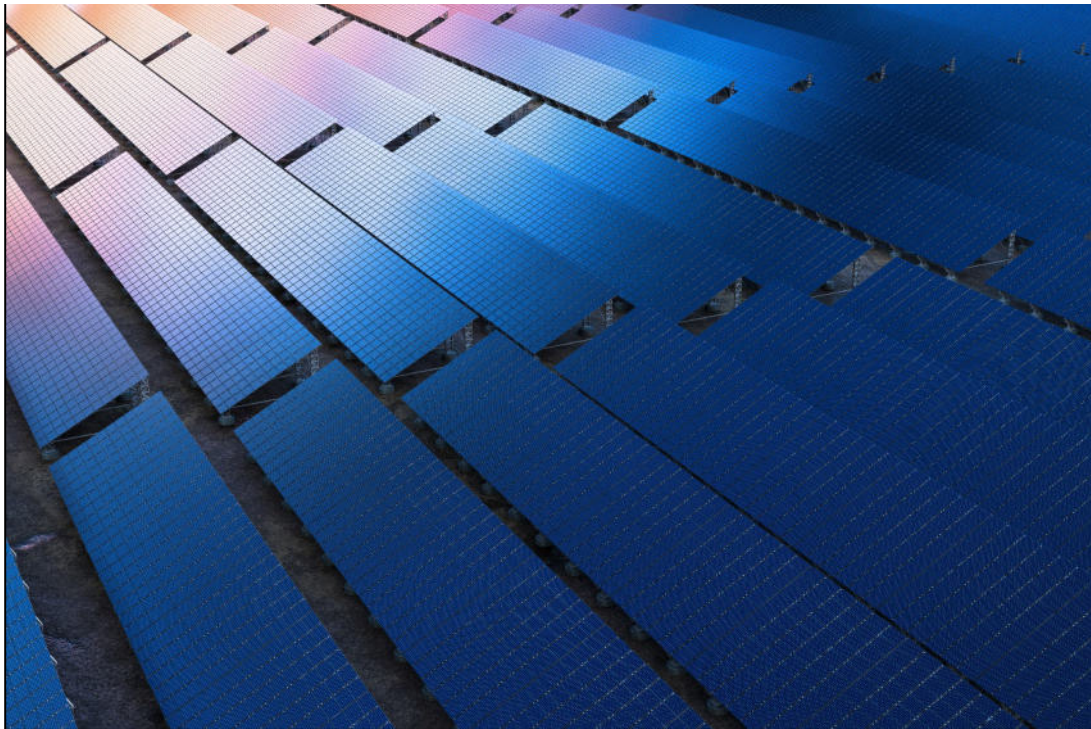


APPENDIX 33

**AVIATION GLINT AND GLARE ASSESSMENT OF THE SOLAR ENERGY
FACILITY INSTALLATION FOR THE PROPOSED EXPANSION OF THE
CAPE WINELANDS AIRPORT, WESTERN CAPE.**

Aviation Glint and Glare Assessment of the Solar Energy Facility Installation for the Proposed Expansion of the Cape Winelands Airport, Western Cape.



Prepared by: Future Impact (Pty) Ltd
Specialist Name: Dr Brett Williams
Prepared for: PHS Consulting (Pty) Ltd

4th March 2025

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Project name	Aviation Glint and Glare Assessment of the Solar Energy Facility Installation for the Proposed Expansion of the Cape Winelands Airport, Western Cape.
Report	Glint and Glare Assessment Report
Report version	Version 2
Client	PHS Consulting (Pty) Ltd PO Box 1752 Hermanus 7200 South Africa
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Date of release	4 th March 2025
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Amendment History

Version 1	Original	06/09/2024
Version 2	Changes made to modelled Solar PV Layout based on Spatial Development Plan Revision 16 provided by the client on the 18 th February 2025.	04/03/2025



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I hereby declare that I do:

- (a) have knowledge of and experience in conducting assessments, including knowledge of the Act, these regulations and guidelines that have relevance to the proposed activity;
- (b) perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- (c) comply with the Act, these regulations, guidelines, and other applicable laws.

I also declare that there is, to my knowledge, no information in my possession that reasonably has or may have the potential of influencing –

- (i) any decision to be taken with respect to the application in terms of the Act and the regulations; or
- (ii) the objectivity of this report, plan or document prepared in terms of the Act and these regulations.



Dr Brett Williams

Future Impact (Pty) Ltd



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EXECUTIVE SUMMARY

Future Impact were appointed by PHS Consulting (Pty) Ltd to conduct a desktop review pertaining to glint and glare impacts on aviation receptors as a result of light reflecting off solar PV installations at the proposed expansion of the Cape Winelands Airport (CWA) in the Western Cape.

The aim of this study was to determine the impact that solar glint and glare would have on various aviation receptors. The FAA model considered the 2-mile receptors on the approach to Runway 01/19 and the Air Traffic Control Tower.

This Report has been updated to reflect the changes made to the modelled Solar PV Layout based on Spatial Development Plan Revision 16 provided by the client on the 18th February 2025.

The initial modelling results in Version 1 of this report indicated that the Air Traffic Control Tower will be exposed to green and yellow glare. It was recommended that the south eastern portion of the Services Precinct (see Figure 8) be excluded from the installation of the Solar PV panels to eliminate the exposure to the Air Traffic Control Tower.

The remodelling conducted in this report (Version 2), was based on the updated layout provided that incorporated the above recommendation. The results of the Version 2 modelling indicate that no glare will be expected.

The Glint and Glare Impacts will therefore be **Very Low** and acceptable in terms of the United States FAA Regulations if the recommendations are implemented. It is therefore recommended that the project receive authorisation from the Civil Aviation Authority from a glint and glare perspective.



Dr Brett Williams

Digitally signed
by Brett Williams



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LIST OF ABBREVIATIONS AND DEFINITIONS

2-Mile Flight Path Receptor: The 2-Mile Flight Path receptor ("FP") simulates an aircraft following a straight-line approach path toward a runway, by default, including a restricted field-of-view to filter unrealistic glare. In addition, it can be modified to represent a worst-case approach and take-off path.

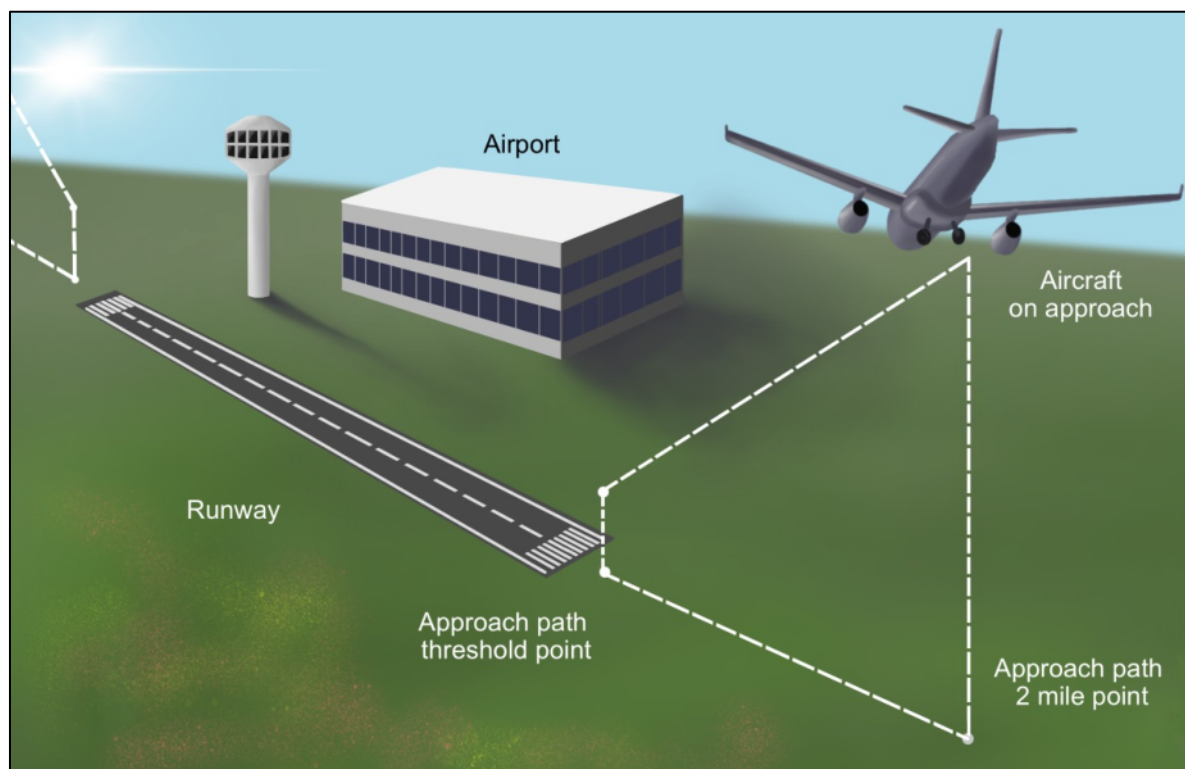


Figure 1: Flight Path

Flight Path Parameters are as follows:

Name: Descriptive alphanumeric label of receptor

Direction (°): Azimuthal angle of approach of aircraft which defines the straight path toward the runway. Measured clockwise from true north.

Glide slope (°): Angle of descent of aircraft toward runway. Default value of 3°.

Threshold crossing height: Height above ground of aircraft when it crosses the runway threshold. (Typically, 50 ft.).

Max downward viewing angle (°): The vertical field-of-view of the pilot, measured positive downward from the XY plane (i.e., flat). A default value of 30° assumes glare appearing beyond that FOV is not visible to the pilot and is acceptable to FAA. A value of 90° assumes the pilot can see glare appearing directly underneath the aircraft.

Azimuthal viewing angle (°): The left and right field-of-view of the pilot during approach. A view angle of 180° implies the pilot can see glare emanating from behind the plane.

Point coordinates: The threshold and 2-mile point ground elevation parameters can be modified in the FP Advanced dialog. The 2-mile point height is calculated from the point elevations and threshold crossing height to ensure a smooth 2-mile descent path.



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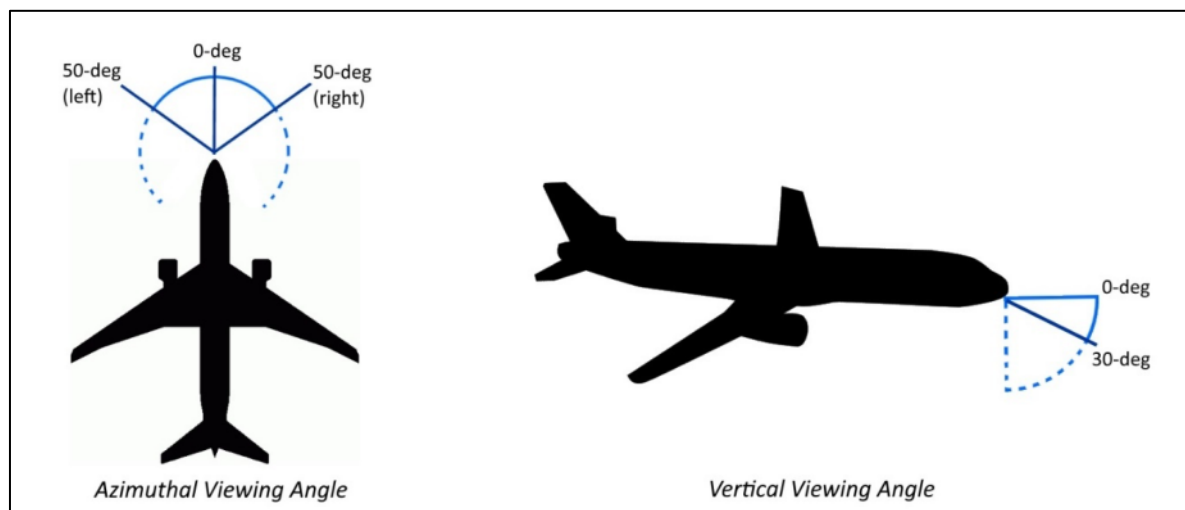


Figure 2: Viewing Angles.

Glint and Glare: Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration. The difference between glint and glare is duration. Industry-standard glare analysis tools evaluate the occurrence of glare on a minute-by-minute basis; accordingly, they generally refer to solar hazards as 'glare'. Based on figure 3 (below), the ocular impact of solar glare is quantified into three categories:

- Green - low potential to cause after-image (flash blindness)
- Yellow - potential to cause temporary after-image.
- Red - potential to cause retinal burn (permanent eye damage)

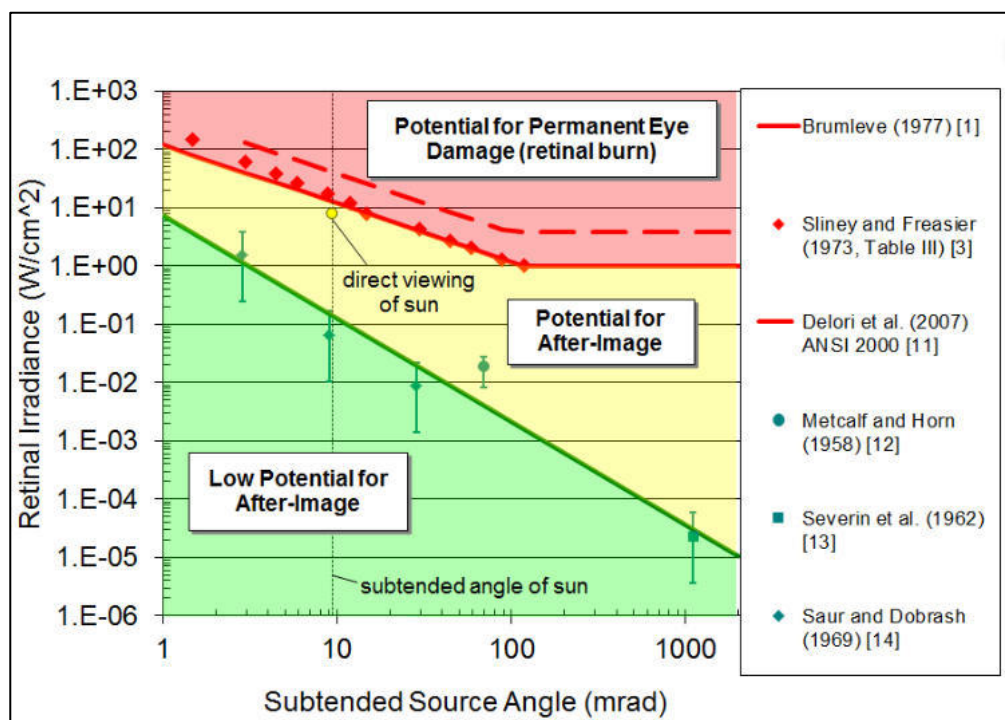


Figure 3: Glare Categories.

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mrاد: Milliradian, equal to one-thousandth of a radian. A radian is a unit of angular measure equal to the angle subtended at the centre of a circle by an arc equal in length to the radius of the circle, approximately 57°17'44.6".

Peak DNI (W/m2 or Wh/m2): The maximum Direct Normal Irradiance at the given location at solar noon. DNI is the amount of solar radiation received in a collimated beam on a surface normal to the sun during a 60-minute period. On a clear sunny day at solar noon, a typical peak DNI is ~1,000 W/m2.

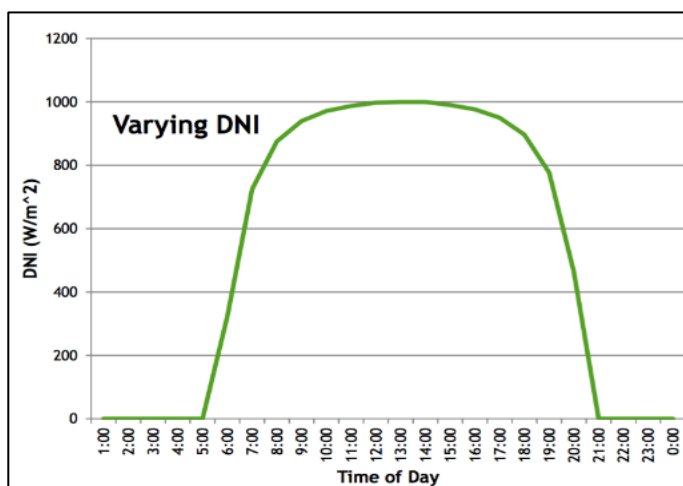


Figure 4: Peak Daily DNI

Slope error (mrاد): Specifies the amount of scatter that occurs from the PV module. Mirror-like surfaces that produce specular reflections will have a slope error closer to zero, while rough surfaces that produce more scattered (diffuse) reflections have higher slope errors. Based on observed glare from different PV modules, an RMS slope error of ~10 mrاد (which produces a total reflected beam spread of 0.13 rad or 7°) appears to be a reasonable value. Not used if correlate slope error to module surface type is checked. In this report, the worst-case scenario was assumed. Therefore, a light-textured PV panel with an anti-glare coating was selected for modelling. The properties of the selected panel are as follow: 9.16mrاد average RMS slope error; 119.00mrاد average beam spread; 3.17 standard deviation of slope error; and 38.00 standard deviation of beam error.

Abbreviations used in the report

AP: Approach Point

ATCT: Air Traffic Control Tower

CWA: Cape Winelands Airport

FAA: Federal Aviation Authority

FAWN: ICAO Code for the Cape Winelands Airport

FoV: Field of View

FP: Flight Path

mRad: milliradian

OP: Observation Point

PV: Photovoltaic

SDP: Spatial Development Plan

RMS: Root Mean Square



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1. INTRODUCTION

This report aims to determine the effect that potential solar PV 'glint and glare' may have on various aviation receptors due to the construction and operation of the solar PV installations at the proposed expansion of the Cape Winelands Airport (ICAO Code: FAWN) in the Western Cape.

The assessment was conducted with the objective of determining how 'glint' and 'glare' will affect aviation receptors such as pilots on final approaches to Runway 01/19 and the air traffic controllers in the air traffic control tower.

The solar PV installations, situated within the project boundary, will be both ground-based and installed on the rooftops of various buildings.

Given the proximity of the solar PV panels to the airport operations and its receptors, a comprehensive glint and glare assessment is necessary to evaluate the potential impacts on aviation safety. This assessment will consider the layout and orientation of the PV panels, the geographical features of the site, and the operational parameters of the airfield to ensure that any potential risks are adequately mitigated.

Other community receptors have not been modelled, such as the nearby suburbs and motor vehicles, as this report's focus is solely on the aviation receptors.

At certain angles, the sun may reflect light in a specular manner off the surface of the Photovoltaic panels which affect the receptors vision, thereby causing an 'after-image' or 'temporary blindness' depending on the strength of the specular reflection.

2. ASSUMPTIONS AND LIMITATIONS

The design specifications of the project were supplied by the client. The final design specifications, layout and configurations of the solar PV panels is not finalized. This report will consider a worst-case scenario of glint and glare exposure due to the installation. This will allow the developer to assess areas of concern and provide the areas within which the development of the solar PV panels will be acceptable to aviation safety, from a glint and glare perspective.

A summary of assumptions and abstractions required by the ForgeSolar analysis methodology is provided below:

- The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, the software developers have validated the models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque USA, and the tool accurately predicted the occurrence and intensity of glare at various times and days of the year.
- Several calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects analyses of path receptors.
- Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including Air Traffic



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Control Towers (ATCT's). The ForgeSolar methodology relies on an analytical, qualitative approach to accurately determine the overall hazard (i.e., green vs. yellow) of expected glare on an annual basis.

- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- The algorithm does not consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
- The variable direct normal irradiance (DNI) feature scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. **The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors such as smoke from fire, mist etc.**
- The ocular hazard predicted by the tool depends on several environmental, optical, and human factors, which can be uncertain. The developers provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results.
- The system output calculation is a DNI-based approximation **that assumes clear, sunny skies all year-round.**
- Hazard zone boundaries shown in the Glare Hazard plot (based on Figure 3) are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
- Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
- Glare vector plots are simplified representations of analysis data. Actual glare emanations and results may differ.
- Due to the final design specifications of the proposed developments not yet being finalized, a standard height of 0.5m above ground was used to model the solar PV structures. Other heights above ground were modelled in 0.5m increments up to 2.5m. The results show that the difference in height had a negligible difference in glint and glare impacts. All results in this report pertain to the 0.5m height above ground.
- **The report has been updated to assess the Solar PV Layout SDP Revision 16. Final Version 1, issued on the 6th of September 2024, is disregarded.**

3. LEGAL REQUIREMENTS

In South Africa, there is limited literature and no regulatory framework with regards to the 'glint and glare' effects from solar panels in relation to airspace use. Various efforts to communicate with various authorities have been made to confirm the availability of Obstacle Notices pertaining to Solar Facilities and the Impacts of Glint and Glare.

In the absence of local regulatory requirements, the United States Federal Aviation Administration: Final Policy, Review of Solar Energy System Projects on Federally Obligated Airports of May 2021 was used as the main reference.



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Within this guideline are numerous case studies of solar projects similar to this project. The FAA approved ForgeSolar software package was used to predict the effects of the glint and glare from the PV panels.

4. PROJECT DESCRIPTION

The full project description for the proposed airport expansion and auxiliary infrastructure is included in the Environmental Impact Assessment Report compiled by PHS Consulting and not repeated here. The project description in this report only pertains to the components of the project that are relevant to the Civil Aviation Glint and Glare Assessment.

Cape Winelands Airport has been operational since 1943 and currently operates under a Category 1 Aerodrome license. The current operational runways (05/23 and 14/32) are used mostly for flight training, charter, recreational flying and other unscheduled general aviation activities. The flight activity under current conditions is 100 air traffic movements per day on average.

The expansion of the Airport will facilitate commercial flight operations both internationally and domestically. As shown in the simplified layout in Figure 5 below, key components of this development are the construction of the 3.5km primary runway (FAWN Runway 01/19), the Air Traffic Control Tower with a height of 40m above ground level, the solar PV panels on the building roofs within the various precincts and the ground based solar PV installation in the southeast corner of the facility's boundary.

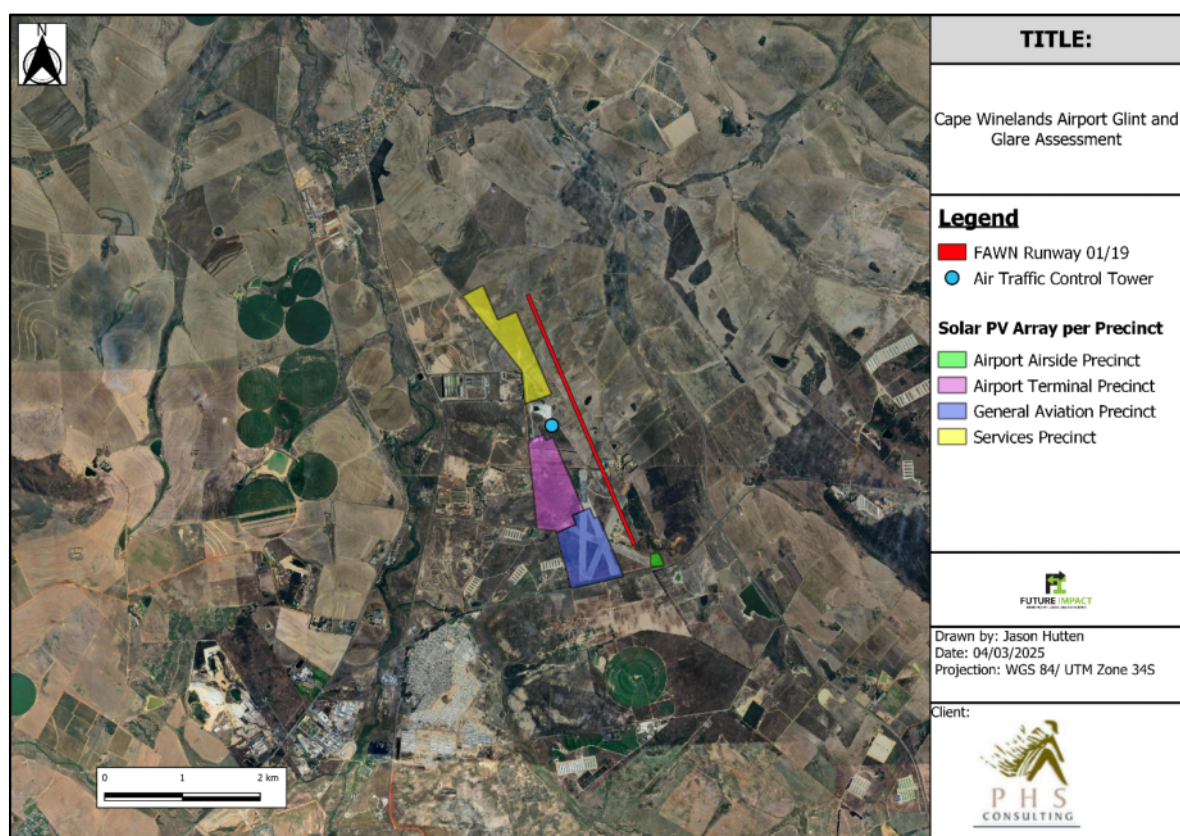


Figure 5: CWA Precinct Layout in relation to FAWN Runway 01/19.

Since the final design and layout of the Solar PV installation have not been finalized, a worst-case scenario approach has been adopted. The layout used in the model represents the maximum potential coverage of the solar PV footprint, considering all possible areas. However, this layout does not account for precise system geometry, including detailed features like gaps between modules, variations in



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PV array height, and support structures. These elements may influence the actual glare results. In the model, the PV array is treated as a footprint consisting of numerous infinitesimally small panels, reflecting sunlight based on the array's tilt and orientation.

The footprint shown above is based on the information extracted from the **updated** layouts supplied in the Electrical Engineering Bulk Services Design Report (Selkirk and Selkirk, 2025) dated 4 March 2025. Annexure A shows the desired layout of the solar PV arrays.

Furthermore, the exact heights above ground of the solar PV panels are not yet finalized. This required an iterative process in the modelling whereby the fixed-tilt configurations described below were modelled "on top" of buildings with heights of 5m, 10m, 15m and 20m. The ground based solar PV panels were set at a standard height of 1.5m (at the midpoint) aboveground. The results of the modelling indicate that the height of these panel has little effect on glint and glare exposure to aviation receptors.

Lastly, the orientation of the tilted solar PV panels will be dependent on the building roof design. Two scenarios were modelled:

- An orientation of 0° (i.e. the panels will face true north and be the optimal solution for energy yields).
- An orientation of 338° (the more likely orientation based on the current building layout which is the direction the building roof lines are oriented).

The fixed parameters for the modelling configurations of the Solar PV panels are as follows:

- **Tracking System:** Fixed Tilt
- **Tilt Angle:** 20° to the horizontal
- **Type of Panel Surface:** Lightly textured glass with Anti-Reflective Coating (this was used as it is the most widely available surface type on the market) with the following reflective properties:
 - Average RMS slope error (mrad) = 9.16
 - Average beam spread (mrad) = 119
 - Standard deviation of slope error = 3.17
 - Standard deviation of beam error = 38.0

5. THE RECEIVING ENVIRONMENT

The proposed project may impact on aviation receptors located in and around proposed Cape Winelands Airport Expansion. This will be a commercial aerodrome with domestic and international flights scheduled. The 3.5km asphalt primary runway 01/19 with two approach paths and 1 Air Traffic Control Tower was considered for the aviation glint and glare receptors. These receptors are labelled as follows:

- 2-Mile Approach Flight Path Receptors
 - FAWN Runway 01
 - FAWN Runway 19
- Air Traffic Control Towers
 - ATCT-1 (40m height above ground)

Note: Only manned ATCT facilities are considered. Digital Camera Towers will be installed but are not assessed in this report.

The above receptors are shown in Figure 6 below.



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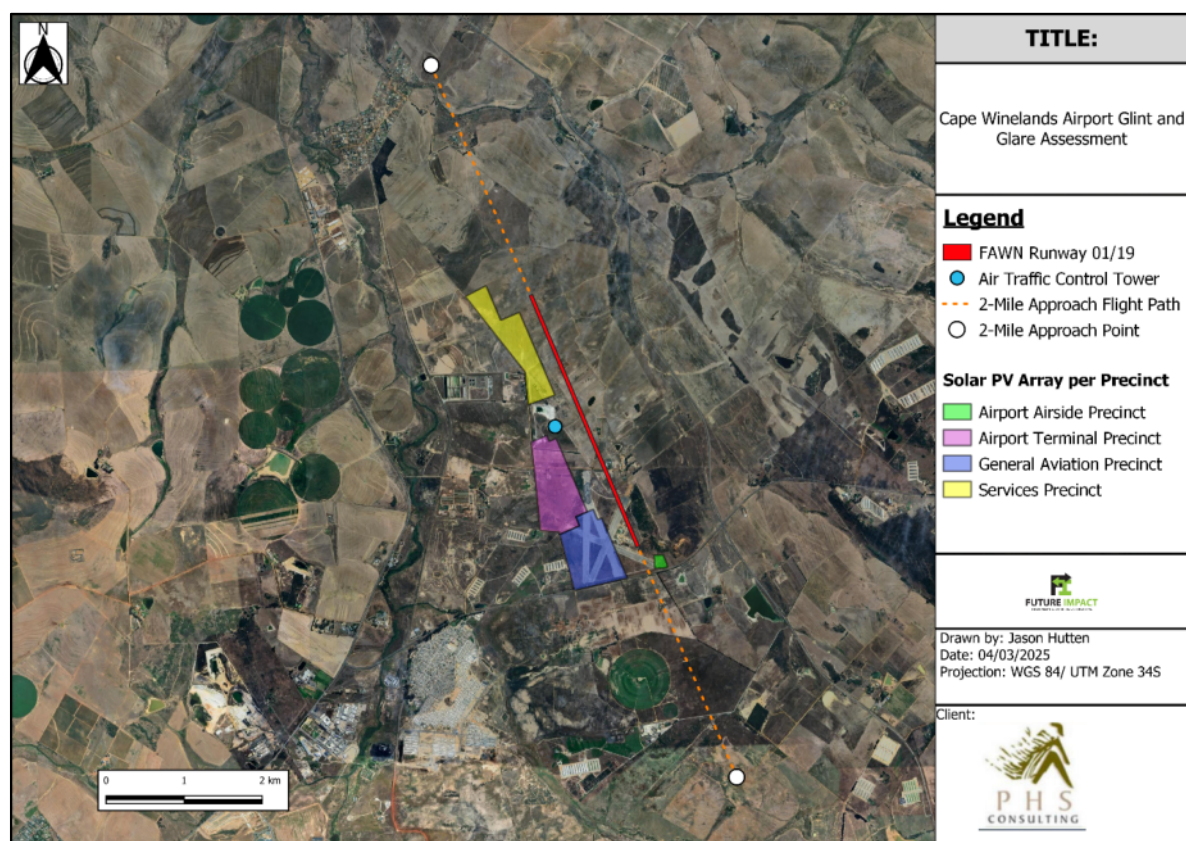


Figure 6: Receiving Environment

6. RESULTS

The modelling results indicate that receptors will experience “Green” and “Yellow” glint and glare exposure for all configurations assessed below.

The analysis parameters and observer eye characteristics were as follows:

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

6.1 Summary of Results: Panels on a Fixed Tilt Axis Orientated 0° (True North)

Table 1 – 4 below shows that no glare exposure will be expected at the different building heights on which the solar PV arrays will be installed for panels that are orientated at 0° azimuth (True North). This is due to the removal of the buildings in the south east corner of the services precinct being removed in the updated layout.

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Table 1: Glint and Glare Yearly Exposure Time - 5m Building Height (0° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

Table 2: Glint and Glare Yearly Exposure Time - 10m Building Height (0° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

Table 3: Glint and Glare Yearly Exposure Time - 15m Building Height (0° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

Table 4: Glint and Glare Yearly Exposure Time - 20m Building Height (0° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

6.2 Summary of Results: Panels on a Fixed Tilt Axis Orientated 338°

Table 5 – 8 below shows the minutes of glare exposure that can be expected at different building heights on which the solar PV arrays will be installed for panels that are orientated at 338° to True North. No Glare is expected due to the removal of the buildings in the south east corner of the services precinct being removed in the updated layout.

Table 5: Glint and Glare Yearly Exposure Time - 5m Building Height (338° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0



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Table 6: Glint and Glare Yearly Exposure Time - 10m Building Height (338° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

Table 7: Glint and Glare Yearly Exposure Time - 15m Building Height (338° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

Table 8: Glint and Glare Yearly Exposure Time - 20m Building Height (338° Orientation)

Receiver Name	Green Glare (mins)	Yellow Glare (mins)	Red Glare (mins)
FAWN Runway Approach 01	0	0	0
FAWN Runway Approach 19	0	0	0
Air Traffic Control Tower (ATCT-1)	0	0	0
Total	0	0	0

7. CONCLUSIONS AND RECOMMENDATIONS

The aim of this study was to determine the impact that solar glint and glare would have on various aviation receptors. The FAA model considered the 2-mile receptors on the approach to Runway 01/19 and The Air Traffic Control Tower.

The initial modelling results in Version 1 of this report indicated that the Air Traffic Control Tower will be exposed to green and yellow glare. It was recommended that the south eastern portion of the Services Precinct (see Figure 8) be excluded from the installation of the Solar PV panels to eliminate the exposure to the Air Traffic Control Tower.

The remodelling conducted in this report (Version 2), was based on the updated layout provided that incorporated the above recommendation. The results of the Version 2 modelling indicate that no glare will be expected.

The Glint and Glare Impacts will therefore be **Very Low** and acceptable in terms of the United States FAA Regulations if the recommendations are implemented. It is therefore recommended that the project receive authorisation from the Civil Aviation Authority from a glint and glare perspective.



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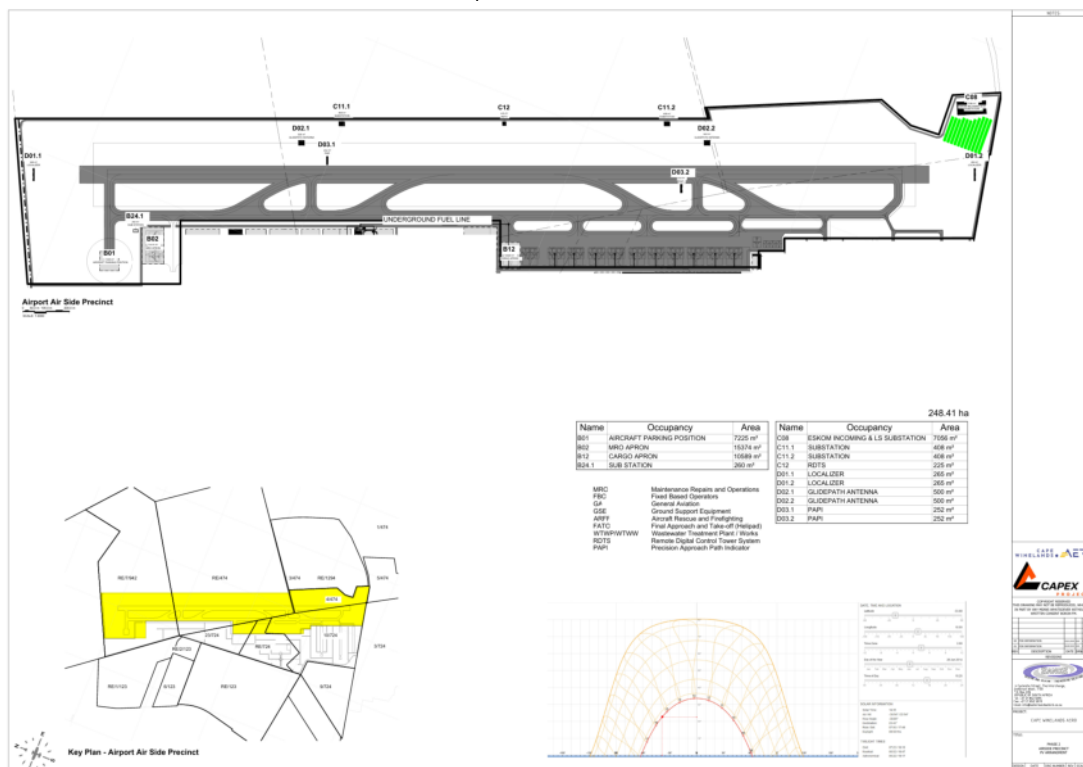
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9. ANNEXURES

Annexure A: Proposed Solar PV Facility Designs (Selkirk and Selkirk, 2025)

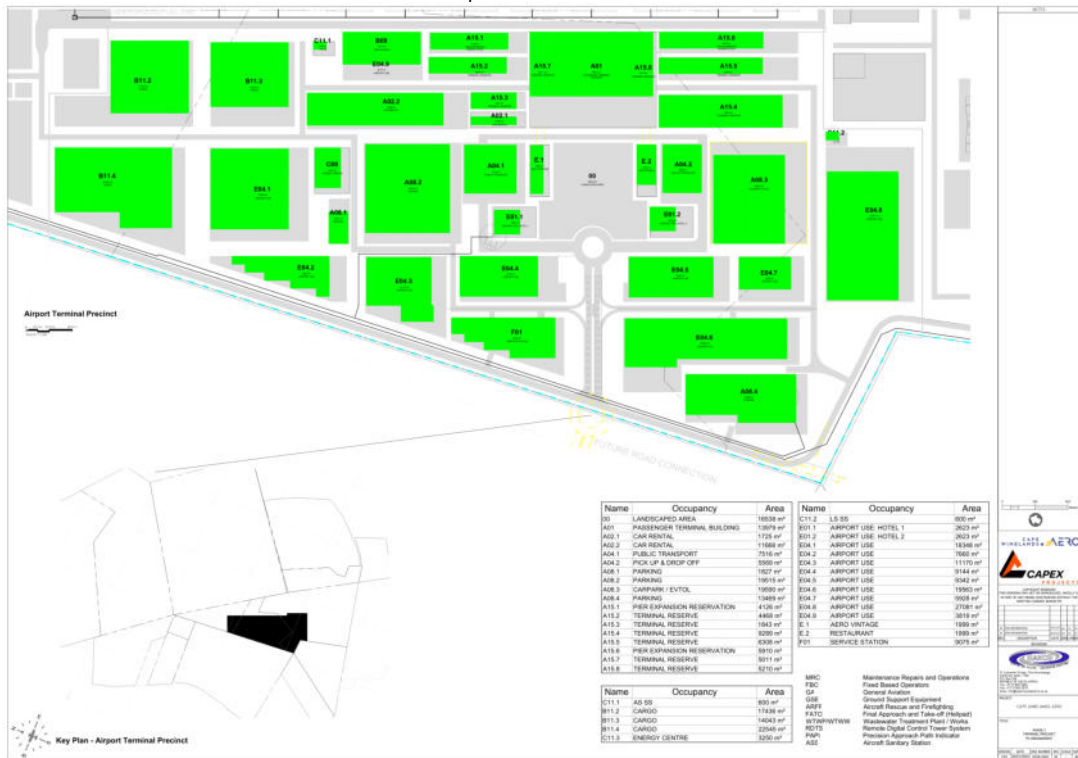
The figures below show the desired location of the solar PV panels as described in the Electrical Engineering Report (solar PV panels in green). The four figures correspond to the three precincts and the ground-based solar PV array as assessed in this report.

Airport Airside Precinct

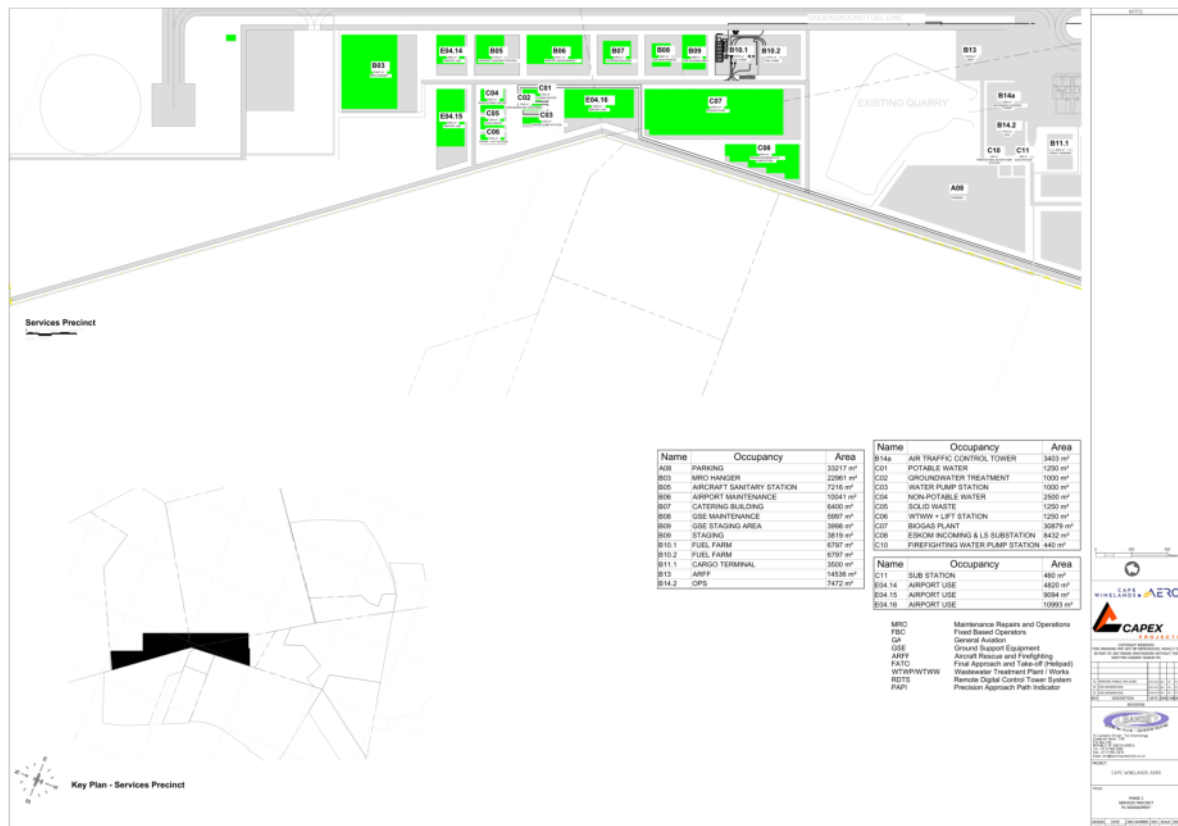


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General Aviation Precinct

