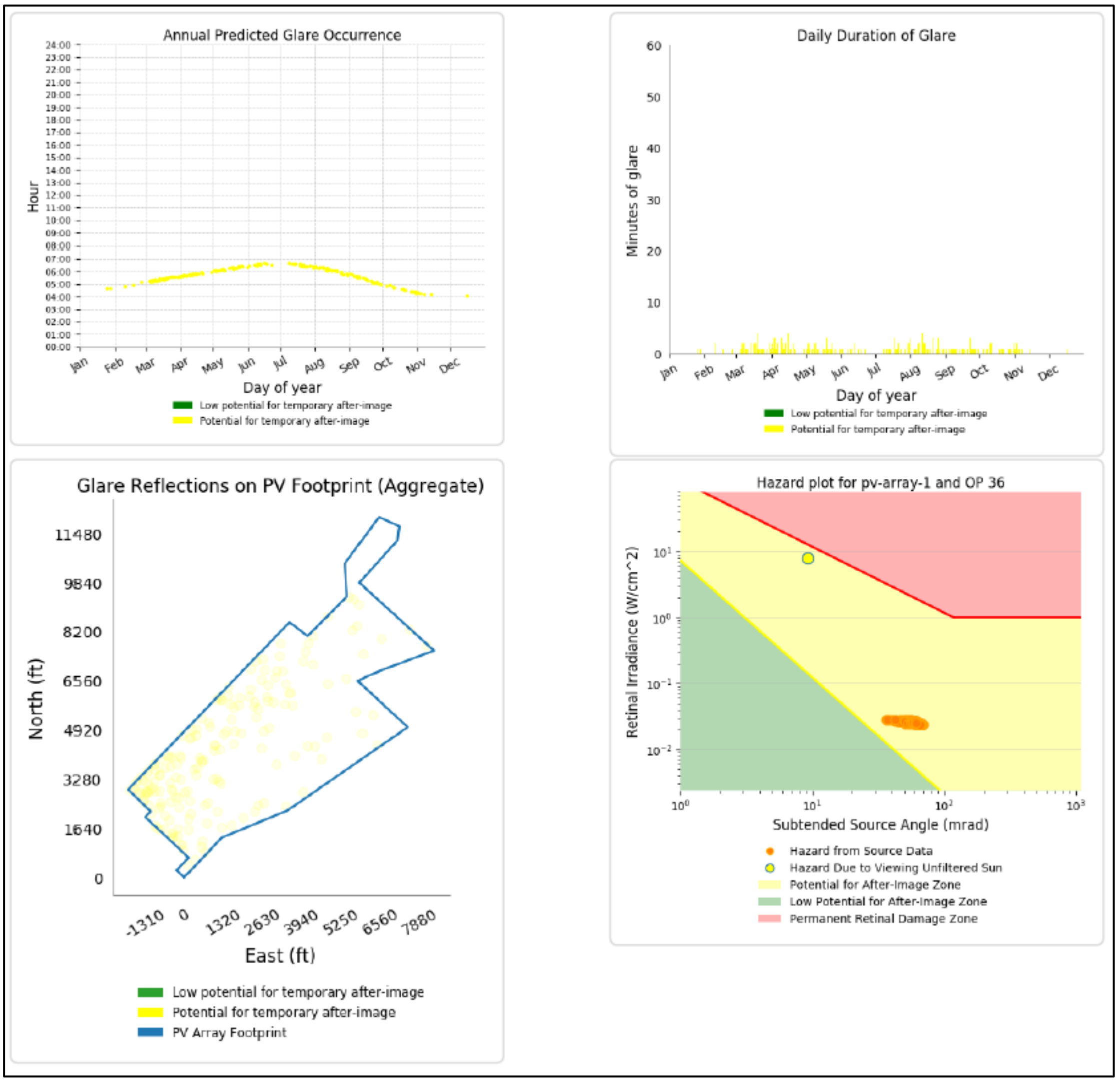
Road 6


Annual Predicted Glare Occurrence
Hour
Day of year
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
11480
9840
8200
6560
4920
3280
1640
0
-1310 0 1320 2630 3940 5250 6560 7880
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 34
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

Road 7


Annual Predicted Glare Occurrence
Hour
Day of year
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
11480 9840 8200 6560 4920 3280 1640 0
-1310 0 1320 2630 3940 5250 6560 7880
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 35
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

Road 8


Annual Predicted Glare Occurrence
Hour
Day of year
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Low potential for temporary after-image
Potential for temporary after-image
Daily Duration of Glare
Minutes of glare
60 50 40 30 20 10 0
Day of year
Low potential for temporary after-image
Potential for temporary after-image
Glare Reflections on PV Footprint (Aggregate)
North (ft)
11480 9840 8200 6560 4920 3280 1640 0
-1310 0 1320 2630 3940 5250 6560 7880
East (ft)
Low potential for temporary after-image
Potential for temporary after-image
PV Array Footprint
Hazard plot for pv-array-1 and OP 36
Retinal Irradiance (W/cm^2)
Subtended Source Angle (mrad)
Hazard from Source Data
Hazard Due to Viewing Unfiltered Sun
Potential for After-Image Zone
Low Potential for After-Image Zone
Permanent Retinal Damage Zone

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