Environmental Scoping Study for Photovoltaic Farm at BNTCL, Christ Church

Final Report

September 30, 2022

Prepared for:

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Revision	Description	Author		Quality Check		Independent Review	

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NON-TECHNICAL SUMMARY

Environmental Scoping Study for Photovoltaic Farm at BNTCL, Christ Church

PDD No. 0858/06/2019E

3 April 2023

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1.0 INTRODUCTION

The Client proposes the construction of a solar farm on lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados (the Project). The Project will deliver carbon-free, and renewable electrical power to be sold to Barbados Light & Power Ltd. The Project will produce approximately 5.0MW AC of renewable energy for integration into the national power grid.

With the release of the Barbados National Energy Policy 2019–2030 (Government of Barbados 2019a), the Government of Barbados officially announced its intention for the island to achieve 100% renewable energy and carbon neutral transformational goals by 2030. As a baseload clean asset, the Project will contribute towards Barbados achieving its renewable energy and carbon neutrality targets.

2.0 DESCRIPTION OF PROJECT

The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres); the array proposed will occupy most of the site. The array will consist of 14,520 ground mounted panels facing in a Southwards direction at a tilt angle of fifteen (15) degrees to the horizontal. These 14,520 panels are expected to produce approximately 5.0MW AC of renewable energy electricity for sale to Barbados Light & Power Co. Ltd.

Primary Access to the proposed PV site shall be from Fairy Valley Road in the South that currently provides access to the BNTCL compound. Access into the fenced and gated PV farm compound shall be from the South; upon entry there shall be a vehicle parking area, control room and equipment storage container.

A control room, in a retrofitted shipping container, shall be placed in the southwestern region of the site and shall contain switches and other equipment for the operation of the facility. The control room will also have a washroom and kitchenette. Also, in the southwestern corner of the site will be an equipment storage container and the transformer pad.

Electricity produced from the farm shall be evacuated from site via cables on overhead utility poles along Fairy Valley Road.

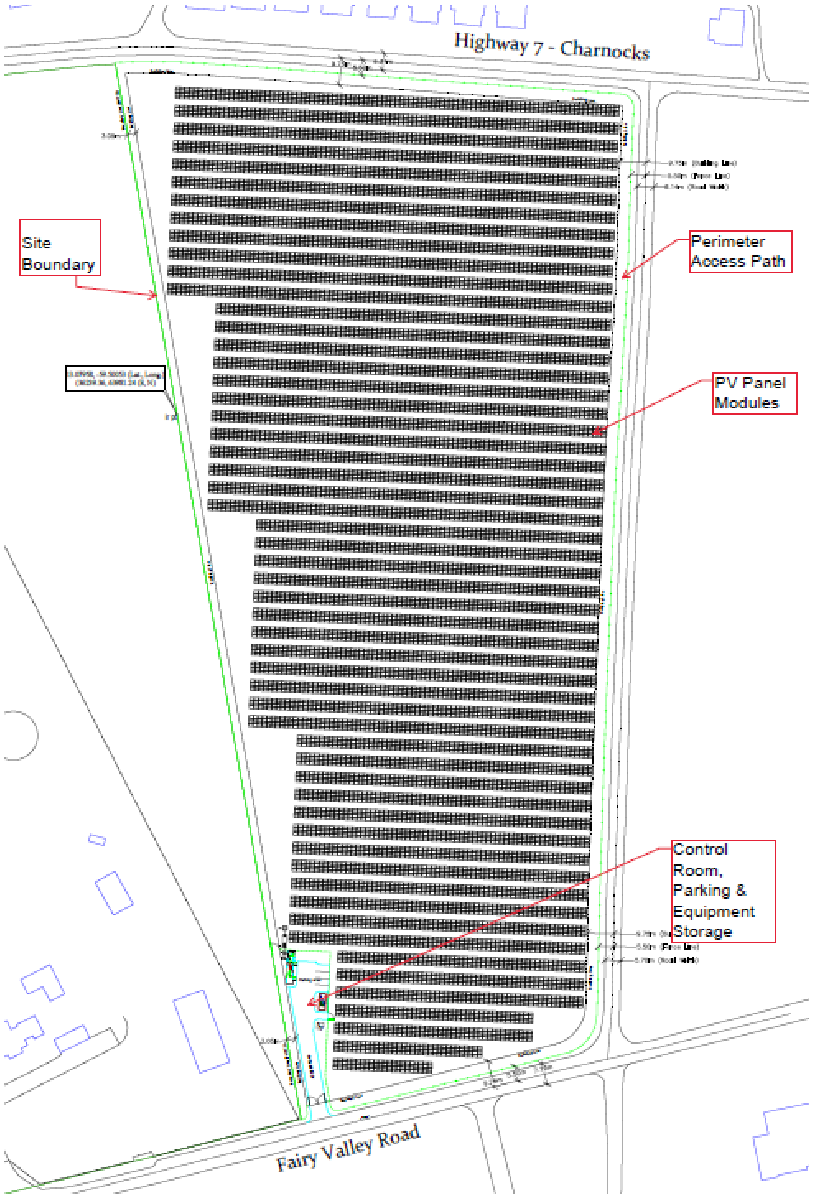

Figure 1: Site Plan

3.0 DESCRIPTION OF ENVIRONMENT

The Project will be located in the south of Barbados on leased lands of BNTCL. Surrounding land use is mainly residential and commercial with pockets of agricultural use. The site is bounded to the East by a parallel secondary access road which is in turn bordered to the East by rab/fallow land, to the North by Highway No.7 which is adjacent to residential and commercial buildings, to the West by other lands of BNTCL and its fuel tank farm and administrative and operations buildings and to the South by Fairy

Valley Road which is in turn bounded to the South by other lands of the Grantley Adams International Airport (GAIA).

The site for development is relatively flat with a gentle slope in a southerly direction. The site consists of mature clay soils with an average thickness of 450mm. Limestone rock depth in the region of 69m is expected below the site for development; groundwater exists beneath the Site as a reservoir resting above saline water, in the coral rock medium, at the interface with seawater; this formation is called sheetwater. The site is located in a Zone 5 Barbados Water Authority (BWA) groundwater protection zone and in Zone D under the revised 2020 Water Protection and Land Use Zoning Policy. Drainage at the site is mainly through overland flow from North to South. There are no natural drainage watercourses in the vicinity of the site for development. Since the site is entirely vegetated, this runoff is expected to dissipate via depressions on site and the infiltration of runoff to the groundwater zones. An urban drainage system exists in the vicinity of the site, which routes runoff primarily from roofs, roads and similar hard standings in southern directions towards the GAIA property. The site for development is disturbed; as such, the surface vegetation is solely natural grasses which are often mowed. Habitat and fauna in the vicinity of the site are expected to be similar to those found on “rab”/fallow land elsewhere in Barbados.

4.0 SUMMARY OF ENVIRONMENTAL IMPACTS AND MITIGATION

4.1 Land Use

Potential Impacts: Though the land use designation of the site is for Employment Areas, soils on the site are Class 1 Super Prime. The development and operation of the PV farm will eliminate the potential for the use of the lands of the site for agriculture and its potential for assisting with shoring up the food security of Barbados.

Mitigation: The site is currently not used for agriculture; thus, the use of the site for a PV farm will not take away from the stock of land currently being used for agriculture. Also, the site is outside of the Soil Protection Overlay Zone (lands identified as an irreplaceable resource for agricultural production) and as such is not within the bank of lands mandated under the Food and Agriculture land use designation for return to agricultural use. The latter statements having been made, there is the potential for sheep grazing agriculture for landscape maintenance as part of the operations of the plant.

4.2 Electromagnetic and Radar Interference

Potential Impacts: Electromagnetic interference from the operation of the PV may impact on nearby communication equipment. The operation of the PV farm may also impact on radar use at GAIA.

Mitigation: Consideration should be given to siting inverters (the only component of the proposed PV system capable of emitting electromagnetic interference) such that they are at least 46m away from the proposed utilities wall. At 46m away from inverters, the electromagnetic field is at background levels. The nearest airfield radar system is greater than 46m from the site and so no impact to operations at GAIA is anticipated.

4.3 Groundwater and Wastewater Assessments

Potential Impacts: During the construction phase, spillages of fuel, lubricants, coolants, etc. from construction equipment have the potential to be leached by rainfall or intense water use activities to the groundwater zone beneath the site.

During the operations stage, the disposal of wastewater from the facility's operation has the potential to impact groundwater quality beneath the site; the site is in a Zone 5/Zone D groundwater protection zone.

Mitigation: Best practices for the proper handling, storage and disposal of spilled hazardous chemicals and fuels should be referenced and included in the contractor's environmental management plan to prevent spillages during the construction phase.

During the pre-construction phase, the foul wastewater disposal system should be designed to Environmental Protection Department guidelines for building wastewater disposal systems in Zone 5 groundwater protection areas.

During the operations phase, an operations management plan should be developed. This plan should schedule the routine inspection and cleaning of the septic tank and soakaway with inspections occurring at least once every six (6) months.

The cleaning of PV panels should only be done with clean water. No detergents or cleaning chemicals should be used; this way water that runs off onto the ground will not have any chemicals entrained.

4.4 Drainage

Potential Impacts: The construction stage of the project may involve the use of heavy equipment, which may result in the removal of the grass surface in areas and increased potentials for the washing of topsoil and soil erosion. Such a scenario could result in soil materials being washed towards the southern regions of the site.

During operation, the presence of solar panels may result in a significant increase in surfaces that prevent water from passing though. This may in turn increase runoff quantities and may cause flooding in downstream areas. South of the site is Fairy Valley Road and other lands of GAIA.

Mitigation: Potential impacts during construction are transient. As such, the possibility of the impact occurring ceases after the completion of the construction stage and the reinstatement of grassed areas. Regardless, potential mitigation measures include the use of silt screens to contain and retard the movement of silt and topsoil from localised areas; temporary boulder barriers/walls at strategic points of surface runoff to retain sediment and control the rate of runoff during the construction phase; and the removal of any stockpiled topsoil that will not be used for re-instatement.

Provided ground conditions beneath solar panels are suitably grassed and maintained, the presence of solar panels on site is not expected to increase runoff or alter the drainage characteristics of the site, and by extension promote flooding on lands downstream of the farm. The increase in impermeable area due to the construction of sheep pens is deemed negligible. Measures that may be implemented to ensure the maintenance of the site's drainage characteristics are:

- Routine maintenance of the grassed surface to ensure that there are no bare patches or inconsistencies, which could result in a change to the runoff characteristics in those areas.

- Consideration could be given to the use of a vegetated buffer strip at the downstream northeastern, eastern and site boundaries – to reduce any excess runoff due to the presence of any bare patches within the solar panel site.

- Consideration should be given during the detailed design stage of the drainage system of the site of creating a depressed area closer to the southern boundary to promote runoff attenuation, infiltration and percolation processes. Consideration should be given to the installation of a drainage suckwell in this depressed area to expedite drainage of captured water and prevent ponding.

4.5 Ecology

Potential Impacts: During operations, the fencing of the PV farm may restrict fauna from traversing the site area, which may have once formed part of the habitat of these animals. The construction of the PV farm may also cause glare and solar flux issues, which could result in bird kills at the site.

Mitigation: The use of galvanized chain link fencing with a raised privacy screen – maybe 450mmm or thereabouts from ground level would allow small animals, typically found in Barbados on “rab” lands, to enter the complex.

The PV farm will not be a Concentrating Solar Power (CSP) farm, so the solar flux related impacts would not occur. The impacts of glare from PV panels on bird kills is an emerging area of research in the PV industry; the true reason for this form of bird kill is still unknown, as are measures that can be taken to mitigate or eliminate this impact.

4.6 Noise

Potential Impacts: During construction, noises emanating from the Project site are expected to be varied and may be linked to various steps in the preparation and building of the site as well as vehicular movements conveying the workforce, construction equipment, and facility infrastructure to and from the site. The following are likely sources of noise:

- Site clearing and grading activity using bulldozers, excavators, trucks, etc.
- Ditching for runoff and trenching for cables.
- Installation of pipeline sections for water supply, cable installation, etc.
- Pouring and forming of concrete for PV racking foundations.
- Creation of laydown areas and the movement of earth and construction materials to and from the site.
- Infrastructure brought to the site such as tanks for oil fuel.
- Commissioning and testing.
- Clean-up and landscaping.
- Workers and equipment brought to site.

During operations, the operation of the PV farm and its substation may result in noise impacts to existing operations at the BNTCL fuel storage facility to the West, persons utilizing building to the South on lands of GAIA and the strip of residential/commercial properties to the North of the site.

Mitigation: During pre-construction, consideration should be given to building concrete infilled reinforced block walls to the South, West and North of the transformer location; these walls would serve as sound attenuation walls. It is possible that the sound attenuation walls could be constructed after the plant is up and running; confirmatory noise readings could be taken to determine whether there is indeed a noise impact from transformer and inverter operations.

During construction, mitigation measures include:

- Construction and post-closure activities are expected to be highly variable and unpredictable at a detailed level. Construction equipment will be operating over a wide-ranging area and specific controls may be necessary when construction activities are near receptors.
- Construction equipment should be maintained in good working order and properly muffled. Also, where possible major noise generation activities should be planned to take place during day-time hours.
- A Monitoring and Protection Plan (part of the contractor's environmental management plan) should be in place to be followed by the contractor to address potential noise and vibration impacts.
- Construction and post-closure vibration levels are not expected to be perceptible at nearby receptors due to their distance away from the site. Ground-borne vibrations are generally more difficult to mitigate than airborne noise. Use of alternative construction methods and tools may reduce vibrations. Examples include:
    - Pre-drilling of pile holes – (if piles are proposed as racking foundations).
    - Use of rubber tired rather than tracked vehicles.
    - Place haul loads away from vibration-sensitive areas.
    - Schedule construction and post-closure activities, particularly any pile driving, for times when the activity does not interfere with vibration-sensitive operations (e.g., avoid night-time activities)

4.7 Glint and Glare

Glint and glare refers to reflected sunlight from shiny surfaces (in this case, the PV panel) that can affect the visual environment of those in surrounding areas. Glint refers to a quick flash of light while glare occurs for an extended period of time. Glint and glare assessments are often required for PV developments around the world.

Potential Impacts: During operations, the existing land use at the BNTCL fuel handling facility in the West, and other existing commercial/industrial operations to the South East and East of the proposed solar farm may be impacted by glint and glare impacts throughout the course of a year.

Mitigation: During pre-construction, a tree screen of height not less than 3m (10 feet) should be constructed along the Northern, Eastern, and Southern site boundaries. Along the line of sight of two-storey buildings, tree screens should be grown to a minimum height of 6m. There is an existing partial screen along the western boundary of the site in the form of an earthen berm with tree line atop, the southern section of this should be extended to the site's southern boundary. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors to the North, South East, and West and by extension mitigate – if not eliminate – the potential for glare impacts. In addition, consideration should also be given to utilizing panels that may reduce glint and glare impacts. The implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm.

Consideration should also be given to optimizing the panel angles and utilising panels that produce less glare to minimize glare impacts; the focus of the optimization should be to eliminate the potential glare effects at the cabin level of the Air Traffic Control Tower (ATCT).

During operations, if there are reports of impacts from residents or other land users near the development, then consideration should be given to replacing offending panels to a type that reduces glare intensity or removing offending panels.

4.8 Solid Waste Disposal Assessment

Potential Impacts: During operations, the improper disposal of solid wastes from the operation of the PV farm could adversely affect the environment, and the health and safety of employees who work from time to time on the farm. Additionally, at the end of the useful life of PV modules, their local disposal in landfills in Barbados – especially construction and demolition landfills, which are unlined – could result in the leaching of heavy metals to groundwater zones.

Mitigation: The Operations Management Plan of the facility should include the use of large capacity municipal garbage skips for the receipt of green waste. Skips should be routinely emptied. Consideration should be given to permitting frequent sheep grazing as means of controlling the volume of green waste produced from the maintenance of grassed areas.

Regarding disposal of panels at their end of life, preference should be given to panels that are composed of less environmentally damaging materials. Additionally, the Developer and the host of other PV developers on the island should approach the Ministry of Health, the Sanitation Service Authority and the Sustainable Barbados Recycling Center (SBRC) to create a mechanism by which all PV farm developers can dispose of their end of life panel modules to the SBRC or other approved local recyclers. The intent would be that panels be shipped overseas to an approved recycling facility, given that such a facility does not exist in Barbados and may not be developed in Barbados – due the development cost, intricacy, and limited market for local/regional recycling.

4.9 Climate Change and Natural Disaster Assessment

Potential Impacts: During operations, a fire on site could spread along grassed lands and impact on the PV farm. Higher temperatures with low rainfall during the dry season increase the potential for bushfires.

In addition, a strong tropical storm or hurricane could impact the PV farm and substantially damage panels and racking support structures resulting in the inability to generate power from the site and the need to dispose of damaged panels

Mitigation: Regarding potential fires, consideration should be given to constructing a firebreak between the outer edge of the panels and the perimeter of the facility as well as the placement of a fire hydrant on site to help the fire department in fighting fire.

The PV farm system should be structurally designed and constructed following guidance given in section 4.10.5 of the ESS report. This includes design and construction to withstand wind speeds projected with climate change. The findings of a geotechnical engineering study should also be used towards structurally designing the foundation of PV module racking.

During operations, the Developer should have his technical team conduct a visual inspection of the supporting structures for the PV modules before the onset of the annual hurricane season to determine whether there are any defects in the PV system which would increase their vulnerability to extreme weather. Where defects are noted, these should be repaired prior to the advent of the annual extreme weather season.

4.10 Visual Impact Assessment

Potential Impacts: During operations, the construction of the PV farm may result in visual impacts to nearby land users.

Mitigation: The site for the PV farm is visible from all directions. Though there are existing screens by way of an earthen berm along the western site boundary and a vegetated hedge along the site's northern boundary, these screens do not extend along the entire lengths of respective boundaries. Following on from the recommendations of the glint and glare study, it is recommended that a tall (minimum 3m high) and thick vegetated screen be planted along the Western, Northern, Southern and Eastern site boundaries. Once erected, these screens shall hide the PV farm site from ground level elevation in all directions from the site. Notwithstanding the presence of the screens the PV site will remain visible to vantage points of upper floors of buildings and from tall structures such as the ATCT, as well as from landing aircraft.

5.0 SUMMARY OF SOCIAL IMPACTS AND MITIGATION

A rapid social assessment was conducted, and a social engagement plan and grievance redress mechanism were prepared.

A rapid social assessment is effectively a desktop study with limited field investigations; it does not include the rigorous field data gathering activities, but primarily relies on the use of census data from the governmental statistical department databases. The potentially affected communities were Charnocks, Seawell, Coverley, Fairy Valley, the airport and its immediate surroundings. Demographic profiles of these communities are provided in social assessment study report in Appendix C of the ESS.

The potential positive and negative effects that the construction and operational phase activities could possibly have on the social components are described in the table below.

Project effects - negative	Project effects- positive
CONSTRUCTION PHASE	
• Noise and vibrations from construction vehicles and equipment • Impaired air quality from dust and other emissions from construction vehicles and equipment • Health and safety risks to on-site workers • Health and safety risks to adjacent communities and general public • Perceived negative aesthetic impacts from the array • Suspicion or objection towards the project.	• Construction related jobs will be created for skilled labour • Increased retail business, primarily food related from construction workers
OPERATIONAL PHASE	
• Potential health and safety impacts on workers and adjacent communities • Accidents (non-routine) events • Perceived negative aesthetic impacts from the array	• Employment opportunities for skilled labour. • Advances the renewable energy policy to increase energy conservation and efficiency, and contribute to mitigation efforts in reducing GHG emissions.

Recommended mitigation measures include:

- A carefully planned and implemented public awareness campaign to address the typical concerns raised in relation to the construction of a solar farm. The campaign should clearly explain the design of the farm, as well as the potential benefits that could accrue to Barbados.
- Compliance of the Project with the legal and statutory labour requirements to safeguard Community and Worker Health and Safety.
- Construction should be based on an approved construction management plan that includes measures to reduce the impacts of noise, dust and vibrations. Details for the management of noise, dust and vibrations should be included in the contractor's Environmental Management Plan. However, at a minimum, these measures should include:
    - Dust management measures such as fitting machinery with emission control devices compliant with International Design Standards, the use waterproof boxes to minimize spillage along roadways, covering all trucks that are hauling material, washing truck tyres before exiting the construction site onto existing paved roads, the observance of the speed limit by construction vehicles traversing the adjacent areas, cleaning spillages on roadways and property accesses promptly to minimize spread of sediment and dust and reducing or eliminating stockpiles as much as practical.
    - Noise management measures such as the installation of mufflers and appropriate sound attenuation devices on construction equipment, conducting work onsite within specifically set times, switching off construction equipment and vehicles when not in use and the

observance of the speed limit by construction vehicles traversing the adjacent areas with minimal use of horns (only as necessary).

  - With respect to vibrations, it is expected that the Contractor would have the required insurance policies to cover any legitimate claims made as a result of any damage that may occur during the construction phase.

- An approved Traffic Management Plan (which should be submitted by the Contractor) to control on-site traffic as well as the practices of construction drivers to and from the construction site.
- Contractors should be required to operate approved occupational health and safety plans which detail the safety provisions according to the type of machinery and materials being utilized. Workers should be required to use protective gear and ergonomic devices should be available, e.g., for lifting and carrying. Only trained and/or certified persons should use specialized equipment and handle dangerous chemicals. There should be appropriate supervision to ensure that workers do not cause harm to themselves or others on the site.
- There should be adequate 24-hour security to prevent curious onlookers from wandering into the construction zones. As required, sufficient and appropriate lighting, clearly visible signage that meets the universal design environmental access requirements/standards for persons with disabilities, and open and unobstructed passageways should be installed to enforce safety in and around the construction zone.
- Public service announcements should be provided to ensure that commercial operators, residents, and the public are updated on the construction activities, especially those that could be disruptive.

5.1 Social Management Plan

The social management plan focuses on the engagement of the stakeholders to ensure that there is a mechanism in place to provide information on the project to the public and to encourage participation of all affected groups in a consultation process. The social management plan comprises two components: 1) the social engagement plan which facilitates open and continuous communication and consultation between various groups including construction contractors, stakeholders, and the general public; and 2) the grievance redress process which ensures that legitimate concerns of the stakeholders are recorded, investigated and addressed. The Social Engagement Plan is described in the social assessment study in Appendix C of the ESS report.

The Grievance Redress Mechanism (GRM) facilitates effective communication between the project and affected persons and can help to win the trust and confidence of community members thereby creating productive relationships between the parties. They provide a structured and systematic way of resolving grievances and disputes relatively quickly before they escalate to an unmanageable level. Based on the rapid social assessment, it can be anticipated that there will likely be complaints about the dust and noise from the project, especially from the residents and businesses in closest proximity to, and downwind of the construction zone. The GRM provides guidance to the BNTCL to be able to address these and any other concerns that might arise during the project. Further details on the GRM and implementing a GRM for this project are described in the social assessment report in Appendix C of the ESS report.

6.0 Alternatives Analysis

To do nothing would result in the site continuing to be vacant with a running cost for maintenance – debushing, etc. The site is zoned for developments that promote employment, so it is a possible the land could be used for the construction of office buildings or similar that could permit employment. To not build the PV would eliminate the possible contribution of the site towards reducing Barbados's fossil fuel bill and carbon footprint. In addition, the potential of the site to contribute to Barbados' green energy policy mandate of 100% renewable sources of energy by 2030 would not be realized.

The production of electricity via the erection of wind turbines on the site is an alternative renewable energy solution that could be considered. Wind studies would first have to be done to determine whether the proposed site is suited for the development of a wind farm. The potential negative impacts to the environment – particularly other nearby residential, and commercial land users – would be greater as compared to the development of the proposed PV farm; there could be visual, ecological, shadow flicker, and noise impacts, as well as height restriction to the turbines given the site's proximity to GAIA.

7.0 Conclusion and Recommendations

It is hereby concluded that if all the recommendations of the scoping study are implemented then it is unlikely that the development of the proposed PV farm on lands leased and maintained by the BNTCL will have an adverse impact on nearby human receptors and the surrounding environment.

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Executive Summary

1.0 EXECUTIVE SUMMARY

The Client proposes the construction of a solar farm on lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados. The farm shall generate power to be sold to Barbados Light & Power Ltd. The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. These 14,520 panels are expected to produce approximately 5MW AC of renewable energy electricity for integration into the national power grid.

The Developer has applied to the Town & Country Development Planning Office (TCDPO) for permission to develop the PV farm. Environmental Scoping Studies (ESS) are required for PV developments in Barbados, given their industrial nature. A Terms of Reference (TOR) for the scoping study has been prepared and is attached in Appendix A of this study.

This document presents the findings of an ESS based on the TOR in Appendix A.

2.0 ENVIRONMENTAL SCOPING STUDY

The Terms of Reference of the ESS included the following:

- Legal and Regulatory Framework
- Description of site and proposed development

Environmental assessments

- Land use
- Noise
- Drainage
- Glint & Glare
- Solid Waste and Wastewater Disposal
- Visual Impact Assessment
- Rapid Social Impact Assessment including stakeholder engagement and grievance redress mechanism
- Alternatives Analyses

During the conduct of the ESS, the following additional assessments were added to the study, as they were ultimately deemed relevant:

- Electromagnetic and Radar Interference
- Ecology
- Climate Change and Natural Disaster Assessment

3.0 LEGAL AND LEGISLATIVE FRAMEWORK

The focus of the development is the production of electrical energy for integration in BL&P's electricity distribution grid; thus, local legislation pertinent to the generation and distribution of electricity is relevant to this project.

In terms of legislative framework, the Town and Country Planning Act Cap.240 specifies the manner in which an application for a development should be submitted to gain permission for a development. The Act also speaks to the Chief Town Planner (CTO) requesting an Environmental Scoping Study (ESS), Environmental and Social Impact Assessment (ESIA), or ESIA of limited scope. Post review and approval of the environmental study by a CTP environmental steering committee, the CTP may request that the Developer host a public meeting to present the findings of the study to the public. The impending Planning and Development Act (2019) – still to be ratified – speaks to the development of a new Planning and Development Board for the consideration of complex applications with the balance of applications passed to the CTP; new Environmental Impact Assessment Regulation are proposed, including – Clause 7 – the applicant having the option of submitting an Initial Environmental Evaluation (similar to a scoping study).

The Physical Development Plan amended 2017 (PDP) for Barbados provides guidance to developers on how their proposed site for development falls within the overall plan for land use in Barbados and what land use permissions currently apply to the particular piece of land(s). The PDP indicates that large renewable energy projects require Environmental Impact Assessments; minimum study requirements for an ESIA are stated.

Policies, laws and regulations that govern the energy sector in Barbados are presented below:

- National Strategic Plan of Barbados for 2005-2025
- The National Sustainable Development Policy
- Sustainable Energy Framework for Barbados
- Draft National Sustainable Energy Policy
- Barbados National Energy Policy 2017-2037
- Barbados National Energy Policy 2019-2030

- The Electric Light and Power Act (2013)
- The Fair Trading Commission Act (2001)
- The Utilities Regulation Act
- Renewable Energy Rider
- Feed-in-tariff

Pertinent pieces of legislation for the development are listed as follows:

- CAP 356: Safety and Health at Work Act
- CAP 283: Underground Water Control Act
- CAP 44: Health Services Act
- CAP 288A: Civil Aviation Act
- CAP 392A: Marine Pollution Control Act

A green paper on revising Barbados' groundwater protection zones promotes the development of solar PV and windfarms on the most restrictive Zone A groundwater protection zone.

4.0 SITE DESCRIPTION

The PV site is situated on leased lands of BNTCL, adjacent and to the East of existing BNTCL buildings. The site is bounded to the East by a parallel secondary access road, to the North by Highway No.7, to the West by other lands of BNTCL and its fuel tank farm and administrative and operations buildings, and to the South by Fairy Valley Road. The Grantley Adams International Airport (GAIA) occupies much of the land to the South of the site. The residential area of Fairy Valley is located 30m to the North and Northwest, with the higher density of development to the Northwest being roughly 220m away from the property's closest boundary. The high-density residential area of *The Villages at Coverley* is located 250m North of the northern site boundary.

The site for development has a relatively flat topography with elevation roughly 64m Above Mean Sea Level (AMSL). The site consists of a shallow Black Association soil cover in the region of 450mm deep. Limestone rock in the region of 69m deep is expected below the site for development; groundwater exists beneath the Site in the form of sheet water. The site is located in a Zone 5 Barbados Water Authority (BWA) groundwater protection zone. Close examination of the Geology Map of Barbados indicates that groundwater beneath the PV site may be flowing in a South-Southeasterly direction under the airport and towards the coastline at Long Bay. Site drainage is predominantly via overland flow in North to South directions with some depression storage and infiltration/percolation. An urban drainage system exists in the vicinity of the site which routes runoff in Southern directions towards the GAIA property. The site for development is disturbed; the surface vegetation is solely natural grasses which are kept mowed for aesthetic purposes. Habitat and fauna in the vicinity of the site are expected to be similar to those found on “rab”/fallow land elsewhere in Barbados.

5.0 PROPOSED DEVELOPMENT

The Developer proposes the construction of a solar farm on leased and maintained lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados. The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southwards direction at a tilt angle of 15° to the horizontal. These panels are expected to produce 5MW AC of renewable energy electricity for integration into the national power grid.

Primary Access to the proposed PV site shall be from Fairy Valley Road in the South that currently provides access to the BNTCL compound. Access into the fenced and gated PV farm compound shall be from the South; upon entry there shall be a vehicle parking area, control room, and equipment storage container.

A 24kV transformer for converting low voltage electricity to high voltage electricity shall be located to the South of the re-purposed 6m x 2.4m steel shipping container used for equipment storage. A total of 14# (preliminary estimate, to be confirmed) string inverters are proposed for the conversion of direct current produced by the panels to alternating current. Each inverter will server a group of PV modules; AC current produced via inverters shall be routed to the transformer for conversion to high voltage electricity for distribution to the BL&P grid. High voltage electricity produced from the farm shall be evacuated from site via high voltage cables on overhead utility poles along Fairy Valley Road.

A control room with switches and other equipment for the operation of the farm; the room is proposed towards the Southwestern region of the site. The room shall be a retrofitted 12m (40ft) steel shipping container, equipped with internet, a washroom, and a kitchenette. Separated effluent from a grease trap and wastewater from the washroom shall be routed to a septic tank and a suckwell soakaway system. Septic tank effluent routed to the suckwell shall percolate and infiltrate to groundwater zones below.

For security purposes, the Developer proposes to fence the perimeter of the farm’s boundary with 2.4m high galvanized chain-link fence with barbed wire atop. Security cameras shall be installed at vantage points that permit the entire compound to be observed. The main entrance to the complex shall be gated and locked. There shall also be perimeter flood lighting. The transformer and inverter station shall be separately fenced and gated to prevent unauthorized persons from coming into contact with those pieces of equipment.

6.0 SUMMARY OF POTENTIAL IMPACTS AND MITIGATION MEASURES

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
Land Use	**Operations Stage**	
	A. Though the land use designation of the site is for Employment Areas, soils on the site are Class 1 Super Prime. The development and operation of the PV farm will eliminate the potential for the use of lands of the site for agriculture and its potential for assisting with shoring up the food security of Barbados.	A. The site is currently not used for agriculture; the use of the site for a PV farm will not take away from the stock of land currently being used for agriculture. Also, the site is outside of the Soil Protection Overlay Zone and as such is not within the bank of lands mandated under the Food and Agriculture land use designation for return to agricultural use. The latter statements having been made, there is the potential for sheep grazing agriculture for landscape maintenance as part of the operations of the plant.
Electromagnetic & Radar Interference	**Pre-Construction Stage**	
	A. Electromagnetic interference from the operation of the PV farm may impact on nearby communication equipment.	A. Consideration should be siting inverters such that they are at least 46m away from the proposed control room.

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
	B. The operation of the PV farm may impact on radar use at the Grantley Adams International Airport (GAIA).	B. The site for development is greater than 46m from the nearest airfield radar system; no impact to the operations of GAIA radar equipment is expected.
Wastewater Assessment	**Pre-Construction Stage**	
		A. The foul wastewater disposal system should be designed to Environmental Protection Department guidelines for building wastewater disposal systems in Zone 5 groundwater protection areas. The guideline permits the use of suckwell/soakway for the disposal of foul sewage in Zone 5 areas.
	Construction Stage	
	A. Spillages of fuel, lubricants, coolants, etc. from construction equipment have the potential to be leached by rainfall or intense water use activities to the groundwater zone beneath the site.	A. Best practices for the proper handling, storage and disposal of spilled hazardous chemicals and fuels should be referenced and included in the contractor's environmental management plan.
	Operations Stage	
	A. The disposal of foul wastewater without treatment – directly to suckwells – has the potential to	A. The Developer should develop an operations management plan, which schedules the routine inspection and cleaning – if necessary – of the

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
	impact groundwater quality beneath the site; the site is in a Zone 5 groundwater protection zone.	septic tank and soakaway; these units should be inspected at least once every six (6) months. B. The cleaning of PV panels should only be done with clean water. No detergents or cleaning chemicals should be used; this way water that runs off onto the ground will not have any chemicals entrained.
Drainage	**Construction Stage**	
	A. The construction stage of the project may involve the use of heavy equipment, which may result in the removal of the grass surface in areas and increased potentials for the washing of topsoil and soil erosion. Such a scenario could result in soil materials being washed towards the southern regions of the site.	A. This is a transient potential impact, the possibility of which ceases after the completion of the construction stage and the reinstatement of grassed areas. B. Silt screens should be used where necessary to contain and retard the movement of silt and topsoil from localised areas. C. Temporary boulder barriers/walls should be provided at strategic points of surface runoff to retain sediment and control the rate of runoff southwards during the construction phase. D. Any stockpiled topsoil that will not be used for re-instatement should be removed from site as soon as possible.

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
	Operations Stage	
	A. The construction of solar panels may result in a significant increase in impermeable surface areas on the site and runoff quantities, which in turn may result in flooding of downstream areas. South of the site is Fairy Valley Road and other lands of GAIA.	A. Provided ground conditions beneath solar panels are suitably grassed and maintained, the presence of solar panels on site is not expected to increase runoff or alter the drainage characteristics of the site, and by extension promote flooding on lands South and downstream of the farm. B. There should be routine maintenance of the grassed surface to ensure that there are no bare patches or inconsistencies, which could result in a change to the runoff characteristics in those areas. C. Consideration could be given to the use of a vegetated buffer strip at the downstream northeastern, eastern and southern site boundaries - to mitigate any excess runoff due to the presence of any bare patches within the solar panel site. D. Consideration should be given during the detailed design stage of the drainage system of the site of creating a depressed area closer to the southern boundary to promote runoff attenuation, infiltration and percolation processes. Consideration should be given to the installation of a drainage suckwell

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		in this depressed area to expedite drainage of captured water and prevent ponding.
Ecology	**Operations Stage**	
	A. The fencing of the PV farm may restrict fauna from traversing the site area, which may have once formed part of the habitat of these animals. B. The construction of the PV farm may cause glare and solar flux issues, which could result in bird kills at the site.	A. With respect to potential impact A, the use of galvanized chain link fencing with a raised privacy screen – maybe 450mmm or thereabouts from ground level would allow small animals, typically found in Barbados on “rab” lands, to enter the complex. B. The PV farm will not be a Concentrating Solar Power (CSP) farm, so the solar flux related impacts would not occur. The impacts of glare from PV panels on bird kills is an emerging area of research in the PV industry; the true reason for this form of bird kill is still unknown, as are measures that can be taken to mitigate or eliminate this impact.
Noise	**Pre-Construction Stage**	
		A. Consideration should be given to building concrete infilled reinforced block walls to the South, West and North of the transformer location; these walls would serve as sound attenuation

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		walls. Up to a 20dBA drop in noise levels can occur when there is a barrier (walls or earthen berms) between the noise source and receptor. It is possible that the sound attenuation walls could be constructed after the plant is up and running; confirmatory noise readings could be taken to determine whether there is indeed a noise impact from transformer and inverter operations.
	Construction Stage	
	A. Noises emanating from the Project site during construction is expected to be varied and may be linked to various steps in the preparation and building of the site as well as vehicular movements conveying the workforce, construction equipment, and facility infrastructure to and from the site. The following are likely sources of noise: • Site clearing and grading activity using bulldozers, excavators, trucks, etc. • Ditching for runoff and trenching for cables • Installation of pipeline sections for water supply, wastewater removal, cable installation, etc. • Pouring and forming of concrete for PV racking foundations	A. Construction and post-closure activities are expected to be highly variable and unpredictable at a detailed level. Construction equipment will be operating over a wide-ranging area and specific controls may be necessary when construction activities are near receptors. B. Construction equipment should be maintained in good working order and properly muffled. Also, where possible major noise generation activities should be planned to take place during day-time hours. C. A Monitoring and Protection Plan (part of the contractor's environmental management plan) should be in place to be followed by the contractor to address potential noise and vibration impacts.

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
	• Creation of laydown areas and the movement of earth and construction materials to and from the site. • Workers and equipment brought to site. • Infrastructure brought to the site such as tanks for oil fuel. • Commissioning and testing. • Clean-up and landscaping.	D. Construction and post-closure vibration levels are not expected to be perceptible at nearby receptors due to their distance away from the site. Ground-borne vibrations are generally more difficult to mitigate than airborne noise. Use of alternative construction methods and tools may reduce vibrations. Examples include: • Pre-drilling of pile holes – (if piles are proposed as racking foundations). • Use of rubber tired rather than tracked vehicles. • Place haul loads away from vibration-sensitive areas. • Schedule construction and post-closure activities, particularly any pile driving, for times when the activity does not interfere with vibration-sensitive operations (e.g. avoid night-time activities).
	Operations Stage	
	A. The operation of the PV farm and its substation may result in noise impacts to existing operations at the BNTCL fuel storage facility to the West, persons utilizing building to the South on lands of	*(addressed via pre-construction stage measures)*

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
	GAIA and the strip of residential/commercial properties to the North of the site.	
Glint & Glare	**Pre-Construction Stage**	
		A. Consideration could be given to optimizing the panel angles and eliminating some panels – via consultation with panel system supplier – to eliminate glare impacts at the ATCT; note that this action could result in a reduction in the solar conversion efficiency of the PV farm. B. A tree screen of height not less than 3m (10 feet) should be constructed along the northern, southern and eastern site boundaries. There is an existing partial screen along the western boundary of the site in the form of an earthen berm with tree line atop; the southern section of this existing screen should be extended in the form of a 3m (10ft) high tree screen towards the site's southern boundary. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors to the North, East, South and West and by extension mitigate – if not eliminate - the potential for glare impacts. The

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm. C. Along the line of sight of two-storey buildings, tree screens should be grown to a minimum height of 6m. The implementation of this recommendation would block the line of sight of PV panels to receptors in targeted two-storey buildings. D. Consideration could be given to utilizing smooth panels without ARC coating.
	Operations Stage	
	A. Existing land use at the BNTCL fuel handling facility in the West, and other existing commercial/industrial operations to the Southeast and East of the proposed solar farm may be impacted by glint and glare impacts throughout the course of a year.	A. If there are reports of impacts from residents or other land users near the development, then consideration should be given to the following: • Replacing offending panels with a deep textured panel – to reduce glare intensity. • Removing the offending solar panels. The above recommendations would also apply to any reports of glare from pilots of approaching aircraft or air traffic controllers in the ATCT.

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
Solid Waste Disposal Assessment	**Operations Stage**	
	A. The improper disposal of municipal and green wastes from the operation of the PV farm could adversely affect the environment, and the health and safety of employees who work from time to time on the farm. B. At the end of the useful life of PV modules, their local disposal in landfills in Barbados – especially construction and demolition landfills, which are unlined – could result in the leaching of heavy metals to groundwater zones.	A. The Operations Management Plan of the facility should include the use of large capacity municipal garbage skips for the receipt of green waste and general waste from the use of the Control Room. Skips should be routinely emptied. B. Consideration should be given to permitting frequent sheep grazing as means of controlling the volume of green waste produced from the maintenance of grassed areas. C. With respect to impact scenario B, the Developer should consider obtaining silicon-based panels versus the CdTe and CIS based panels. D. Also with respect to impact scenario B, the Developer and the host of other PV developers on the island should approach the Ministry of Health, the Sanitation Service Authority and the Sustainable Barbados Recycling Center (SBRC) to create a mechanism by which all PV farm developers can dispose of their end of life panel modules to the SBRC or other approved local recyclers. The intent would be that panels be shipped overseas to an approved recycling facility, given that such a facility does not exist in Barbados and may not be developed in Barbados

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		– due the development cost, intricacy and limited market for local/regional recycling.
Climate Change & Natural Disaster Assessment	**Pre-Construction Stage**	
		A. Consideration should be given to a 3m wide minimum firebreak consisting of a marled surface between the outer edges of all panels and the perimeter fencing of the facility along the North and East boundaries and partially along the South and West boundaries; the firebreak would not be required in the region of the control and vehicle parking area. Consideration should also be given to having a fire hydrant placed on site to facilitate the fire department fighting fire. B. The PV farm system design should be structurally designed and constructed following guidance given in section 4.10.5 and in the (Burgess et. al., 2018) report. With respect to the impact of climate change on extreme wind forces, it is recommended that the latest ASCE 07 code be utilized for wind design as the latest version of this code incorporates projected changes in wind regimes as would be expected with climate change.

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		C. The findings of a geotechnical engineering study should be used towards structurally designing the foundation of PV module racking.
	Operations Stage	
	A. A fire on site could spread along grassed lands and impact on the PV farm. Higher temperatures with low rainfall during the dry season increase the potential for bushfires. B. A strong tropical storm or hurricane could impact the PV farm and substantially damage panels and racking support structures resulting in the inability to generate power from the site and the need to dispose of damaged panels.	A. Prior to the commencement of every hurricane season, the Developer should have his technical team conduct a visual inspection of the supporting structures for the PV modules paying special attention to corrosion, loose bolting etc, which would increase the vulnerability of the PV system during extreme weather. Where defects are noted these should be repaired prior to the advent of the annual extreme weather season.
Visual Impact Assessment	**Pre-Construction Stage**	
		A. The site for the PV farm is visible from all directions. Though there are existing screens by way of an earthen berm along the western site boundary and a vegetated hedge along the site's northern boundary, these screens do not extend along the entire lengths of respective boundaries. The earthen berm along a portion of the site's western boundary is tall and completely screens

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		the PV site from ground level areas within the northern region of the BNTCL complex. The vegetated hedge along a portion of the northern boundary is roughly 2.4m tall and effectively screens roadway commuters and ground levels of buildings - North and adjacent to Highway 7. Following on from the recommendations of the glint and glare study, it is recommended that a tall (minimum 3m high) and thick vegetated screen be planted (see Figure 12 below): • Along the eastern boundary of the site. • Along the northern site boundary from the western edge of the existing hedge to the site's western boundary. • Along the southern boundary terminating at the Southwestern access point to the site. • Along the western boundary from the earthen berm southwards to the region of the car parking area. Once erected these screens shall hide the PV farm site from ground level elevation in all directions from the site. Notwithstanding the presence of the screens the PV site will remain visible to vantage points of upper floors of

ESS Assessment	Potential Environmental Impacts	Proposed Mitigation Measures
		buildings and from tall structures such as the ATCT, as well as from landing aircraft.
	Operations Stage	
	A. The construction of the PV farm may result in visual impacts to nearby land users – post its construction.	

7.0 SOCIAL SCOPING ASSESSMENT STUDY

The terms of reference for the ESS requested the production of a rapid social assessment, social engagement plan, and grievance redress mechanism. A rapid social assessment is effectively a desktop study with limited field investigations; it primarily relies on the use of census data from the governmental statistical department databases. Google Earth was first used to identify and characterize communities and social amenities surrounding the development site. This was followed by a drive through of the areas immediately surrounding the site to ground truth the information collected via Google Earth. The communities identified were Charnocks, Coverly, Fairy Valley, the airport, and its immediate surroundings. The significant elements in the social environment that may be impacted by the project activities during the construction and operational phases were determined:

Social components	Justification
Residents, businesses, and social amenities in close proximity to, as well as down-wind of the project's activities.	Noise, dust, odours and vibrations from the construction activities as well as other activities during the operations phase could affect the residents, businesses and users of social amenities in adjacent communities. Potential concerns about the impacts of the array on the aesthetics of the area.
Residents, businesses, and social amenities along the routes to be traversed by the construction vehicles.	Noise, dust, odours, and vibrations from construction vehicles could affect the residents, businesses and users of social amenities.
Worker health and safety.	There is always a risk associated with work on construction sites, e.g. falls, chemical spills, accidents with equipment etc. In addition, there are several pollutants occurring in solar cells and parts which include arsenic, chrome, lead and cadmium in batteries.
Public health and safety.	There is always a risk to adjacent communities and the general public with respect to construction sites.

The potential positive and negative effects that the construction and operational phase activities are likely to have on the valued social components:

Project Effects – Negative	Project Effects – Positive
CONSTRUCTION PHASE	
• Noise and vibrations from construction vehicles and equipment • Impaired air quality from dust and other emissions from construction vehicles and equipment • Health and safety risks to on-site workers • Health and safety risks to adjacent communities and general public • Perceived negative aesthetic impacts from the array • Suspicion or objection towards the project.	• Construction related jobs will be created for skilled labour • Increased retail business, primarily food related from construction workers

Project Effects – Negative	Project Effects – Positive
OPERATIONAL PHASE	
• Potential health and safety impacts on workers and adjacent communities • Accidents (non-routine) events • Perceived negative aesthetic impacts from the array	• Employment opportunities for skilled labour. • Advances the renewable energy policy to increase energy conservation and efficiency, and contribute to mitigation efforts in reducing GHG emissions.

Potentially adverse effects from the construction of the farm must be minimized and mitigated to the extent feasible to reduce impacts on the project workers, residents, and users of social amenities and commercial enterprises. Construction should be based on an approved construction management plan that includes measures to reduce the impacts of noise, dust, and vibrations. Details for the management of noise, dust, and vibrations should be included in the contractor's Environmental Management Plan. There should also be an approved Traffic Management Plan to control on-site traffic as well as the practices of drivers to and from the site.

Contractors should be required to operate approved occupational health and safety plans which detail the safety provisions according to the type of machinery and materials being utilized. There should be appropriate supervision to ensure that workers do not cause harm to themselves or others on the site.

There should be adequate 24-hour security to prevent curious onlookers from wandering into the construction zones. Public service announcements should be provided to ensure that commercial operators, residents, and the public are updated on the construction activities, especially those that could be disruptive, e.g., construction activities planned outside of typical work hours such as late evening or night.

The Social Management Plan focuses on the engagement of the stakeholders to ensure that there is a mechanism in place to provide information on the project to the public and to encourage participation of all affected groups in a consultation process. There are four critical steps in a stakeholder engagement process:

1. Identification of required resources
2. Identification and analysis of the stakeholders
3. Developing key messages and selecting appropriate engagement channels
4. Implementing, reviewing, and revising the engagement plan

People adversely affected by a project will complain about actual or perceived impacts in order to find a satisfactory solution. Affected persons (APs) must be able to raise their grievances and be given an adequate hearing; satisfactory solutions should be found that mutually benefit both the APs and the project. Based on the rapid social assessment, it can be anticipated that there will likely be complaints about the dust and noise from the project, especially from the residents and businesses in closest proximity to, and downwind of the construction zone. The Grievances Redress Mechanism provides guidance to the BNTCL to be able to address these and any other concerns that might arise during the project. It recommends a procedure that should be followed for the management of complaints and grievances that arise during the project. It describes the scope and procedural steps and specific roles and responsibilities of the parties involved. It should be revised and updated based on the experience and feedback from the stakeholders.

8.0 ALTERNATIVES ANALYSIS

To do nothing would result in the site continuing to be vacant with a running cost for maintenance – debushing, etc. The potential of the site to contribute to Barbados' green energy policy mandate of 100% renewable sources of energy by 2030 would not be realized.

The production of electricity via the erection of wind turbines on the site is an alternative renewable energy solution that could be considered. However, the potential negative impacts to the environment – particularly other nearby residential, and commercial land users – would be greater as compared to the development of the proposed PV farm; there could be visual, shadow flicker, and noise impacts. There would also be a height restriction to the turbines given the site's proximity to GAIA.

9.0 CONCLUSION

It is hereby concluded that if all the recommendations of the scoping study are implemented then it is unlikely that the development of the proposed PV farm on lands leased and maintained by the BNTCL will have an adverse impact on nearby human receptors and the surrounding environment.

1.0 INTRODUCTION

1.1 BACKGROUND

The Client proposes the construction of a solar farm on lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados. The farm shall generate power to be sold to Barbados Light & Power Ltd. The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. These 14,520 panels are expected to produce approximately 5MW AC of renewable energy electricity for integration into the national power grid.

The Developer has applied to the Town & Country Development Planning Office (TCDPO) for permission to develop the PV farm. Environmental scoping studies (ESS) are required for PV developments in Barbados, given their industrial nature. A Terms of Reference (TOR) for the scoping study has been prepared and is attached in Appendix A of this study. This document presents the findings of an ESS based on the TOR in Appendix A.

1.2 ENVIRONMENTAL SCOPING STUDIES

An ESS provides information on the proposed development and its likely effects on the environment. Potential negative impacts on the environment are identified and measures to mitigate impacts recommended. Positive impacts are also identified. The ESS enables “Developers” to comply with their own environmental standards and minimize environmental impacts, where necessary. An ESS assesses a proposed development and makes recommendations, which should be taken into consideration and incorporated during the detailed design phase of a project to mitigate environmental impacts; an ESS is not meant to present detailed design solutions for mitigation measures.

1.3 TERMS OF REFERENCE

TCDPO planning application drawings are shown in Appendix D.

In short, this study covers the following TORs:

- Legal and Regulatory Framework
- Description of site and proposed development

Environmental assessments

- Land use
- Noise

- Drainage
- Glint & Glare
- Solid Waste and Wastewater Disposal
- Visual Impact Assessment
- Rapid Social Impact Assessment including stakeholder engagement and grievance redress mechanism
- Alternatives Analyses

During the conduct of the ESS, the following additional assessments were added to the study, as they were ultimately deemed relevant:

- Electromagnetic and Radar Interference
- Ecology
- Climate Change and Natural Disaster Assessment

1.4 NEEDS ASSESSMENT

The Barbados National Energy Policy 2019-2030 proposes the transformation of the petroleum-based economy of Barbados to one that is 100% renewable energy based by the year 2030. Currently, fossil fuels are the main source of energy for Barbados with over 90% of the energy being sourced from these fuels. Bunker “C” heavy fuel oil (HFO) is the main fuel for electricity generation.

The transformation to a renewable energy driven Barbados is expected to realize significant reductions in the outflow of foreign exchange and maximize the participation of local business entities and individuals in the production of renewable energy.

At the time of the generation of the Energy Policy, the average consumption of electricity in Barbados was 926.8 MWh; the energy policy states that Barbados’ demand for energy has been on a declining trend. Barbados’ demand for fossil fuels for energy was estimated during 2014 to be 10,132 barrels of oil per day. The highest fossil fuel demand is HFO for electricity production – 37% of the total demand.

Given the intermittency of energy generation from renewable energy sources, a mix of renewable energy initiatives are required to meet the Policy’s renewable power generation target of 625 MW. The following mix is proposed:

- Solar PV Centralised – 205 MW
- Solar PV Distributed -105 MW
- Wind Farm Onshore -150 MW

- Wind Farm offshore – 150 MW
- Biomass and Waste to Energy – 15MW

Battery storage on the grid in the region of 200MW was determined as necessary to compensate for the intermittency of wind and solar power generation.

This project falls directly in line with the centralized solar energy source requirement of the Energy Policy, and by extension the implementation of this project will assist the Government of Barbados in its march towards 100% energy supply via renewables by 2030.

1.5 REPORT OUTLINE

The balance of the report commences with a presentation on the legal and legislative framework that applies to this proposed development followed by a description of the development site and the proposed development in turn followed by the various scoping environmental and rapid social impact assessments. The report is drawn to a close via the presentation of a project alternatives analysis.

2.0 LEGAL AND LEGISLATIVE FRAMEWORK

2.1 GENERAL

The focus of the development is the production of electrical energy for integration in BL&P's electricity distribution grid; thus, local legislation pertinent to the generation and distribution of electricity is relevant to this project. The facility will be industrial in nature where technical persons will be required to manage its operation and conduct maintenance from time to time; consequently, legislation pertaining to the health and safety of workers also apply to this project. The site is near the Grantley Adams International Airport (GAIA) thus legislation related to civil aviation would apply to this development. Groundwater exists below the site for development; any activities that could result in solid wastes or wastewaters impacting groundwater are a concern, hence legislation pertaining to the proper disposal of wastes and the protection of groundwater are also relevant to the project.

This section of the ESS addresses key elements of the formal institutional arrangements that apply to the project.

2.2 LEGISLATIVE FRAMEWORK

2.2.1 Town and Country Planning Act

2.2.1.1 TCPA Cap 240

In Barbados, physical planning was directed by the **Town and Country Planning Act (TCPA), Cap. 240,** which is *"an Act to make provision for the orderly and progressive development of land in both urban and rural areas and to preserve and improve the amenities thereof, for the grant of permission to develop land and for the other powers of control over the use of land, to confer additional powers in respect of the acquisition and development of land for planning, and for purposes connected with matters aforesaid."*

The TCPA directly empowered the Chief Town Planner (CTP) to request an impact assessment under Section 17 (1), and further allowed the CTP *"by notice in writing to require the applicant to submit such further information as the CTP thinks fit"* through Section 17 (1B). The TCPA provided for the preparation of development plans relating to both parts of and the overall island.

2.2.1.2 Environmental and Social Impact Assessments

To complete the review of the application, the CTP may have requested a report constituting an Environmental and Social Impact Assessment (ESIA) for any development which has the potential for a significant environmental effect.

In the case of a simple application with minor impacts, the assessment requested may have been an Environmental Scoping Study (ESS) or an ESIA of limited scope. Where the project involves the potential for more significant impacts, a more comprehensive ESIA would have been required. Generally, the process was an interactive one, involving meetings and discussions between the TCDPO and other agencies as determined by the CTP, including the relevant governmental agencies and departments. An Environmental Impact Assessment Review Panel (the Panel) was formed consisting of key agency personnel, who assessed the initial requirements and final contents of the ESIA.

The ESIA study was initiated after the TOR for the project was approved by the CTP (via the Panel). The contents of the ESIA TOR were required to include the following broad categories:

- An outline of the environmental issues and the disciplines required for studying them.
- A list of the government and other agencies that appear to have an interest in the application. A consultation program is also included.
- A proposed program for consultation with the local public.

Broadly, the steps involved in completing the ESIA following the approval of the TOR included gathering of baseline data, analysing/modelling the inputs and outputs and their impacts, consulting with respective agencies and the public, and completing the ESIA document for circulation. Discharges to the environment, raw material requirements, waste management, fire safety issues, social issues and any other relevant details were required for the ESIA. Upon completion, the ESIA was submitted to the CTP for review by the Panel, which received comments from interested agencies and the general public.

On the CTP's acceptance of the ESIA, the applicant was expected hold at least one (1) public meeting in defence of the ESIA submission no earlier than twenty-eight (28) days after the reports were made available for public inspection. When the Panel was satisfied that the ESIA adequately addressed the environmental impacts, approval (or the recommendation to the Minister of such as per Section 18 of the TCPA) was provided by the CTP which may have included a list of conditions in order to control aspects of design, construction, and operations.

If permission was granted and conditions deemed acceptable to the applicant, the project team needed to prepare and submit a range of detailed design drawings and documents (known as "reserved matters") that must satisfy the conditions and subsequently be approved prior to commencing respective works. The CTP (generally) allowed no development of the site without prior approval.

2.2.2 Planning and Development Act (2019) – enacted December 2021

Issue No. 87 of *The Official Gazette* of Barbados, published on December 7, 2021, includes a proclamation indicating that the new Planning and Development (P&D) Act officially came into operation on that date, thereby also repealing the former TCPA in accordance with section 106 of the new P&D Act. The same issue of *The Official Gazette* also includes *Planning and Development (Environmental Impact Assessment) Regulations, 2021* (EIA Regulations) established under section 30(4) of the P&D Act, as well as the *Planning and Development (Amendment Act), 2020* (P&D Amendment Act). The following information refers to the version of the P&D Act that is currently in force, which includes the revisions specified in the P&D Amendment Act.

Similar to the former TCPA, the new P&D Act makes provisions for *"the orderly and progressive development of land; the grant of permission to develop land; powers to regulate land use and development; and related matters".*

Part II of the P&D Act

- establishes a Planning and Development Board (the Board) that consists of the Director and 12 appointees.

- establishes a new Planning and Development Department (PDD) that is headed by the Director and replaces the former TCDPO. The mandate of the PDD is to assist the Minister and the Board in the administration and enforcement of the P&D Act, including by reviewing and evaluating all applications submitted under Part IV of the P&D Act and facilitating the carrying out of Environmental Impact Assessments (EIAs) and other studies that may be required in connection with those applications.

- formalizes related administrative matters such as the procedures of the Board, which include appointing a Design and Engineering Committee, Environmental Impact Assessment Committee (EIA Committee), and *"such other ad hoc committees or working groups as it thinks fit to assist in the performance of its functions"*; applications to be determined by the Board; and the duties of the Director.

  The Third Schedule of the P&D Act sets out the constitution, functions, and procedures of the EIA Committee and states that the EIA Committee shall include persons with expertise in: ecology; geology, hydrology, and soil conservation; environmental, coastal, and civil engineering; marine science; disaster risk mitigation and management; public health; economics; sociology; and physical planning. The mandate of the EIA Committee is to advise the Board and the Minister with respect to EIA studies through performance of the following functions: screening Applications for Planning Permission to determine whether an EIA is required; reviewing the Environmental Impact Statement (EIS) submitted by the applicant; reviewing public comments on the EIS; making recommendations to the Board with respect to the environmental impacts of proposed development projects; and making recommendations to the Board with respect to the imposition of conditions of approval for the purposes of avoiding, mitigating, or offsetting adverse environmental impacts.

  Part IV of the P&D Act pertains to the regulation of land development and includes the following requirements that are particularly relevant to the Project:

- Section 21 of the P&D Act states that Planning Permission must be obtained by a proponent prior to commencing or carrying out "any development of land in Barbados". Planning Permission is therefore required to enable the Project to proceed.

- Section 30(1) of the P&D Act states that the Director may require that an applicant conduct an EIA *"in respect of any application for permission to develop land, if the proposed development, by reason of its nature, scale or location, could significantly affect the environment.*" Section 30(2) of the P&D Act further states that, unless the Minister directs otherwise, the Director shall require an EIA *"in respect* *of an application for a development of any kind mentioned in the Sixth Schedule."* The Sixth Schedule of the P&D Act specifies matters for which an EIA is required, including an *"alternative energy generation plant having a capacity greater than one megawatt, including but not limited to hydro-electric plants, geo-thermal energy plants, wind-power plants, solar-voltaic arrays, and waste-to-energy plants."* This Project therefore triggers EIA requirements under the P&D Act due to its inclusion of a solar PV power plant with a capacity greater than 1 MW.

The Board is responsible for the determination of all Applications for Planning Permission, other than those referred to the Minister under section 33 of the P&D Act[1], and may delegate this responsibility to the Director. However, complex applications of any class specified in the Fourth Schedule of the P&D Act must be determined by the Board. The Fourth Schedule includes *"[a]ll applications, except applications to be determined by the Minister under section 33, for which an [EIA] is required"* and "*[a]ll applications for a material change in the use of […] agricultural land of 1 hectare [or] more in area".* The Application for Planning Permission in support of the Project must therefore be determined by the Board, rather than delegated to the Director, since the Project triggers EIA requirements and entails changing the use of agricultural land.

2.3 PHYSICAL DEVELOPMENT PLAN

The planning objectives and policies of the Government of Barbados are outlined within the Physical Development Plan (PDP) Amended 2017 which provides:

> *"a vision for sustainable growth and development of the nation by setting out policies to guide relationships among land uses, built form, mobility, community facilities and physical infrastructure. It is also intended to be a framework to facilitate and guide investment, both public and private, in Barbados to the year 2035 to advance a healthy, prosperous and resilient nation".*

The PDP has been heavily influenced by sustainable development concepts including a renewed emphasis on the protection of the natural environment and heritage resources, establishment of EIA criteria and procedures, effects of climate change, protection of the population from negative development impacts, protection of agricultural lands from incompatible urban development, and promotion of employment-generating land use opportunities in mixed-use centres and corridors, among others.

The PDP provides guidance to developers on how their proposed site for development falls within the overall plan for land use in Barbados and what land use permissions currently apply to the particular piece of land or land(s).

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[1] Section 33(1) of the PDA states that the Minister may give directions to the Director requiring that "any application or class of applications for planning permission specified in the direction, being development which would involve either a significant departure from the approved physical development plan or is of strategic economic or environmental significance, shall be referred to the Minister for determination."

With respect to renewable energy and energy conservation, the PDP states that the Government of Barbados will promote the *"use of renewable energy, a reduction in the use of fossil fuels, and overall energy conservation as part of Barbados' transition to a green economy".*

Though specific mention of photovoltaic installations is not given, the PDP – appearing to refer more so to wind turbine installations - states the following in section 2.5/7: that renewable energy projects over 2MW shall be subjected to an Environmental Impact Assessment with consideration given to scale and size of development, geology, conflicting land uses, noise, heritage and visual impacts, biodiversity, bird migratory routes, electromagnetic interference, safety and air traffic control adjoining land use set back distances and shadowing. Also, section 5.3/6 of the PDP states that special industries such as an electricity generating plant – such as a PV plant – requirement impact assessments.

2.4 OTHER REGULATORY CONSIDERATIONS – ENERGY SECTOR

Other policies, laws and regulations that govern the energy sector in Barbados are presented below *(source of data in table below: Social Assessment Study – Appendix B).*

Legislation	Description
National Strategic Plan of Barbados for 2005–2025	The National Strategic Plan of Barbados 2005 – 2025, was developed to enhance Barbadian society to become prosperous and globally competitive by 2025. One objective within the Plan was to ensure an efficient and reliable energy sector. This included programmes to expand renewable energy; 40% of the energy supply was to be derived from renewable energy and increased renewable energy production and usage.[2][3]
The National Sustainable Development Policy	The National Sustainable Development (NSD) Policy attempted to encourage an integrated and holistic approach to sustainable development. The NSD Policy sought to ensure Barbados met the obligations as a party of UNFCCC through alternative energy, energy efficiency and conservation.[4]
Sustainable Energy Framework for Barbados	The objective of the Sustainable Energy Framework for Barbados was to promote renewable energy and energy efficiency to reduce the fossil fuel dependency while enhancing energy security and environmental sustainability[5].
Draft National Sustainable Energy Policy	Developed as a complementary policy to the Sustainable Energy Framework, the Draft National Sustainable Energy Policy addressed the high importation of fossil fuels and sought to increase efficiency and sustainability in the energy supply and demand. The policy aimed

[2] Government of Barbados. 2005. "National Strategic Plan of Barbados 2005-2025." Government of Barbados, Bridgetown, Barbados. http://www.sice.oas.org/ctyindex/BRB/Plan2005-2025.pdf

[3] Green Growth Knowledge Platform. 2019. "Barbados Draft National Sustainable Energy Policy." Accessed 13th August 2019. https://www.greengrowthknowledge.org/national-documents/barbados-draft-national-sustainable-energy-policy.

[4] Government of Barbados. 2004. "National Sustainable Development Policy for Barbados." Government of Barbados, Bridgetown, Barbados

[5] Division of Energy 2019. "Sustainable Energy Framework for Barbados." Accessed 1st July 2019. https://www.energy.gov.bb/web/sustainable-energy-framework-for-barbados

Legislation	Description
	to encourage energy cost reduction technologies, reduce fossil fuel dependency, and decrease the impacts of global warming[6].
Barbados National Energy Policy 2017 – 2037	The Barbados National Energy Policy 2017 – 2037 aimed to provide a direction for Barbados to transition from a fossil fuel-based economy to mainly renewable energy. The BNEP 2017 – 2037 sought to ensure energy security that was affordable with a sustainable energy sector with increased renewable energy and energy efficiency[7].
Barbados National Energy Policy 2019 – 2030	The Barbados National Energy Policy 2019 – 2030 outlines the transition to a 100% renewable energy and carbon-neutral island by 2030. The policy attempts to ensure the provision of reliable, sustainable climate-friendly energy with zero domestic fossil fuel consumption and expansion of research and development in renewable energy[8].
The Electric Light and Power Act (2013)	The Electric Light and Power Act (ELPA) allows independent power producers (IPPs) (residential and commercial) with a license to generate electricity from renewable energy sources and supply the excess to the BL&P. The ELPA initially allowed 20MW of solar PV and 15 MW of wind energy to be supplied to the grid[9].
The Fair Trading Commission Act (2001)	The Fair Trading Commission Act allows the Fair Trading Commission (FTC) and regulation of the Renewable Energy Rider[10].
The Utilities Regulation Act	The Utilities Regulation Act enforced by the FTC, monitors and establishes the rates to be passed to consumers while determining a maximum rate charge[11].
Renewable Energy Rider	The Renewable Energy Rider was an agreement allowing domestic customers to sell energy back to the electrical grid at 1.6 times the level of the Fuel Clause Adjustment[12].
Feed-in-tariff	The feed-in-tariff is a pricing framework that provides fixed electricity rates paid to renewable energy producers for each unit of energy produced and sent to the electrical grid. This action offers stability and confidence for investors into renewable energy. The feed-in-tariff replaces the renewable energy rider, established in 2010[13] (Government Information Service 2019b).

[6] Division of Energy. 2019. “National Sustainable Energy Policy.” Accessed 30th June 2019. https://www.energy.gov.bb/web/national-sustainable-energy-policy.
[7] Division of Energy. 2019. “National Energy Policy for Barbados 2017 - 2037.” Accessed 30th June 2019. http://www.energy.gov.bb/web/barbados-national-energy-policy-2017-2037
[8] Division of Energy. 2019. “National Energy Policy for Barbados 2019 - 2030.” Accessed 5th December 2019. https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030.
[9] Brown, Desmond. 2017. “Barbados Steps Up Plans for Renewables, Energy Efficiency | Inter Press Service.” 2017. http://www.ipsnews.net/2017/07/barbados-steps-plans-renewables-energy-efficiency/.
[10] International Business Publications. 2017. Barbados Energy Policy, Laws and Regulations Handbook Volume 1 . https://books.google.com/books?id=-AcABwAAQBAJ&pg=PA54&lpg=PA54&dq=the+fair+trading+commission+barbados+and+renewable+energy&source=bl&ots=eOnp0SgTxE&sig=ACfU3U3ouuVWaeGBhmvb2sUWc9K46B44dA&hl=en&sa=X&ved=2ahUKEwjqqpuq6q3lAhWlxFkKHb1hArMQ6AEwB3oECAkQAg#v=onepage&q=the fair trading commission barbados and renewable energy&f=false.
[11] REEEP. 2013. “Barbados (2014).” Accessed 15th August 2019. https://www.reeep.org/barbados-2014
[12] Government of Barbados. 2017. Barbados National Energy Policy (2017-2037). Government of Barbados, Bridgetown, Barbados.
[13] Government of Barbados. 2019. “The National Strategic Plan of Barbados 2006-2025: Global Excellence, Barbadian Traditions.” Accessed 13th August 2019. https://www.greengrowthknowledge.org/national-documents/national-strategic-plan-barbados-2006-2025-global-excellence-barbadian-traditions.

2.5 OTHER PERTINENT ENVIRONMENTAL LEGISLATION

The following pieces of legislation are deemed pertinent to the proposed PV development.

CAP 356: Safety and Health at Work Act – An Act which makes provision for securing the health, safety and welfare of persons at work, controlling certain emissions into the environment, and consolidating the law relating to health, safety, and welfare in the workplace. For the purpose of the Act, a "factory" can be defined as *"any premises on which machinery or equipment is being used, whether mechanically or otherwise, for agricultural purposes."*

CAP 283: Underground Water Control Act. This Act makes provision for the establishment of a Water Board and the granting of licenses for abstraction of ground water. The Act also prescribes against contamination of groundwater sources. The Barbados Water Authority (BWA), established under the **Barbados Water Authority Act, CAP.274A**, 1980, through its Board of Directors, has assumed the role of the Water Board. The BWA has been mandated to manage the island's water resources. One effective management policy is the **National Groundwater Protection Zoning Policy**, 1963 (updated 2010), which delineates the island into 5 zones. Public supply wells are located in the most restricted Zone 1 areas (see development control zones below).

			DEVELOPMENT CONTROL ZONES	
Zone	**Definition of Zone Boundary**	**Soak-away Pit Max. depth**	**Domestic Controls**	**Industrial Controls**
1	300 day travel time	None allowed	No new housing or water connections, No change to existing wastewater disposal except BWA secures improvements.	No new industrial development.
2	600 day travel time	6.5m	Septic Tank + soak-away pit required, No storm runoff to soak-away pit, No new petrol or fuel oil tanks.	All liquid industrial waste to be disposed as specified by BWA. Max soak-away pit depths as for domestic waste.
3	5 – 6 Yrs travel time	13m	As above for domestic wastewater, petrol or fuel oil tanks to approved leak proof design.	As for Zone (2) above
4	Extends to all high land	No limit	No restrictions on domestic wastewater disposal. Petrol or fuel oil tanks to approved leak proof design.	As for Zone (2) above.
5	Coastline	No limit	No restrictions on domestic wastewater disposal. Siting of new fuel storage tanks subject to BWA approval.	As for Zone (2) above

CAP 44: Health Services Act. The Act makes the Minister *"responsible for the promotion and preservation of the health of the inhabitants of Barbados"*. His functions include:

- The preservation, treatment, limitation, and suppression of disease, including the conduct of investigations and enquiries thereof; and
- The abatement of nuisances and the removal or correction of any condition that may be injurious to the public health.

The Act further empowers the Minister to make Regulations for a number of prescribed items including the prevention, abatement, or removal of nuisances and unsanitary conditions on premises. The Health Services Act can also be used to regulate waste disposal under both the Nuisances regulations and the Disposal of Offensive Matter regulations. The Act does not set numerical standards for discharges, but requires that permission be granted to discharge these wastes. It is current policy to use the Draft List of Prohibited Concentrations and End of Pipe Discharge standards developed under the Marine Pollution Control Act as the benchmark for granting permission under the Health Services Act.

CAP 288A[14] Civil Aviation Act makes provision in Section 12 for the control over land in interest of civil aviation. Specifically, the Minister can declare any land, structure, works or apparatus specified in the order, subject to control, if satisfied that it is necessary to do so in the interest of civil aviation.

CAP 392A: Marine Pollution Control Act is an "Act" to prevent, reduce, and control pollution of the marine environment of Barbados from whatever source" (MCPA, Act, 1998). The act covers all wastes that can impact the marine environment; it applies to *both inland disposal of wastes that pollute groundwater (which can ultimately discharge to the sea), as well as piped discharges along the coast.* There is a list of prohibited concentrations of certain chemicals (pesticides, nutrients etc), which effectively form the standards that dischargers must meet before discharge to the environment. Essentially any discharge that exceeds the ambient standards will require either an extra-strength agreement or a compliance agreement; the compliance agreement being a temporary agreement to allow dischargers the opportunity to put pollution reduction equipment in place within a specified period. It is an offence to discharge at higher concentrations than the standards or above the levels agreed with the Environmental Protection Department (EPD) of the Government of Barbados. For the first offence, maximum penalties can be $200,000.00 or imprisonment for 5 years or both on indictment. For secondary or any subsequent offence the fine is $400,000.00 or 7 years or both. There are other fines under the MCPA. The Polluter may also be required to execute remediation works at his own cost to clean up pollution caused. Note that the regulations are in draft form and as such are not enforceable but are typically used for guidance purposes.

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[14] Government of Barbados. 1983. *Civil Aviation, Cap 288 A.* Commencement 1983/156. Bridgetown, Barbados: Government of Barbados (GOB), Printing Department

2.6 GREEN PAPER FOR NEW GROUNDWATER ZONES

As presented in section 3.2.6 of this report, the site for development is in a Zone 5 groundwater protection zone.

Though not set in law currently, it is proposed that the groundwater protection zones – introduced above - be re-configured to boost groundwater water quality protection due to the presence of more recalcitrant persistent pollutants and also to release more lands in the current Zone 1 protection areas for development.

The 2020 Water Protection and Land use Zoning Policy – Green Paper[15] – produced by the Ministry of Energy and Water Resources, and the BWA states the following:

- The existing policy – over 50 years old – does not protect against persistent chemical pollutants.
- Proposed that the existing Zones 1 to 5 are replaced with Zones A to E, with Zone A termed a *strict exclusion zone* smaller than the existing Zone 1.
- Only agriculture Class Two will be permitted within Zone A; this type of agriculture includes *“horticulture, fruit growing, seed growing, use of lands for farmers markets, bursary grounds, woodland or forestry”.*
- Solar PV farms and wind farms – deemed to have low environmental impact – may also be allowed in Zone A areas under specific permitting conditions.

[15] Tentative government consultation document of policy proposals for debate and discussion.

3 EXISTING SITE & PROPOSED DEVELOPMENT

3.1 GENERAL

This section of the scoping study focuses on the description of the site for the development of the PV farm. Information on surrounding land use, topography, geology, hydrogeology, and drainage is given. A description of the development proposal is also given in this chapter.

3.2 EXISTING SITE

3.2.1 Site Access and Surrounding Land Use

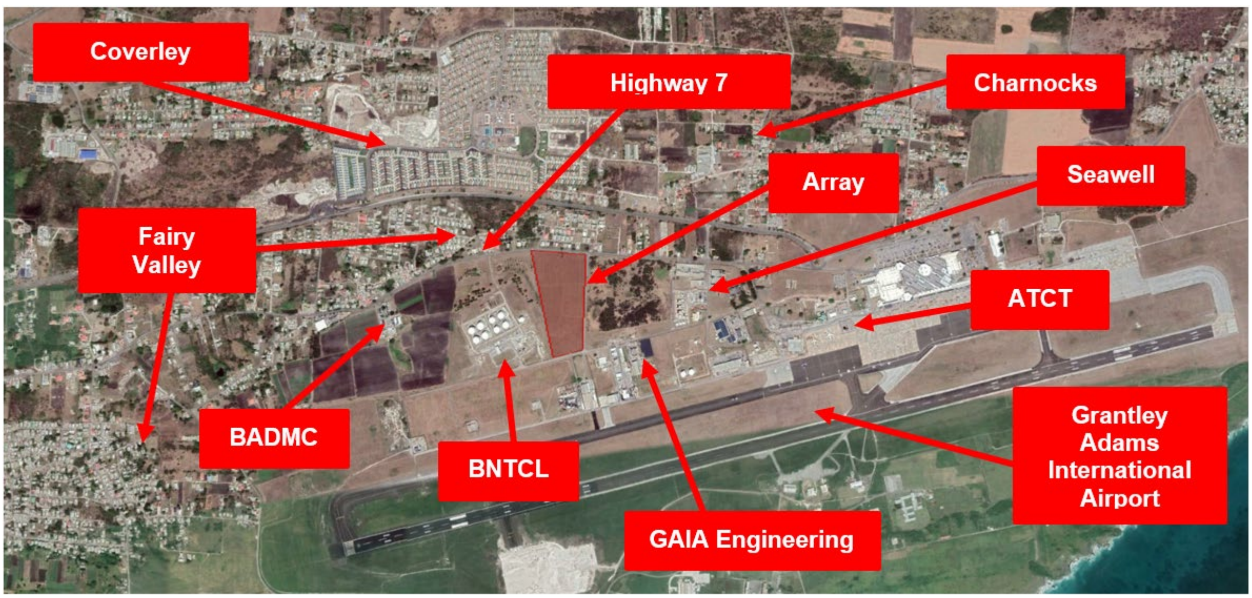

Figure 1 – The Site

The PV site is situated on leased lands of BNTCL, adjacent and to the East of existing BNTCL buildings. The site is bounded:

- To the East by a parallel secondary access road, which is in turn bordered to the East by rab/fallow lands.
- To the North by Highway No.7, which is in turn adjacent to residential and commercial buildings to the North.
- To the West by other lands of BNTCL and its fuel tank farm and administrative and operations buildings.

- To the South by Fairy Valley Road, which is in turn bounded to the South by other lands of the Grantley Adams International Airport (GAIA).

The residential area of Fairy Valley is located 30m to the North and North West, with the higher density of development to the North West being roughly 220m away from the property's closest boundary. The high density residential area of *The Villages at Coverley* is located 250m North of the northern site boundary.

Other land use in the environs was determined as follows:

- The closest residential commercial building to the North – 30m.
- Closest operations building with the BNTCL compound – 35m to the West.
- Closest commercial building on lands of GAIA – 65m to the Southeast.
- Closest commercial building (due South) (private sector aircraft hanger) – 116m.
- Air Traffic Control Tower (ATCT) of GAIA – 950m to the South East.
- Barbados Light & Power (BL&P) Seawell Power Generation Station – 336m due East of the site.
- Other lands under agriculture under the jurisdiction of the BADMC – 331m due East
- Barbados Agricultural Development Marketing Center (BADMC) Fairy Valley Complex – 511m West of the western site boundary

With respect to existing installations of solar PV facilities in the environs, there are three (3) facilities near to the proposed site and the GAIA facility (see Figure 2.0 below):

- Roof top PV system at DHL Express Service Point.
- Ground mounted PV system on lot of land to the immediate East of GAIA's Engineering Office.
- Roof top PV system – Goddards Catering Group building.
- Roof top installations at the BADMC Fairy Valley complex.

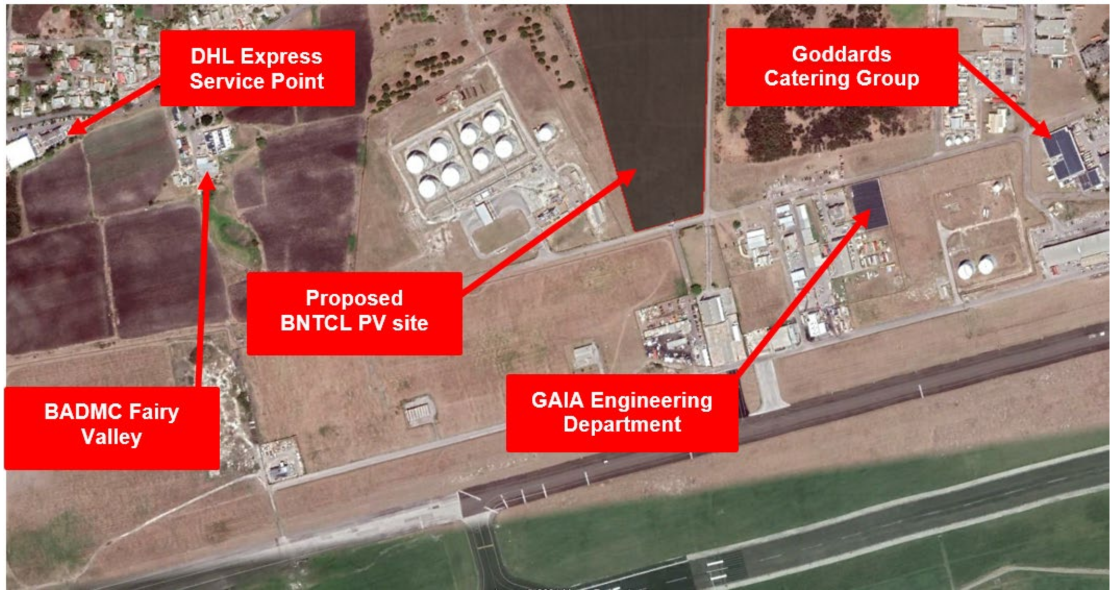

Figure 2 - Existing PV Installations within site environs

Primary access to the proposed PV site shall be from Fairy Valley Road in the South, which currently provides access to the BNTCL compound. Access into the fenced and gated PV farm compound shall be from the South; upon entry there shall be a vehicle parking area, control room and equipment storage container (see Figure 7.0 below)

The proposed PV site has been maintained to prevent vegetation overgrowth, and as such there is a clear view of the surrounding developments and businesses from the site. To the West and North-West of the site a tree lined earthen berm was observed; the berm followed a Westerly path to the North of the BNTCL facility, almost to the Western extent of the facility.

3.2.2 Topography

Based on site reconnaissance, the site is relatively flat with a gentle sloping grade with reducing elevation in a southerly direction. Scrutiny of topographical information received from the Lands and Surveys Department of the Government of Barbados indicates a gently sloping site from North to South East towards the Grantley Adams International Airport. Land elevation at the site ranges from 64m Above Mean Sea Level (AMSL) at its northern boundary to 57m AMSL at its southern boundary – resulting in an average fall across the site from North to South of 1.9%.

An examination of contours in the area does not reveal any natural drainage water courses.

3.2.3 Geology

Scrutiny of the soils maps of Barbados (Vernon & Carroll, 1966) reveals that the site consists of Black Association soils. The Black Association refers to less mature smectoid clay soils with an average thickness of 450 mm overlying coral limestone and is most common in the southern part of Barbados from Bridgetown to Christ Church.

These soils represent the insoluble weathering by-products of the coral itself and from later ash falls from volcanic activity at neighbouring islands. Four associates have been identified: normal (deeper than 18 inches or 450 mm), shallow (a depth 10 to 18 inches or 250 to 450 mm), very shallow (less than 10 inches or 250 mm) and poorly drained (a gleyed subsoil). The composition of the soil is described as 3% coarse sand, 11% fine sand, 9% silt, 60% clay, 9% moisture, 7% calcium carbonate, and 2% loss in solution (Vernon and Carroll, 1966). While the sand content can be found to be higher, the texture of the soil is clay.

Vernon and Carrol (1966) provide the following classification of permeability for the associates (actual numeric values of permeability are not provided):

- Normal – slow,
- Shallow – moderate,
- Very shallow – rapid, and
- Poorly drained – very slow.

Scrutiny of the soil map in the vicinity of the PV site reveals that soils are of the normal associate.

3.2.4 Hydrogeology

The site is located in the Coral Region of Barbados. A shallow topsoil – introduced in the prior section - followed by porous/Karst limestone rock with depths up to 300m are characteristic in this region. The base of the limestone rock is underlain by an impermeable clay formation known as the Oceanics – known to be several hundred meters deep. The combination of limestone rock and the impermeable Oceanics forms an unconfined aquifer through which groundwater flows. Scrutiny of the Geology Map of Barbados (Poole & Barker, 1983)[16] indicates that the elevation of Oceanics with respect to mean sea level ranges from zero (0) m AMSL at the site's northern boundary to -20m AMSL at the site's southern boundary. Taking into consideration the average site elevation of 60.5 AMSL and a shallow topsoil in the region of 1.2 to 1.8m implies depths of limestone rock beneath the site in the region of 69m (226'-0").

The level of the surface of the Oceanics layer with respect mean sea level (MSL) indicates whether groundwater in the unconfined aquifer exists as 'streamwater' or 'sheetwater'. Oceanic elevations Below Mean Sea Level (BMSL) indicate that groundwater may exist as sheetwater, whilst levels above MSL

[16] Poole, E.G. and L. H. Barker, 1983.Geology of Barbados. D.O.S. 1229, 1:50,000 Scale. Energy and Natural Resources Division, Ministry of Finance and Planning, St. Michael, Barbados.

indicate the possible existence of 'streamwater'. Streamwater, found in the higher land elevations of Barbados, is defined as groundwater flowing at the coral rock/Oceanics interface towards regions of lower elevation or towards the sea, after having percolated through overlying coral rock and its fissures. Sheetwater, found at lower elevations, is a reservoir of groundwater resting above saline water, in the coral rock medium, at the interface with seawater. Given that the elevation of the Oceanics beneath the site is below sea level, groundwater beneath the site and the immediate environs exists as sheetwater.

Close examination of the Oceanics contours of the Geology Map of Barbados indicates that groundwater beneath the PV site may be flowing in a south - south easterly direction under the airport and towards the coastline at Long Bay.

3.2.5 Drainage

'Rainfall Intensity-Duration-Frequency Maps for Barbados' as published by the Caribbean Meteorological Institute in 1972 provide excellent data on rainfall events of various duration and return periods. Based on rainfall records for the period 1887-1986, the average annual rainfall that can be expected across the development area is 1250 mm/year.

The rate at which stormwater leaves the several areas of a catchment and enters a main drainage (gully/watercourse) system is dependent on a number of factors: soil type, gradient, land use, rainfall intensity, losses and defined drainage channels. 'Losses' reduce the amount of surface runoff resulting from a rainfall event. These are primarily depression storage (water stored in localised surface depressions), interception (water trapped by tree leaves etc.), and infiltration (vertical flows towards groundwater zones).

There are no natural drainage watercourses in the vicinity of the site for development. Drainage – taking into consideration the generally shallow grade of the area - is predominantly via overland flow in the direction of reducing land elevations – North to South. The entire site area is vegetated, thus it is expected that runoff is dissipated via depression storage, and infiltration and percolation of runoff to groundwater zones.

There is an urban drainage system within the environs of the site – to the North, East and South of the site. The urban drainage system consists of interconnected roadside kerb and slippers drains, roadside open channel drains, culverts, earthen swales across larger empty lots, and suckwells, which collectively drain runoff from roofs, roads, and other hard standings in the area. During more intense and prolonged rainfall events it has been observed that the network of roadways within the site environs conveys excess runoff generally in a southern direction towards GAIA.

Summarizing, there are no defined natural watercourses within the environs of the site. Drainage on site and within the site environs is predominantly via overland flow in North to South directions. Depression storage and infiltration/percolation of rainwater to groundwater zones are expected to occur on site. An urban drainage system exists in the vicinity of the site, which routes runoff primarily from roof, roads and similar hard standings in southern directions towards the GAIA property.

3.2.6 Groundwater Protection Zone

Reference is made to section 2.5 of this report where the groundwater protection system for Barbados was introduced.

Figure 3 Site location with respect to BWA Groundwater Protection Zones

The site proposed for development falls within a BWA Zone 5 groundwater protection zone; restrictions on development that apply to the zone are described in Section 2.5.

There are no potable groundwater supply wells South and downstream of the site.

Section 2.6 of this study introduced a green paper -2020 Water Protection and Land use Zoning Policy – which describes a revised groundwater protection zoning system for Barbados. The site for development shall fall within a Zone D groundwater protection zone when this revised system is activated. Zone D areas are deemed to be groundwater recharge zones; water resources in these areas can be treated as sensitive by regulators.

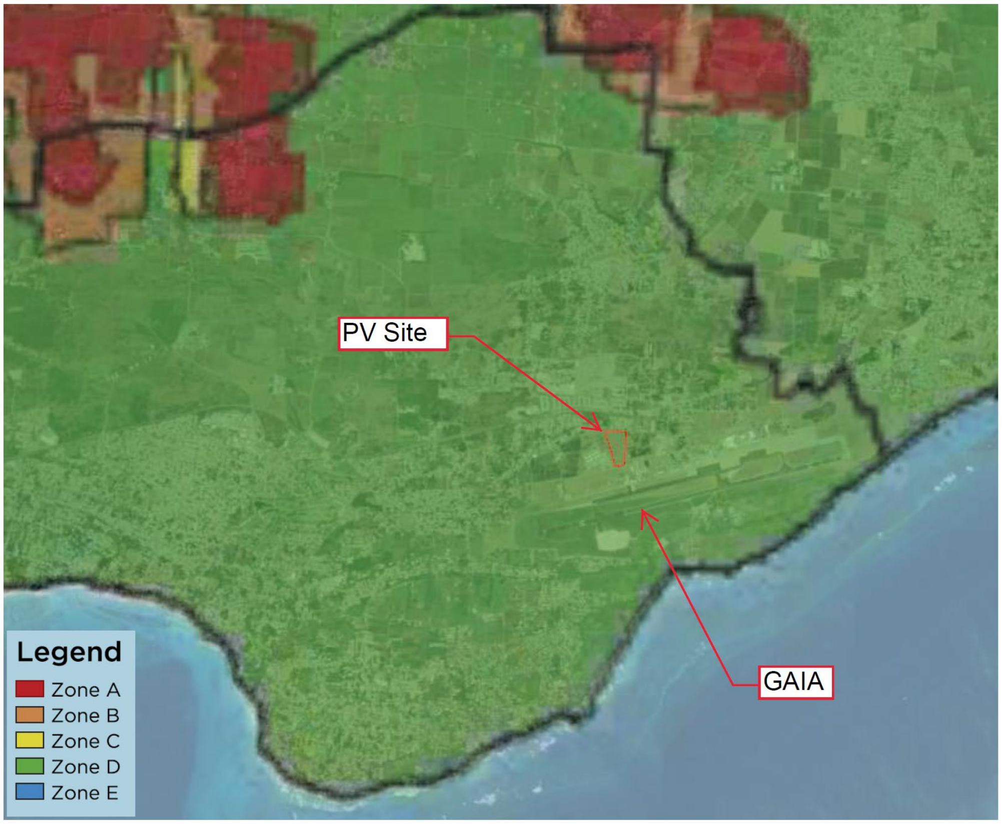

Figure 4- Proposed Revised Zone D in vicinity of site[17]

3.2.7 Ecology

2.6.1.1 Flora

No trace of the original pattern of vegetation now exists in Barbados. Removal of once dense forests for cane plantations proceeded rapidly from the onset of European settlement in the 17th century. Only relics remain of the original vegetation at Turner's Hall Wood in the Scotland District, Foster Hall Wood under the brow of Hackelton's Cliff and possibly in some gullies, but even these locations have been invaded by secondary growth.

Indeed, the site for development is disturbed. The surface vegetation is solely natural grasses, which are often mowed for aesthetic purposes.

[17] Image source: Green paper on 2020 Water Protection and Land Use Zoning Policy

2.6.1.2 Fauna

Habitat and fauna in the vicinity of the site are expected to be similar to those found on "rab"/fallow land elsewhere in Barbados. Given the extent of the grassed area, it is expected that rats, mice and centipedes may be present. Birds in the vicinity may include the ground dove, black-faced grassquit, grey kingbird, cattle egret, Carib grackle and green heron.

3.3 PROPOSED DEVELOPMENT

3.3.1 The Development

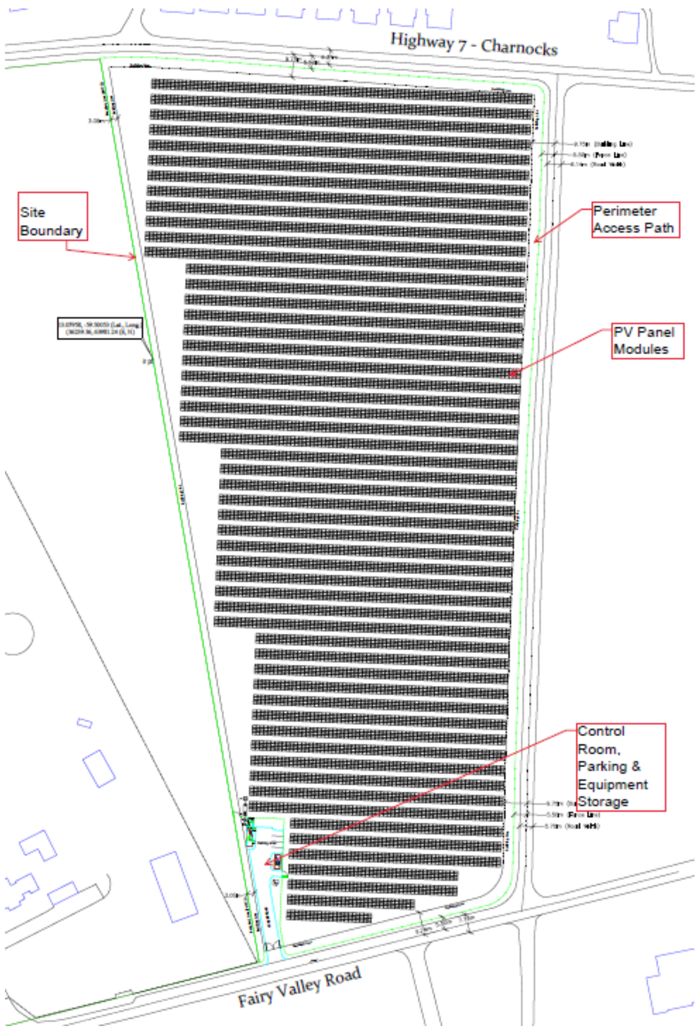

Figure 5 - Site Plan

The Developer proposes the construction of a solar farm on leased and maintained lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados. The farm shall generate power to be sold to Barbados Light & Power Ltd. The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. These 14,520 panels are expected to produce approximately 5MW AC of renewable energy electricity for integration in the national power grid.

Primary access to the proposed PV site shall be from Fairy Valley Road in the South that currently provides access to the BNTCL compound. Access into the fenced and gated PV farm compound shall be from the South; upon entry there shall be a vehicle parking area, control room and equipment storage container (see Figure 7.0 below)

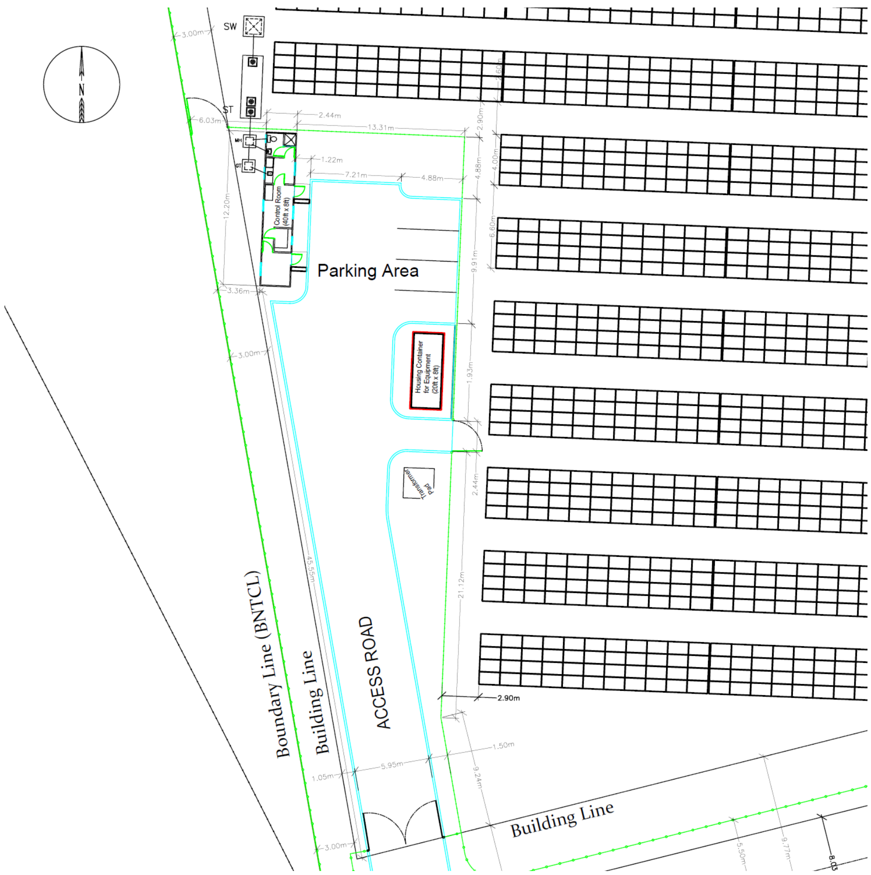

Figure 6 - Part site plan of farm

A 24kV transformer for converting low voltage electricity to high voltage electricity shall be located to the South of the equipment storage container shown in Figure 6 above; the equipment storage container shall be a re-purposed 6m long x 2.4 m wide steel shipping container. A total of 14# string inverters (preliminary estimate, to be confirmed) are proposed for the conversion of direct current (DC) produced by the panels to alternating current (AC). Each inverter will serve a group of PV modules; AC current produced via inverters shall be routed to the transformer for conversion to high voltage electricity for distribution to the BL&P grid.

The control room shall contain switches and other equipment for the operation of the farm; the room is proposed towards the south western region of the site. The room shall be a retrofitted 12m (40ft) steel shipping container. The control room shall have a washroom and kitchenette. Grease from the kitchen shall be routed to a grease trap. Separated effluent from the grease trap and wastewater from the washroom shall be routed to a septic tank and a suckwell soakaway system. Septic tank effluent routed to the suckwell shall percolate and infiltrate to groundwater zones below.

High voltage electricity produced from the farm shall be evacuated from site via high voltage cables on overhead utility poles along Fairy Valley road.

For security purposes, the Developer proposes to fence the perimeter of the farm's boundary with 2.4 m high galvanized chainlink fencing with barbed wire atop. Security cameras shall be installed at vantage points that permit the entire compound to be observed. The main entrance to the complex shall be gated and kept locked. There shall also be perimeter flood lighting.

For safety reasons, the transformer and inverter station shall be separately fenced and gated to prevent unauthorized persons from coming into contact with those pieces of equipment.

The facility will be connected to the internet via the proposed control room allowing remote monitoring of the performance of the plant and the camera security system.

3.3.2 PV Panels

3.3.2.1 General

Photovoltaic panels consist of several layers of materials. The top layer is typically glass with high transmissivity and low reflectance[18] values. The glass layer is typically followed by a structural layer - usually the back sheet. The semi-conductor solar cells along with electrical circuitry are usually between the glass and the back sheet; they are normally bound together by encapsulating materials on the front and back of the PV cell layer. To further stabilize and protect the edges of a panel, a frame - usually made from aluminum - is used.

With respect to the top glass layer, this layer can be specially treated to lower the reflectance of the panel and improve its efficiency. An Anti-Reflective Coating (ARC) can be applied to the glass layer to increase the amount of light absorbed into the cell; the ARC can be applied to smooth or textured glass of a panel.

Textured glass was predominantly used to reduce the reflectivity of solar panels before AFCs became more affordable. On clean surfaces textured glass improves the efficiencies of solar devices; incoming light is reflected off the raised surface of textured glass and is re-directed to other portions of the surface improving the solar energy capture efficiency. Another benefit of textured glass surfaces is that they reduce PV panel glare. Drawbacks of textured solar PV glass structures are:

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[18] Reflectance of the surface of a material is its effectiveness in reflecting radiant energy.

- Higher cost due to the additional material required to create the textured surface.
- Textured surfaces may trap dirt left behind by evaporation in the small grooves or low spots of the textured surface. That dirt can reduce the amount of transmitted energy and thus reduce the device's efficiency.

3.3.2.2 Types of Silicon Based Panels

The actual photovoltaic (PV) cells consist of two or more layers of silicon or similar semi-conducting material. Pure silicon metal is produced in electric arc furnaces from quartz; the process involves very high temperatures and utilizes reduction elements such as coke, coal, wood chips, charcoal, and the furnace's graphite electrodes.

Electrical charges are generated when the semiconductor in the panel is exposed to light; electric charges generated in the conductor are conveyed away as direct current (DC). Charges from a singular semi-conductor cell are small; stringing together multiple cells results in the production of the DC current.

The two most common panels on the market are Monocrystalline and Polycrystalline silicon panels. Monocrystalline panels have cells that are made from a single cylindrical silicon crystal. The manufacturing process of these types of semiconductors is intricate and costly; these panels have an energy conversion efficiency rate of 15%. Polycrystalline cells are made from an ingot of melted and recrystallized silicon. Production costs are cheaper than those associated with the Monocrystalline technology; the efficiency of energy conversion is in the region of 12%.

There are other types of silicon-based panels such as the Thick-Film silicon-based panel, which is a variant of the multi-crystalline technology, and the Amorphous panel. The silicon in an Amorphous setup is deposited as a thin homogenous layer onto a substrate rather than on a rigid crystalline structure. Amorphous silicon can be placed on flexible or rigid surfaces; an application of its use is placement directly on roofing tiles. Energy conversion efficiencies are low in the region of 6%.

3.3.2.3 Other Types of Panels

There are other non-silicon based semi-conductor panels. Cadmium Telluride (CdTe) and Copper Indium Diselenide (CIS) are being used as semi-conductor elements in some panels; there are number of other silicon substitutes. Efficiencies of these panels are comparable to silicone-based panels ranging from 9% to 13% with the CIS based panel giving higher efficiencies. Disposal of CdTe at end of life is a concern given that cadmium is an environmentally toxic chemical.

3.3.3 Panel orientation and tilt

Solar PV panels work best when their absorbing surface is perpendicular to the rays of the sun. As well as moving across the sky, the sun moves up and down the sky throughout a given year.

A panel's orientation is its horizontal angle relative to North; a panel facing Southwards – for example – would have an orientation of 180 degrees from North. To maximize exposure to the direct sun rays, panels should be oriented towards the terrestrial equator. Thus, in the Northern hemisphere (where Barbados is) panels should face Southwards; in the Southern hemisphere panels should be face Northwards.

The tilt of a PV panel is the angle between the panel surface and the earth' surface. The proposed tilt of PV panels for the BNTCL solar PV farm is 15 degrees.

3.3.4 Proposed Panel Arrangement

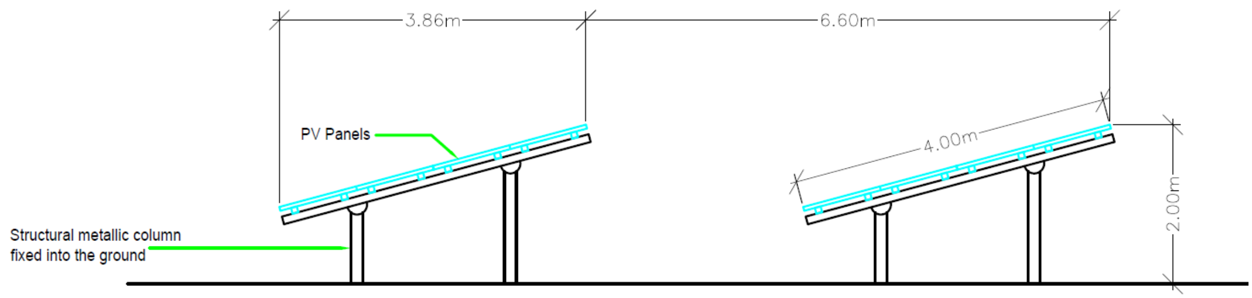

Figure 7 - PV Panel Mounting

The PV panels shall be fixed to a galvanized steel frame or racking. The racking shall be constructed from steel channels fixed to a pair of pole mounts (see Figure 7 above). Transverse steel channels shall span between pole mounted support and associated channels. PV modules shall be fixed to transverse channels.

To prevent the pull out of pole supports during high wind scenarios, poles shall be fixed to the ground either via ballasted footings of reinforced concrete, which typically do not involve significant ground penetration or via connection to piles driven into the soil and/or rock.

Generally, power cabling shall be run under racking – held together and in place by proprietary hangers or within cable trays spanning between pole mounts. Where cabling meetings roadways, cabling shall be directed underground and ultimately to the transformer introduced earlier.

3.3.5 PV Farm Drainage Infrastructure

The intent is that the primary form of drainage from the farm follows the same pattern as now exists, that is: overland flow from North to South directions. To manage runoff, especially where proposed flow paths intersect roadways, it is proposed that shallow earthen swales be dug directly adjacent to and parallel to roadways; culverts or fording(s) in roadways shall be used to allow runoff captured in swales to cross roadways at key locations. A drainage suckwell shall be constructed in a depressed area – to be formed by excavation - closer to the farm's southern boundary to capture and maintain runoff onsite.

The parking and hardstanding areas toward the southwestern region of the PV farm site shall be drained via a catchbasin and drainage suckwell.

3.3.6 PV Farm Electricity Supply

The primary purpose of the PV farm is the production of high voltage electricity for delivery and sale to Barbados Light and Power Ltd (BL&P). The control room, security lighting and camera system will need stepped down low voltage electricity to operate. The intent is that this power be constantly provided by BL&P; this power supply would be separately metered.

3.3.7 Operations

3.3.7.1 Staffing

The facility will not be permanently staffed. It is anticipated that there may be two maintenance personnel who shall visit the plant twice per week to check on and maintain the facility. Maintenance of the facility shall be primarily done at night, when the sun is down and the facility is not generating electricity; this is a health and safety best practice with respect to the maintenance of PV farms. The base of operation of the crew who shall visit the farm from time to time will be the control room. Equipment required for maintenance purposes shall be obtained from the equipment storage shipping container.

3.3.7.2 Potable Water

Potable water will be required for the lone washroom on the facility and for use in the washing of the panels from time to time. Typical daily water use in offices is 57 litres (15 US gallons) per person per day (Metcalf & Eddy, 1991). Assuming two staff members visiting the site twice a week per month, the total estimated water demand is 228 litres (60 US gallons) per week or 912 litres (241 gallons) per month.

The washing of panels due to soiling is not expected to be a routine operation; it is assumed that the quantities of water required can be embodied in the estimate given above.

Water will be brought to the site by the Barbados Water Authority via a buried pipeline; the water connection to the farm shall be metered.

3.3.7.3 Industrial and Foul Wastewater Disposal

Foul wastewater generated on the farm shall come from the maintenance crew's use of the lone washroom on the property; this wastewater shall be disposed to the septic tank, and suckwell soakaway system - introduced earlier.

The resultant water from the washing of panels may be construed as industrial wastewater; this water shall fall to the ground surface, and infiltrate and percolate towards groundwater zones.

3.3.7.4 Solid Waste Disposal

Very little solid waste from maintenance of the facility shall be generated. Solid waste shall be generated from staff member's use of the Control Room - office paper waste, and waste from the washroom. The mowing/clipping of the grassed areas in and around PV panel racking systems shall generate green solid waste.

Solid waste shall be dumped in a garbage bin on the property for collection by the Sanitation Service Authority (SSA) of Barbados or garbage skip for ultimate collection by a private waste hauler when filled; solid waste shall be transported to the Mangrove Landfill/Sustainable Barbados Recycling Centre (SBRC) complex for disposal.

3.3.7.5 General Maintenance

The following are routine or frequent operations that will be done during the operations stage of the PV farm.

- Dirty panels or soiling reduces the energy output of a PV array. Soiling can come from dust and bird droppings - for example. The economical and water saving means of cleaning is the use of buckets of water, strip cleaner and squeegee using overlapping vertical strokes – similar to cleaning car windshields; the use of high pressure hoses, solvents, harsh detergents and abrasives is generally not recommended for cleaning panels. During rainy seasons, heavy rains clean panels, reducing - if not eliminating - the need to use potable water for cleaning.

- Bird control – birds are known to build nests on ledges beneath PV racking. Higher bird populations result in greater instances of birds walking on and soiling panels. Removal of bird nests and birds forms part of routine PV farm maintenance.

- Rodent control – rodents are known to chew on exposed power cables. Controlling rodent populations helps to prolong the electrical cabling infrastructure. Indeed, part of routine maintenance will involve inspections of above ground and exposed cabling for integrity.

- Vegetation control – keeping grassed areas low will be a routine activity; this can be done using grass mowers or sheep or a combination of both. Sheep grazing is a best practice for vegetation control using animals; cattle and horses are large and can damage panels by impact or using panels for scratching. Goats are known to chew on cables and jump atop panels.

- Given the potential for exposure to extreme storm conditions in Barbados, especially during the hurricane season (June to the end of October), there are checks and preparatory activities that will have to be done on the farm prior to the advent of the season. These checks would include, for example, ensuring the tightness of fasteners and clamps, and wire ties for cabling. Where necessary, remedial works would be done to ensure structural integrity and a scan of areas surrounding the farm towards removing any fallen branches or other objects that could become airborne and impact panels.

4 ENVIRONMENTAL SCOPING ASSESSMENTS

4.1 GENERAL

This section of the scoping study presents the potential impacts and mitigation measures related to identified Valued Ecosystem Components. Valued Ecosystem Components (VECs) are environmental issues identified through scoping and pathways exercises. These VECs are the subjects on which the effects assessment is based.

This environmental scoping section shall focus on environmental assessments that are impacted by the site specifics of the development; VECs to be assessed are as follows:

- Land use
- Electromagnetic Interference
- Wastewater
- Drainage
- Ecology
- Noise
- Glint & Glare
- Solid Waste
- Climate Change and Natural disasters
- Visual Impact

The following potential impacts to areas of special concern were identified as likely to occur because of the proposed Project. Potential impacts are presented in the form of scenarios; mitigation measures are recommended for each impact identified. It is anticipated that mitigation measures identified may be incorporated into the design, construction, and operation stages of the development.

4.2 LAND USE ASSESSMENT

Per the Physical Development Plan of Barbados (USI et. al, 2017), the site is located within the "Employment" land use designation. The site is located outside of the Soil Protection Overlay.

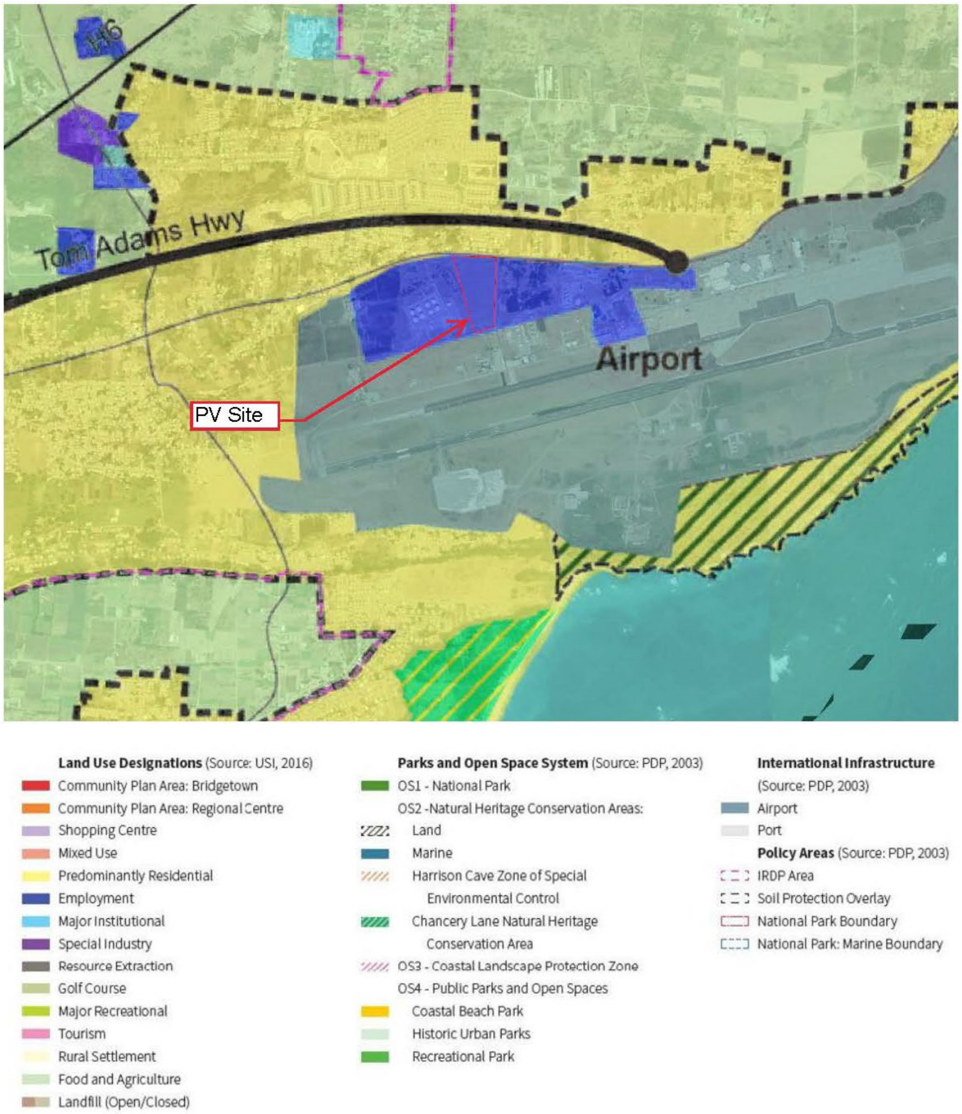

Figure 8 - Land Use Development Plan (Excerpt - USI et. al., 2017)

The best agricultural soils in Barbados occupy 9.5% of the total area of the island; these lands are deemed irreplaceable. It is a policy of the Government of Barbados that restrictions are placed on prime agricultural land to prevent them being used for other development – residential etc. Per the Physical Development Plan (2017), the **Food and Agriculture** designation and the Soil Protection Overlay are part of four protection measures implemented to safeguard agricultural lands. Lands within the Food and

Protection land use designation are to: accommodate food production and *"restrict alienation of land to any other use"* unless proposed land use meets set criteria. Within the **Soil Protection Overlay,** non-agricultural uses will not be permitted and the Government will encourage the return of idle agricultural lands to productive use.

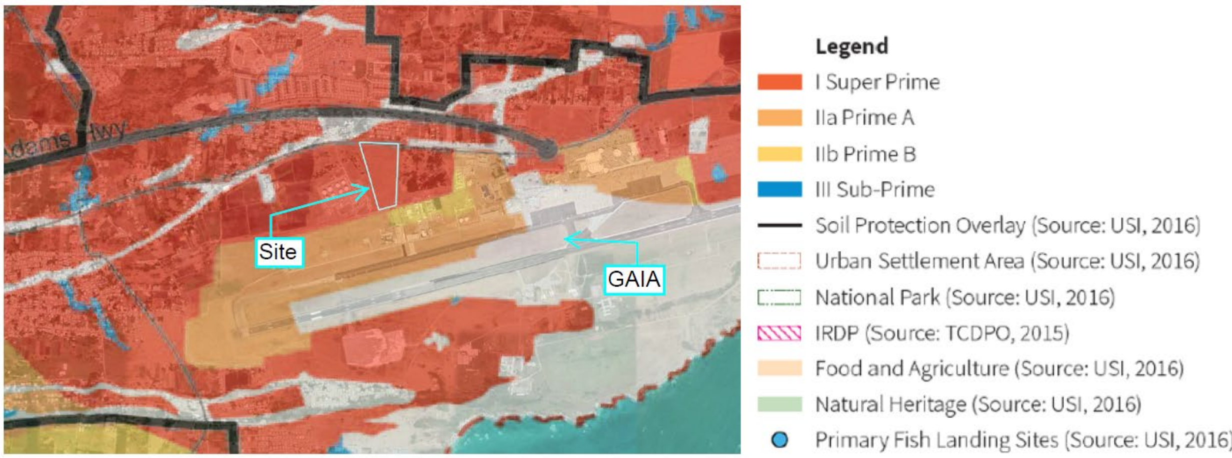

Figure 9 - Agricultural Soils (Excerpt - USI et. al., 2017)

Section 17 b) of the Physical Development Plan states that Solar PV farms of a large scale shall not be permitted within the Soil Protection Overlay zone; Section 17 c) states that ground mount PV farms will be permitted on grazing land.

Soils within the site are Class 1 Super Prime soils (see Figure 9 above). Notwithstanding this observation – as mentioned prior – the site is designated as an Employment land use area where developments that promote employment and contribute to national economy can be sited. Types of developments permitted on the site include light industrial, office buildings, institution operations such as education campuses, restaurants, and retail facilities. The proposed PV development could be considered light industrial.

4.2.1 Potential Impacts

4.2.1.1 Operations Stage

A. Though the land use designation of the site is for Employment Areas, soils on the site are Class 1 Super Prime. The development and operation of the PV farm will eliminate the potential for the use of the lands of the site for agriculture and its potential for assisting with shoring up the food security of Barbados.

4.2.2 Mitigation Measures

4.2.2.1 Operations Stage

A. The site is currently not used for agriculture; thus, the use of the site for a PV farm will not take away from the stock of land currently being used for agriculture. Also, the site is outside of the

Soil Protection Overlay Zone and as such is not within the bank of lands mandated under the Food and Agriculture land use designation for return to agricultural use. The latter statements having been made, there is the potential for sheep grazing agriculture for landscape maintenance as part of the operations of the plant.

4.3 ELECTROMAGNETIC AND RADAR INTERFERENCE

The physical development plan (USI et. al., 2017) states that environmental studies of PV farms should consider the potential for impact from electromagnetic interference (EMI).

EMI is deemed to be caused by radio frequency (RF) emissions from PV systems, which have the potential to impact radio receivers, communication devices, and navigational aids. The proposed inverters are the only components of the proposed PV system capable of emitting EMI. Inverters however typically emit low EMI frequency – of a magnitude similar to typical electrical appliances. Typically, at 46m (150ft) away from inverters, the EM field is at background levels (NREL, 2017).

The radar interference concern relates to a PV farm blocking nearby radar emissions as would be used by a control tower of an airport. Ground mounted farms generally tend to have a low profile/height with respect to radar surveillance equipment, which is normally located on elevated towers or platforms (NREL, 2017). PV farms should have a minimum set back from nearest edge of PV array of 76m away from an airfields radar system.

4.3.1 Potential Impacts

4.3.1.1 Pre-Construction Stage

A. Electromagnetic interference from the operation of the PV may impact on nearby communication equipment.

B. The operation of the PV farm may impact on radar use at the Grantley Adams International Airport (GAIA).

4.3.2 Mitigation Measures

4.3.2.1 Pre-Construction Stage

A. Consideration should be siting inverters such that they are at least 46m away from the proposed control room.

B. The site for development is greater than 46m from the nearest airfield radar system; no impact to the operations of GAIA radar equipment is expected.

4.4 WASTEWATER ASSESSMENT

As mentioned in section 3.3.7.3, wastewater from the operation of the farm shall come from the use of the lone washroom on site and from washing panels to remove soiling. Wastewater may also be produced during the construction stage of the project.

4.4.1 Potential Impacts

4.4.1.1 Construction Stage

A. Spillages of fuel, lubricants, coolants, etc. from construction equipment have the potential to be leached by rainfall or intense water use activities to the groundwater zone beneath the site.

4.4.1.2 Operations Stage

A. The disposal of foul wastewater without treatment – directly to suckwells – has the potential to impact groundwater quality beneath the site; the site is in a Zone 5 groundwater protection zone.

4.4.2 Mitigation Measures

4.4.2.1 Pre-Construction Stage

A. The foul wastewater disposal system should be designed to Environmental Protection Department guidelines for building wastewater disposal systems in Zone 5 groundwater protection areas. The guideline permits the use of suckwell/soakway for the disposal of foul sewage in Zone 5 areas.

4.4.2.2 Construction Stage

A. Best practices for the proper handling, storage and disposal of spilled hazardous chemicals and fuels should be referenced and included in the contractor's environmental management plan.

4.4.2.3 Operations Stage

A. The Developer should develop an operations management plan, which schedules the routine inspection and cleaning – if necessary – of the septic tank and soakaway; these units should be inspected at least once every six (6) months.

B. The cleaning of PV panels should only be done with clean water. No detergents or cleaning chemicals should be used; this way, water that runs onto the ground will not have any chemicals entrained.

4.5 DRAINAGE

4.5.1 Site Drainage

The site for development is totally vegetated. As mentioned earlier, runoff is predominantly via overland flow in a southerly direction (see section 3.2.5 above). As the following discussion shall demonstrate, provided the site remains grassed beneath panels, runoff increase due to the construction of the farm is not expected to a significant degree.

4.5.2 Hydraulic Response of Solar Farms

Solar panels are impervious to rainfall; however, they are generally mounted on supports above permeable lands. Cook et. al. (2013) investigated the hydrologic effects of solar farms and examined whether stormwater management is needed to control runoff volumes and rates – post the development of a farm. During the study, a model of a solar farm was created for simulating runoff conditions for pre and post paneled conditions. The study conducted sensitivity analyses taking into consideration varying conditions including changing the storm duration and volume, soil type, ground slope, panel angle, and ground cover - all towards determining the effect that each of these factors would have on the volumes and peak discharge rates of runoff.

Cook et al. (2013) concluded the following:

- The addition of a solar panel over a grassy field does not have much of an effect on the volume of runoff, the peak discharge nor the time to peak; given that lands beneath the panels are permeable.
- However, when land cover type is changed under the panels – such as the use of gravel or a hard pavement – (and the space between is patchy ground or bare), the peak discharge in the model increased by 100%.
- The kinetic energy of water draining from a solar panel is 10 times greater than rainfall resulting in the possibility that soil below panel could erode due to concentrated flow of water off the panel; a scenario which is heightened if there is bare earth.

Cook et. al. (2013) ultimately recommended that a grass covered soil beneath panels and in the pathway/space beneath panels be consistent and well maintained. Where use of gravel and hard pavements underneath and between panels is unavoidable, the study recommended the use of a vegetated buffer strip at the downstream site boundary - to control excess runoff and ensure adequate losses.

4.5.3 Potential Impacts

4.5.3.1 Construction Stage

A. The construction stage of the project may involve the use of heavy equipment, which may result in the removal of the grass surface in areas and increased potentials for the washing of topsoil and soil erosion. Such a scenario could result in soil materials being washed towards the southern regions of the site.

4.5.3.2 Operations Stage

A. The construction of solar panels may result in a significant increase in impermeable surface areas on the site and runoff quantities, which in turn may result in flooding of downstream areas. South of the site is Fairy Valley Road and other lands of GAIA.

4.5.4 Mitigation Measures

4.5.4.1 Construction Stage

A. This is a transient potential impact, the possibility of which ceases after the completion of the construction stage and the reinstatement of grassed areas.

- Silt screens should be used where necessary to contain and retard the movement of silt and topsoil from localised areas.
- Temporary boulder barriers/walls should be provided at strategic points of surface runoff to retain sediment and control the rate of runoff southwards during the construction phase.
- Any stockpiled topsoil that will not be used for re-instatement should be removed from site as soon as possible.

4.5.4.2 Operation Stage

A. As discussed in Section 4.5.2, provided ground conditions beneath solar panels are suitably grassed and maintained, the presence of solar panels on site is not expected to increase runoff or alter the drainage characteristics of the site, and by extension promote flooding on lands South and downstream of the farm.

- There should be routine maintenance of the grassed surface to ensure that there are no bare patches or inconsistencies, which could result in a change to the runoff characteristics in those areas.
- Consideration could be given to the use of a vegetated buffer strip at the downstream northeastern, eastern and southern site boundaries - to mitigate any excess runoff due to the presence of any bare patches within the solar panel site.

- Consideration should be given during the detailed design stage of the drainage system of the site of creating a depressed area closer to the southern boundary to promote runoff attenuation, infiltration and percolation processes. Consideration should be given to the installation of a drainage suckwell in this depressed area to expedite drainage of captured water and prevent ponding.

4.6 ECOLOGY

As demonstrated in section 3.2.7 above, the site for development is totally grassed with little variety in vegetation and natural fauna – rats, birds etc.

The fencing of lands around a PV farm can restrict the movement of small animals, resulting in a change in habitat for these animals – affecting their hiding spots, preying strategy, and food availability. A quantitative study of impacts from solar power measured deaths of birds, bats and insects at a concentrating solar power tower[19] at a farm in the United States; there were bird deaths and the incineration of hundreds of insects per hour; ultimately impacts were considered to be low when compared to other anthropogenic sources of bird and insect deaths (Turney D. et al., 2011).

On the matter of solar PV farm avian mortality, Watson Jr. et al. (2016) posits that there are two (2) known types of solar PV farm related mortality:

i) Collison related mortality resulting from birds flying directly into PV infrastructure.

ii) Solar flux-related mortality due to concentrated light burning/singeing effects, which could result in direct mortality or singed feathers affecting flight, which in turn affects the bird's ability to avoid predators or forage.

In connection with i) above, it is further hypothesized (Oberhaus D., 2020) that birds may mistake glare from a PV farm as coming from a water surface and may swoop down for a landing and impact panels.

In connection with ii), L. J. Watson Jr. et al. (2016) further states that solar flux related bird kill has only been observed at concentrating tower PV farm facilities.

[19] Mirrored tower that concentrates sunlight onto a field of PV panels

4.6.1 Potential Impacts

4.6.1.1 Operations Stage

A. The fencing of the PV farm may restrict fauna from traversing the site area, which may have once formed part of the habitat of these animals.

B. The construction of the PV farm may cause glare and solar flux issues, which could result in bird kills at the site.

4.6.2 Mitigation Measures

4.6.2.1 Operation Stage

A. With respect to 4.6.1.1 A, the use of galvanized chain link fencing with a raised privacy screen – maybe 450mmm or thereabouts from ground level would allow small animals, typically found in Barbados on “rab” lands, to enter the complex.

B. The PV farm will not be a Concentrating Solar Power (CSP) farm, so the solar flux related impacts would not occur. The impacts of glare from PV panels on bird kills is an emerging area of research in the PV industry; the true reason for this form of bird kill is still unknown, as are measures that can be taken to mitigate or eliminate this impact.

4.7 NOISE

4.7.1 Definition and Characteristics

Noise is unwanted or undesired sound. Sound/noise vibrations are propagated in a spherical manner (in all directions) from their sources. Sound is caused by the vibration of air molecules. When vibrated air molecules reach the ear, sound is heard. The magnitude of a sound is expressed as a “sound pressure level” (SPL) in logarithmic decibel units. The nature of the logarithmic scale means that an increase of 10dBa is perceived by the ear as a doubling in loudness; a decrease of 10dBa is perceived as having the opposite effect.

If noise emanates from an object – such as a piece of machinery or a vehicle – the sound intensity drops by a factor of four (4) when the distance from the source is doubled. The latter mentioned fact follows the principle of "energy conservation”. Based on the information above, the doubling of the distance between a source and receptor results in a new sound level that is 10log(4) or approximately six (6) dB lower than the noise level at source.

Also, given that the decibel is a logarithmic unit, a doubling in the number of noise sources results in a SPL increase of 3dB (if sources are independent); a further doubling of noise sources raises SPLs another 3dB, and so on. In other words, if the number of sound generators with the same noise level doubles then there would be a 3dB increase in the SPL.

4.7.2 Impact of Noise on the Human Receptor

Zero (0) dBa is the minimum threshold of sound, and levels greater than 120dbA result in pain to the human receptor. In addition to being a nuisance, noise causes several other negative impacts:

a. Research (Kiernan, 1997) indicates that children raised in areas subject to constant level of noise develop poorer reading skills and abilities to discern and understand human speech than those who grew up in quieter areas.

b. Constant noise levels are known to cause anxiety and depression in those exposed to these levels.

c. Constant overexposure to high noise levels can damage hair cells near the base of the cochlea, where high frequency sounds are processed. Such damage can result in the receptor being unable to clearly hear sounds as well as a low tolerance for loud sounds.

Noise-induced hearing loss is a major problem because people are generally unaware of its warning signs and effects until it's too late.

4.7.3 International Standards

There is general agreement amongst international[20] noise standards/guidelines and recommendations as to desired average sound levels expected for different land use areas during day and night-time periods. The average day and night-time noise levels expected in residential areas are 52dBa and 44dBa respectively. With respect to commercial areas, day and night-time levels required are 58dBa and 53dBa respectively, and for industrial areas, day and night-time levels required are 64dBa and 59dBa respectively.

For workers operating noisy equipment over a standard working day (8 hours), international standards are generally in agreement. They stipulate that maximum time weighted averages (TWA) of noise levels should not exceed 85 – 90dBa over an 8-hour workday and that maximum impulse noises should not exceed 140dBa. The major difference within the standards is the recommended measures that employers must implement when maximum noise levels are exceeded. Regulations in most developed countries require: adequate ear protection for workers; the retrofitting of equipment to lessen noise produced from the same equipment, and/or the provision of "quiet areas" where workers can get relief from ambient noisy conditions.

[20] World Health Organisation (WHO), US EPA, Japan, Canada, Australia

4.7.4 Noise Emission from Substations

A small substation is proposed as part of the BNTCL PV farm development. The noise generating aspects of the substation shall be the transformer and inverter.

The proposed transformer shall have a rating of 2400kVA (2.4 MVA). Noise levels from inverters are typically significantly less than levels from transformers.

McDonald, J. D. (2012) states that noise complaints are common from substations with transformers of sizes 20 to 150 MVA, especially if receptors are at distances of 170m to 200m away; very few complaints are received due to sub-stations with transformers with less than 10 MVA capacity, unless they are located in denser urban areas. Noise levels of transformers are a function of the MVA; levels are typically between 60 and 80 dBA.

If it is assumed that a noise level of 70 dBA is heard at a distance away of 3m from the transformer then via the 6dBA noise attenuation rule of thumb introduced above, noise levels fall to 50 dBA 189m away from the transformer and 44dBA 381m away from the transformer. Note that a hypothetical doubling of the transformer noise (due for example due to the presence of inverters) raises the source noise level to 73 dBA (see section 5.7.1).

Based on the proposed location of the substation (towards the south west of the site) , note the following:

- The closest building on the BNTL office and fuel storage site to the West is 44m.
- The closest building to south and south east is 189m away.
- Closest residential property to the North is 344m.

4.7.5 Potential Impacts

4.7.5.1 Construction Stage

A. Noises emanating from the Project site during construction is expected to be varied and may be linked to various steps in the preparation and building of the site as well as vehicular movements conveying the workforce, construction equipment, and facility infrastructure to and from the site. The following are likely sources of noise:

   - Site clearing and grading activity using bulldozers, excavators, trucks, etc.
   - Ditching for runoff and trenching for cables
   - Installation of pipeline sections for water supply, wastewater removal, cable installation, etc.
   - Pouring and forming of concrete for PV racking foundations

- Creation of laydown areas and the movement of earth and construction materials to and from the site.
- Workers and equipment brought to site.
- Infrastructure brought to the site such as tanks for oil fuel.
- Commissioning and testing.
- Clean-up and landscaping.

4.7.5.2 Operation

A. The operation of the PV farm and its substation may result in noise impacts to existing operations at the BNTCL fuel storage facility to the West, persons utilizing building to the South on lands of GAIA and the strip of residential/commercial properties to the North of the site.

4.7.6 Mitigation Measures

4.7.6.1 Pre-Construction Stage

A. Consideration should be given to building concrete infilled reinforced block walls to the South, West and North of the transformer location; these walls would serve as sound attenuation walls. Up to a 20dBA drop in noise levels can occur when there is a barrier (walls or earthen berms) between the noise source and receptor. It is possible that the sound attenuation walls could be constructed after the plant is up and running; confirmatory noise readings could be taken to determine whether there is indeed a noise impact from transformer and inverter operations.

4.7.6.2 Construction Stage

A. Construction and post-closure activities are expected to be highly variable and unpredictable at a detailed level. Construction equipment will be operating over a wide-ranging area and specific controls may be necessary when construction activities are near receptors.

B. Construction equipment should be maintained in good working order and properly muffled. Also, where possible major noise generation activities should be planned to take place during day-time hours.

C. A Monitoring and Protection Plan (part of the contractor's environmental management plan) should be in place to be followed by the contractor to address potential noise and vibration impacts.

D. Construction and post-closure vibration levels are not expected to be perceptible at nearby receptors due to their distance away from the site. Ground-borne vibrations are generally more difficult to mitigate than airborne noise. Use of alternative construction methods and tools may reduce vibrations. Examples include:

- Pre-drilling of pile holes – (if piles are proposed as racking foundations).
- Use of rubber tired rather than tracked vehicles.
- Place haul loads away from vibration-sensitive areas.
- Schedule construction and post-closure activities, particularly any pile driving, for times when the activity does not interfere with vibration-sensitive operations (e.g. avoid night-time activities).

4.8 GLINT & GLARE

Reference is made to Appendix B where the complete Glint and Glare study can be found.

Glare is generally described as direct sunlight or reflected sunlight from a surface for an extended duration. Glint is a momentary flash of light from a reflective surface, which can cause discomfort to those impacted. Solar panels are designed to absorb as much light/solar energy as possible to attain maximum efficiency; they are designed to absorb light and not reflect it. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow and steel (metal sheeted roofs etc). PV panels usually reflect 2% of incident sunlight.

SGHAT – a glare modelling software – was used to estimate the potential glare at eleven (11) observation/receptor points (OPs) - including the Air Traffic Control Tower- ATCT at GAIA, three (3) route (public roadway) receptors and two (2) flight path receptors (pilot landing an aircraft at GAIA) – all points within sight of the solar farm.

The model indicates that there is potential for glare impacts at receptors predominantly to the East and West; the model also predicts that receptors OP2 *(first floor BNTCL office)* and OP9 *(first floor of GAIA Engineering building)* may be exposed to the most prevalent glare received by building receptors, while the road along the southern boundary of the PV site (Fairy Valley Road) may experience glare from panels throughout most of the year. Glare when it is predicted to occur does so within discrete hours of a given day – not exceeding a period of 3 hours on the days with the longest duration of glare. In the airport, at the ATCT, the model predicted that glare may occur during the evening, between the hours of 5:30pm and 6:00pm from March to mid-May, and from August to mid-October. “Green” glare, defined as a ***Low Potential Hazard*** – glare with low potential to leave an after-image, was also predicted at the ATCT, the road along the southern boundary of the PV site and along the flight path of aircrafts landing at GAIA from the West and East.

The United States (US) Department of Energy in collaboration with the US Federal Aviation Administration (FAA) has determined that glare from PV farms in the vicinity of airports can impact air traffic controllers and pilots of aircraft. The FAA has set the following acceptance criteria for farms in the vicinity of airports:

- No potential for glare at cabin level (where air traffic controllers work).
- Glare impacting pilots during last two miles of standard straight in landing approach to have a low potential for after image.

The results of the glint and glare study indicate potential glint and glare impacts to air traffic controllers at the ATCT receptor location and green glare impacts (low potential for after image) to landing pilots.

4.8.1 Potential Impacts

4.8.1.1 Operations Stage

A. Existing land use at the BNTCL fuel handling facility in the West, and other existing commercial/industrial operations to the South East and East of the proposed solar farm may be impacted by glint and glare impacts throughout the course of a year.

4.8.2 Mitigation Measures

4.8.2.1 Pre-Construction Stage

A. Consideration could be given to optimizing the panel angles (and possibly removal of some panels) – via consultation with panel system supplier - to minimize glare impacts; the focus of the optimization should be to eliminate the potential glare effects at the cabin level of the ATCT. Note that this action could result in a reduction in the solar conversion efficiency of the PV farm.

B. A tree screen of height not less than 3m (10 feet) should be constructed along the northern, southern and eastern site boundaries. There is an existing partial screen along the western boundary of the site in the form of an earthen berm with tree line atop; the southern section of this existing screen should be extended in the form of a 3m (10ft) high tree screen towards the site's southern boundary. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors to the North, East, South and West and by extension mitigate – if not eliminate - the potential for glare impacts. The implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm.

C. Along the line of sight of two-storey buildings, tree screens should be grown to a minimum height of 6m. The implementation of this recommendation would block the line of sight of PV panels to receptors in targeted two-storey buildings.

D. Consideration could be given to utilizing smooth panels without ARC coating.

4.8.2.2 Operations Stage

A. If there are reports of impacts from residents or other land users near the development, then consideration should be given to the following:

- Replacing offending panels with a deep textured panel – to reduce glare intensity.
- Removing the offending solar panels.

The above recommendations would also apply to any reports of glare from pilots of approaching aircraft or air traffic controllers in the ATCT.

4.9 SOLID WASTE DISPOSAL ASSESSMENT

Solid waste shall be generated during the construction stage of the PV farm. During the operations stage, solid waste will include office based municipal waste from the staff member's use of the Control Room. Green waste shall be produced from the mowing of the lawn areas in and around the PV panel modules. These types of solid wastes are not expected to be significant; indeed, if the Developer proposes to use sheep as a means of maintaining grassed areas, solid waste quantities that would need to be carted away off property would be substantially reduced.

PV modules are typically expected to last at least 30 yrs. Of concern is the need to dispose of panels at the end of their useful life. As introduced earlier, there are alternative panels where the photo active material is cadmium telluride (CdTe) rather than silicon based. There is the concern that the disposal of certain types of panels to landfills could result in the release of Cadmium, Lead and Selenium, given that some panels contain small amounts of these materials. The challenge with recycling solar panels at the end of their useful life is that the concentration, value, and amount of reclaimable materials is low (Fthenakis V.M., 2000).

The current PV recycling industry revolves around recycling scrap materials stemming from the manufacture of PV modules. There is a "centralized" and "decentralized" approach to PV systems recycling. The centralized approach involves the use of large smelters that would receive the panel module as a whole and process same in a smelter; the low metal concentration in PV modules is not of significant value, however the glass content is of value to smelters operators who have to purchase silica for their fluxing operation. Copper smelters can remove glass and any contact metals (Ni), selenium, cadmium, and tellurium that may be contained within. Cadmium is not typically removed in copper smelters and is generally in the resultant waste streams. Zinc smelters can however recover cadmium; it is implied that the processing of the waste stream from the copper smelter by the zinc smelter can result in the removal of cadmium (Fthenakis V.M., 2000).

The decentralized approach focuses on separating the components of the panels and then processing them separately. One method used by a service provider in the United States of America to recycle CdTe modules is to (Fthenakis V.M., 2000):

- Disassemble module and recover wires; crush glass in a mill, and extract crushed glass using chemical dissolution, mechanical separation and precipitation or electrodeposition. At this point the mounts, glass and Ethylene Vinyl Acetate (EVA) glazing laminate are recovered.
- Remaining metallic sludge containing Cadmium, Tellurium, Selenium, Nickel, Copper etc. is sent to a third party where metals are recovered.

4.9.1 Potential Impacts

4.9.1.1 Operation Stage

A. The improper disposal of municipal and green wastes from the operation of the PV farm could adversely affect the environment, and the health and safety of employees who work from time to time on the farm.

B. At the end of the useful life of PV modules, their local disposal in landfills in Barbados – especially construction and demolition landfills, which are unlined – could result in the leaching of heavy metals to groundwater zones.

4.9.2 Mitigation Measures

4.9.2.1 Operation Stage

A. The Operations Management Plan of the facility should include the use of large capacity municipal garbage skips for the receipt of green waste and general waste from the use of the Control Room. Skips should be routinely emptied.

B. Consideration should be given to permitting frequent sheep grazing as means of controlling the volume of green waste produced from the maintenance of grassed areas.

C. With respect to impact scenario 4.9.1.1(B), the Developer should consider obtaining silicon-based panels versus the CdTe and CIS based panels.

D. Also with respect to impact scenario 4.9.1.1(B), the Developer and the host of other PV developers on the island should approach the Ministry of Health, the Sanitation Service Authority and the Sustainable Barbados Recycling Center (SBRC) to create a mechanism by which all PV farm developers can dispose of their end of life panel modules to the SBRC or other approved local recyclers. The intent would be that panels be shipped overseas to an approved recycling facility, given that such a facility does not exist in Barbados and may not be developed in Barbados – due the development cost, intricacy and limited market for local/regional recycling.

4.10 CLIMATE CHANGE & NATURAL DISASTER ASSESSMENT

4.10.1 General

With Barbados proposing to move to 100% renewable energy production by 2030, a primary concern is the climate change and natural disaster resilience of the renewable energy systems proposed. A hurricane – for example – impacting Barbados and significantly damaging its stock of PV farms could seriously hamper the ability of the country to provide electricity to the populace immediately post an event and thereafter.

4.10.2 Climate Change

The Intergovernmental Panel on Climate Change Report (IPCC, 2007)[21] confirms that human activity has resulted in an increase in the emission of greenhouse gases, which in turn has resulted in an acceleration of climate change on the planet.

Small islands – such as Barbados - are deemed particularly vulnerable to the negative effects of climate change; effects include: sea level rise, which has the potential to damage coastal infrastructure and property; reduction in water resources – more severe and extended droughts; increases in temperature; and increases in incidences of heavy rainfall and more frequent and intense extreme storm events.

General Circulation Models (GCMs) are accepted tools for projecting future climate information. GCMs are mathematical models of the physical and dynamic processes within and between the earth's atmosphere, ocean, cryosphere, and land masses. A limitation of GCMs is the fact that due to their coarse resolution relative to the higher resolution detail found in specific regional scales, GCMs may not fully describe interactions between physical processes and the local details that describe a specific location or region. Thus, for an island nation with a small geographical footprint such as Barbados, larger-scale GCMs must be combined with Regional Climate Models (RCMs) to improve the model's mathematical representations of physical processes[22].

Relevant climate change information for Barbados reported in the following section was derived from a combination of recently reviewed climate data sources and climate model projections of future scenarios using an ensemble of 15 GCMs and the Regional Climate Model (RCM) known as PRECIS. RCM simulations from PRECIS were driven by two different GCMs (ECHAM4 and HadCM3) to project climate to the Barbados level (CCCRA, 2012). This modelling represents future change under three different greenhouse gas emissions scenarios, namely (CCCRA, 2012): High Emission Scenario (A2); Medium Emissions Scenario (A1B), and Lower Emissions Scenario (B1).

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[21] Intergovernmental Panel on Climate Change (IPCC), (2007); Fourth Assessment Report: Climate Change 2007. Cambridge: Cambridge University Press.
[22] CARIBSAVE Climate Change Risk Profile for Barbados (CCCRA, 2012)

4.10.3 Climate Change Projection Barbados

Regional Climate Model (RCM) projections indicate the potential for sea level rise, temperature increases, and decreases in annual rainfall in Barbados. GCM projections predict a reduction in maximum 1-day rainfall totals by the 2080s.

Of relevance to the site for development is the potential for increase in the frequency and magnitude of extreme weather – tropical storms and hurricanes – to which PV farms are vulnerable. Climate change models are deemed relatively primitive with respect to representing tropical storms, hurricanes etc. and by extension primitive in their ability to determine future changes in frequency and intensity of these storms. Recent studies indicate that the frequency of storms may decrease; in some of the same studies the intensity of hurricanes is expected to increase (despite reductions in frequency) – CCCRA, 2012.

4.10.4 Natural Disasters

The United Nations defines a disaster as a *"serious disruption of the functioning of society causing widespread human, material or environmental loses, which exceeds the capacity of the affected society to cope using its own resources"*.

There are three (3) broad categories of natural hazards:

- Hydrometeorological – hurricane, tropical storm, flooding, drought, storm surge, landslide/mudflow.
- Geological – earthquake, volcano, tsunami.
- Biological – epidemic & wildfire/bushfire.

Barbados is exposed to all hazards above including volcanoes – considering the ash fall from the 2021 eruption of the La Soufriere volcano in St. Vincent.

4.10.5 Vulnerability of PV Farms

The resilience of PV farms in the Eastern Caribbean to strong hurricanes experienced during the 2017 hurricane season was researched by the Rocky Mountain Institute (Burgess et. al., 2018). The 2017 season saw hurricanes Maria, Harvey, and Irma. It is reported that notwithstanding record 180 mph wind speeds, several of the farms survived; there were those that did not. Lessons learned on why observed PV systems failed include:

- Undersized rack or rack support system not designed for wind load.
- Undersized bolting and under torqued bolts.
- Lack of vibration resistant connections.
- Failure of clamps used to fix PV panels to modules to racking.
- General use of self-tapping screws instead of through bolting for fixings.

Observations of common attributes of PV farms that did survive hurricane wind force impacts include:

- Dual post piers.
- Solar module through bolting.
- Vibration resistant bolted connections.
- Oversight of construction by Engineer of Record (EOR) with quality assurance and control program.

Recommendations from (Burgess et. al., 2018) towards the construction of resilient PV farms in the Caribbean include proper specifications for systems and recommendation for design collaboration between developers and module suppliers.

Figure 10 - Dual post pier of racking system (Source: Burgess et. al., 2018)

Key recommendations follow:

- Specify high load PV modules – currently available from tier 1 manufacturers.
- Structural design to ASCE 7 design wind code with consideration of findings of a geotechnical engineering study.
- Specify through bolting of modules instead of T-clamps or top down bolting.
- Specify and have EOR ensure best practice bolting design and checks on bolt torqueing.
- Structural engineer design check on racking and electrical hardware.
- Dual post ground mounts of PV modules.
- All hardware to have design life of 25 years or greater to mitigate impacts of corrosion.

4.10.6 Potential Impacts

4.10.6.1 Operation Stage

A. A fire on site could spread along grassed lands and impact on the PV farm. Higher temperatures with low rainfall during the dry season increase the potential for bushfires.

B. A strong tropical storm or hurricane could impact the PV farm and substantially damage panels and racking support structures resulting in the inability to generate power from the site and the need to dispose of damaged panels.

4.10.7 Mitigation Measures

4.10.7.1 Preconstruction stage

A. Consideration should be given to a 3m wide minimum firebreak consisting of a marled surface between the outer edges of all panels and the perimeter fencing of the facility along the North and East boundaries and partially along the South and West boundaries; the firebreak would not be required in the region of the control and vehicle parking area. Consideration should also be given to having a fire hydrant placed on site to facilitate the fire department fighting fire.

B. The PV farm system design should be structurally designed and constructed following guidance given in section 4.10.5 and in the Burgess et. al. (2018) report. With respect to the impact of climate change on extreme wind forces, it is recommended that the latest ASCE 07 code be utilized for wind design as the latest version of this code incorporates projected changes in wind regimes as would be expected with climate change.

C. The findings of a geotechnical engineering study should be used towards structurally designing the foundation of PV module racking.

4.10.7.2 Operation Stage

A. Prior to the commencement of every hurricane season, the Developer should have his technical team conduct a visual inspection of the supporting structures for the PV modules paying special attention to corrosion, loose bolting etc., which would increase the vulnerability of the PV system during extreme weather. Where defects are noted these should be repaired prior to the advent of the annual extreme weather season.

4.11 VISUAL IMPACT ASSESSMENT

4.11.1 General

The site for PV farm development is flat and currently clearly visible from southerly, easterly, and northerly directions. There is partial screening of the site from the West due to an existing tall earthen berm; there is partial screening of the site from northerly directions (Fairy Valley Residential/Commercial area) by an existing vegetated hedge along the site's northern boundary.

Figure 11 -Site Environs and Locations where photographs taken

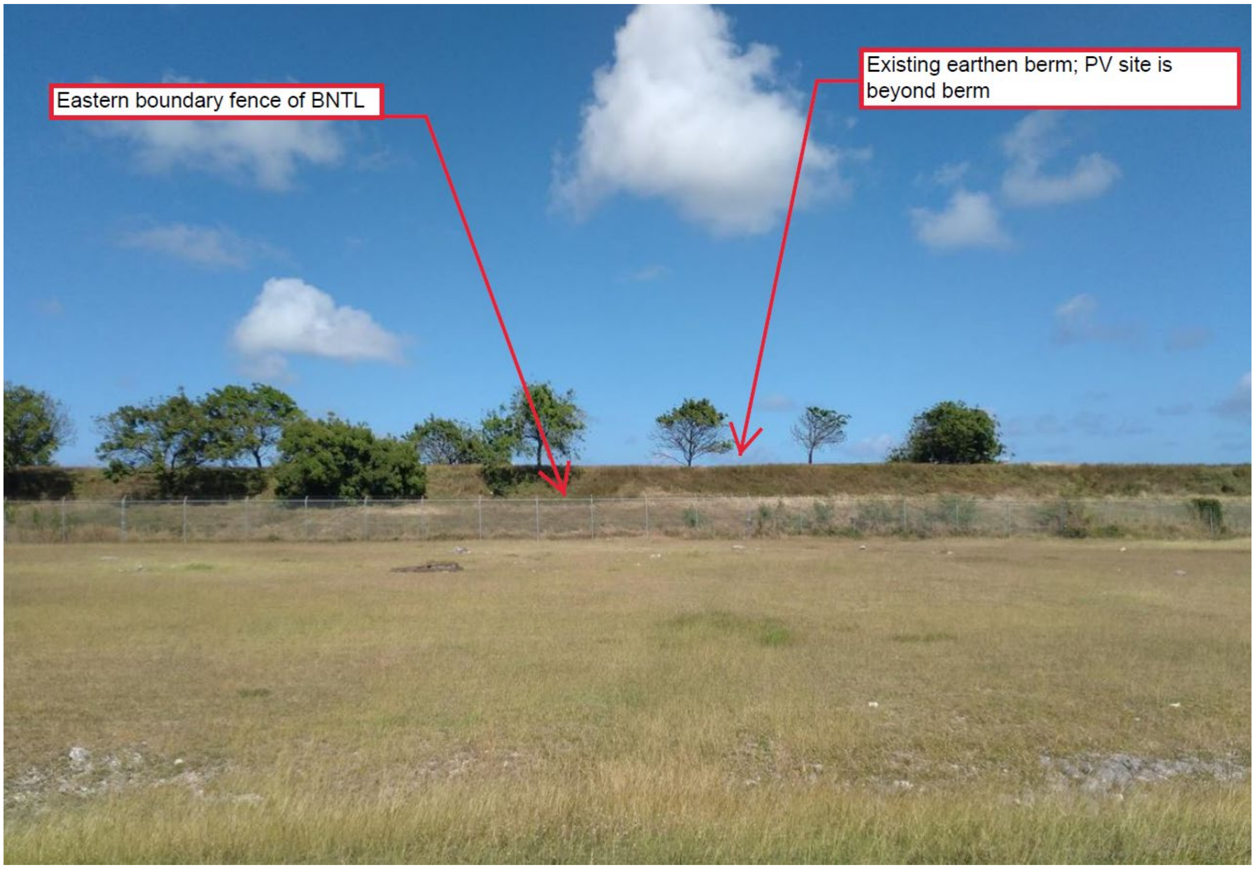

Photo 1 (P1): Looking eastward towards site from the north eastern region of the BNTCL site. *As can be seen, the earthen berm screens the PV site from the northern region of the BNTCL compound.*

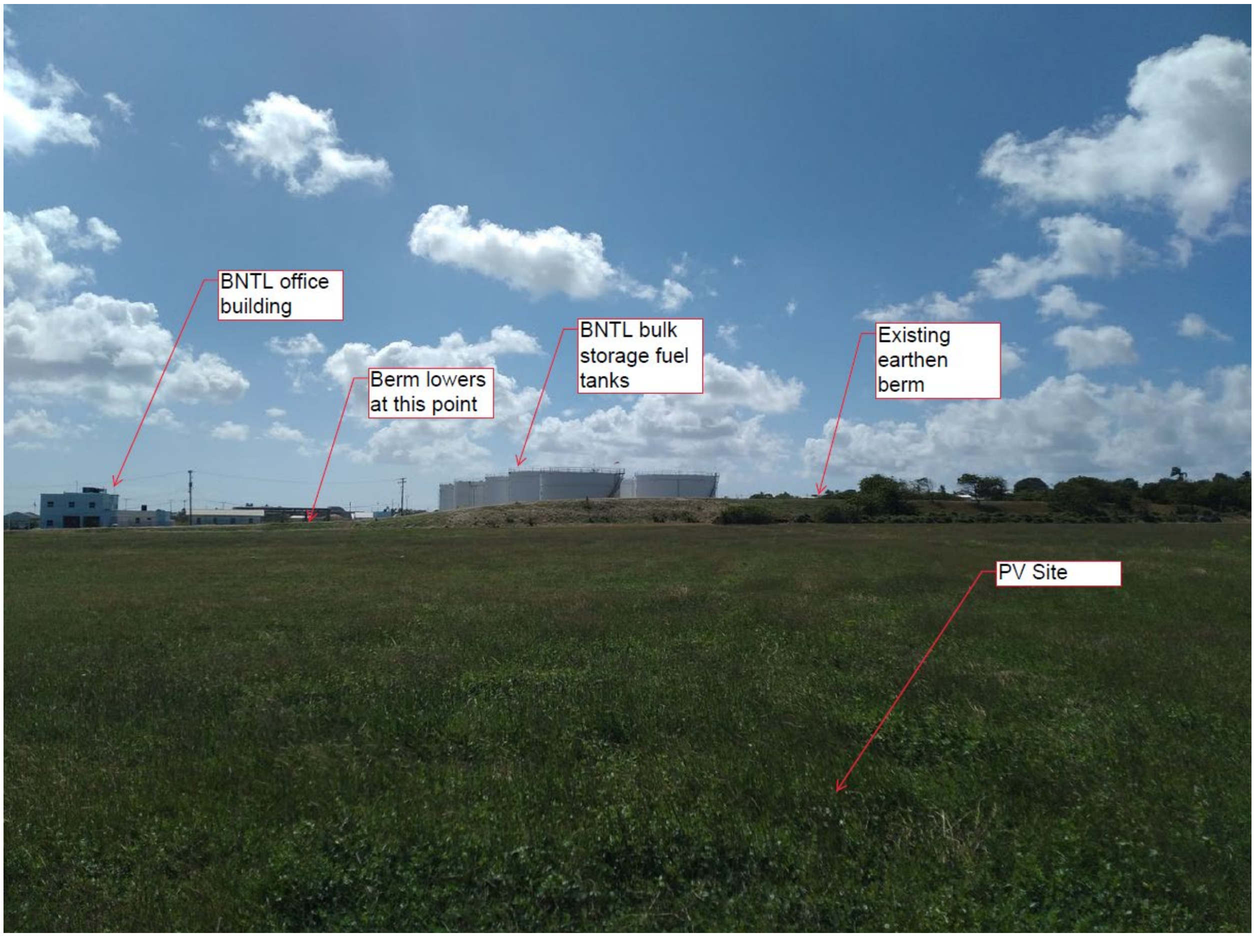

Photo 2 (P2): Looking westwards from PV site towards the BNTCL complex. *Earthen berm can be seen diminishing in southward direction towards BNTCL office building; BNTCL office complex to the South fully visible from site implying that site is fully visible from BNTCL office complex.*

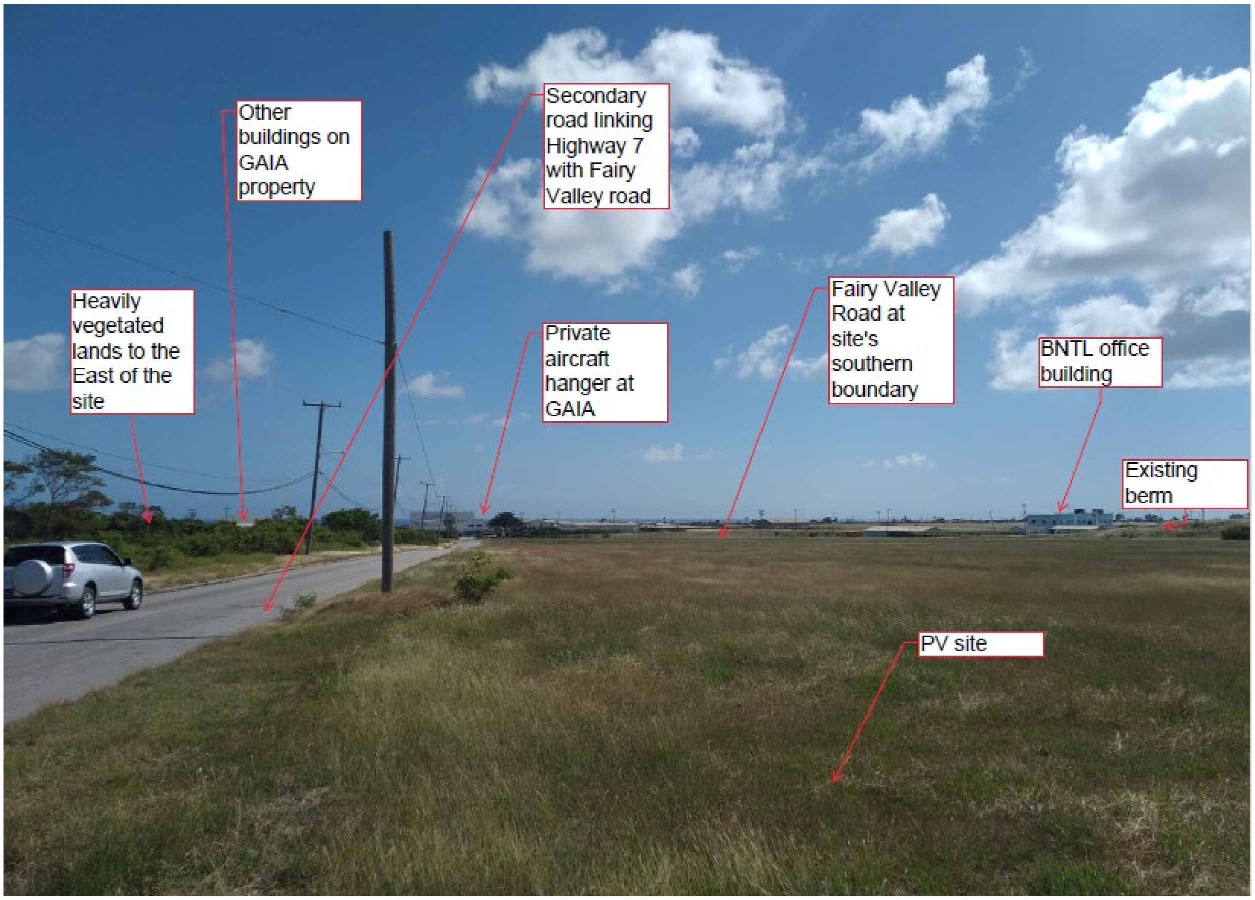

Photo 3 (P3): Looking southward from north eastern region of PV site. *BNTCL office complex as well as several buildings on GAIA grounds were visible; visibility of these buildings implies that the PV site will be visible from these buildings. Heavily vegetated nature of vacant land to the East can be seen in this photograph.*

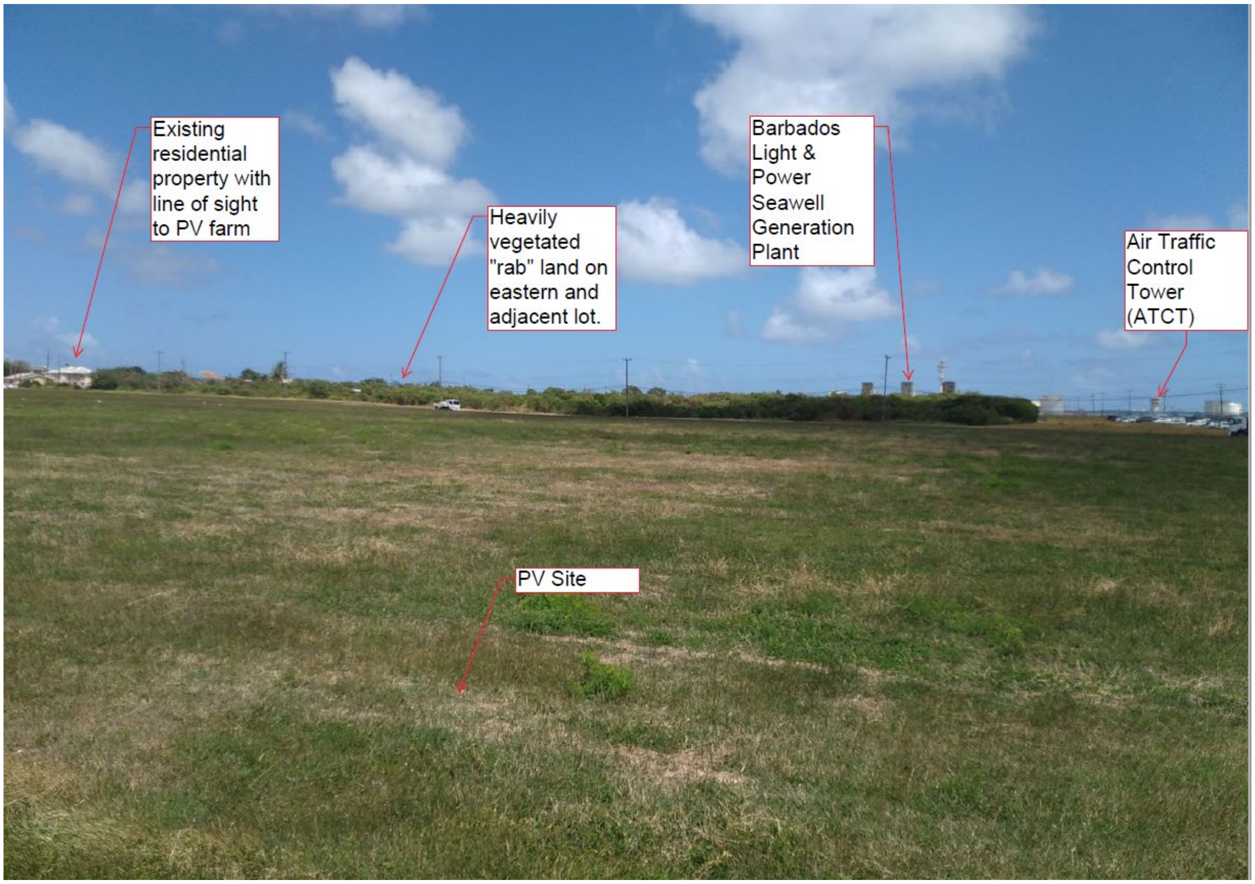

Photo 4 (P4): Looking eastward from within the PV site. *Buildings within the airport including the Air Traffic Control Tower (ATCT) can be seen. The generators of the Barbados Light and Power Co. Ltd. (BL&P) Seawell power generation facility can be seen as well as a two-storey residential property. Latter observations imply that air traffic controllers in the ATCT and residents in the mentioned building can currently see the site for PV development. The heavy vegetation on the vacant land currently screens the site from the bulk of the BL&P Seawell property.*

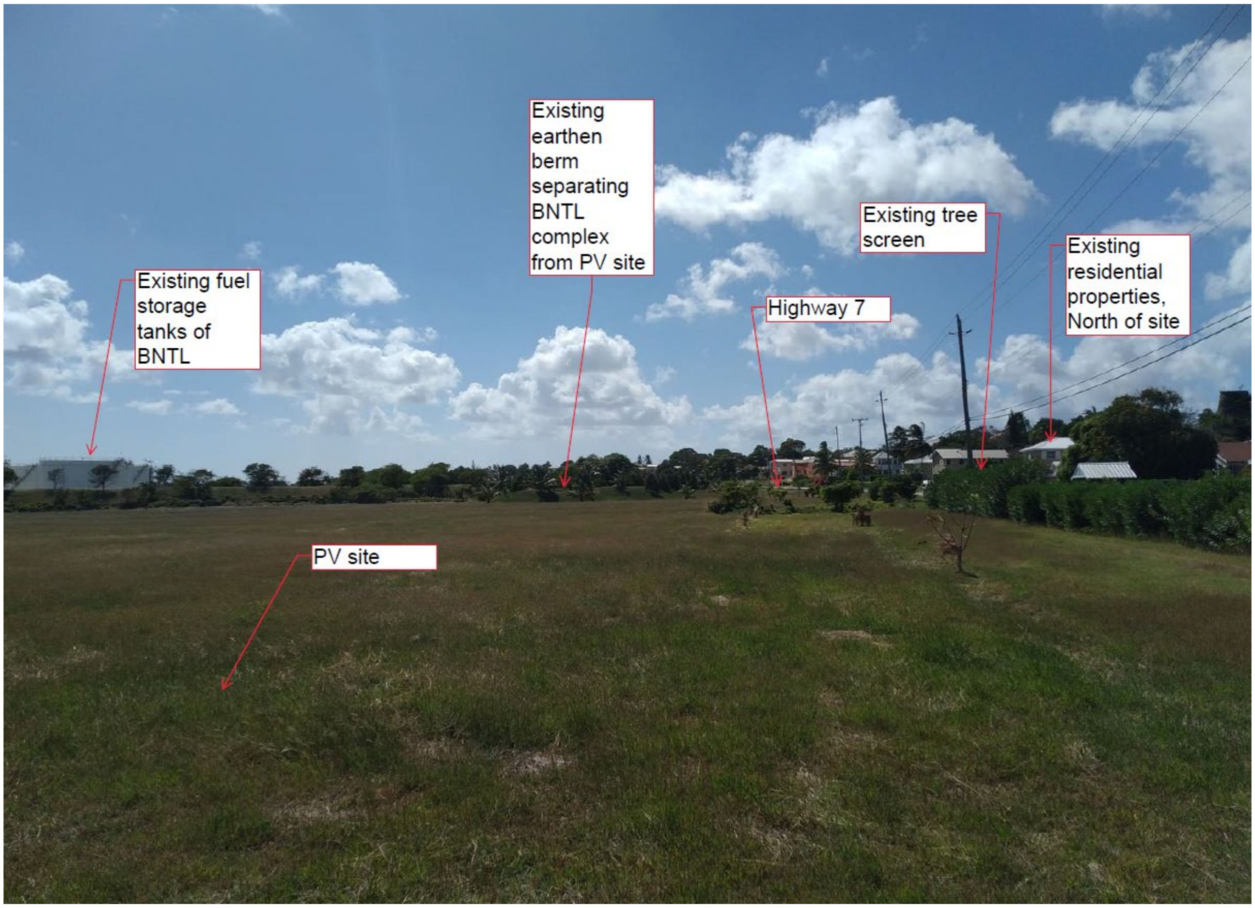

Photo 5 (P5): Looking westward from within the site close to its northern boundary. *Residential and commercial buildings North and across Highway 7 can be clearly seen, implying the site is visible from these buildings. The earthen berm between the site and the BNTCL complex can be seen. There is an existing partial screen in the form of a vegetated hedge along the eastern half of the site's northern boundary. At its current height, this hedge screens roadway commuters and the ground floor levels of buildings - North of the screen - from the PV site.*

4.11.2 Potential Impacts

4.11.2.1 Operation Stage

A. The construction of the PV farm may result in visual impacts to nearby land users – post its construction.

4.11.3 Mitigation Measures

4.11.3.1 Pre-Construction Stage

A. The site for the PV farm is visible from all directions. Though there are existing screens by way of an earthen berm along the western site boundary and a vegetated hedge along the site's northern boundary, these screens do not extend along the entire lengths of respective boundaries. The earthen berm along a portion of the site's western boundary is tall and completely screens the PV site from ground level areas within the northern region of the BNTCL complex. The vegetated hedge along a portion of the northern boundary is roughly 2.4m tall and effectively screens roadway commuters and ground levels of buildings - North and adjacent to Highway 7.

Following on from the recommendations of the glint and glare study, it is recommended that a tall (minimum 3m high) and thick vegetated screen be planted (see Figure 12 below):

- Along the eastern boundary of the site.
- Along the northern site boundary from the western edge of the existing hedge to the site's western boundary.
- Along the southern boundary terminating at the south western access point to the site.
- Along the western boundary from the earthen berm southwards to the region of the car parking area.

Once erected these screens shall hide the PV farm site from ground level elevation in all directions from the site. Notwithstanding the presence of the screens the PV site will remain visible to vantage points of upper floors of buildings and from tall structures such as the ATCT, as well as from landing aircraft.

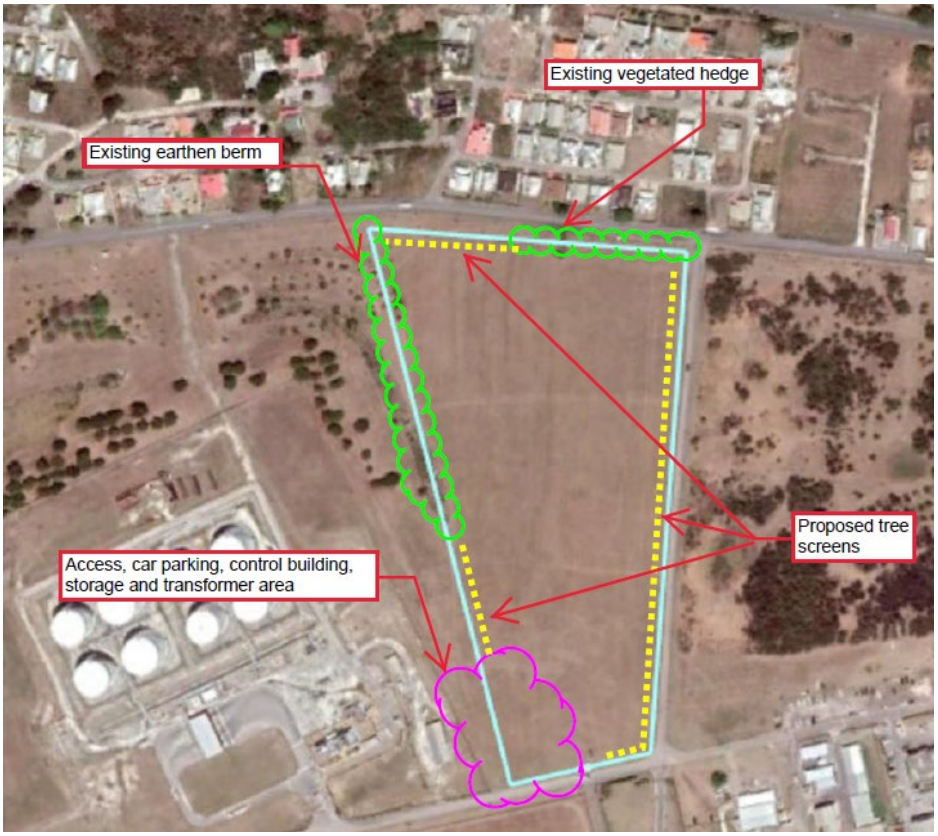

Figure 12 - Recommended vegetated screening mitigation measures

4.12 SOCIAL SCOPING ASSESSMENT STUDY

2.6.2 General

The terms of reference for the ESS requested the production of a rapid social assessment, social engagement plan, and grievance redress mechanism. This section of the ESS summarises the findings of the latter listed assessments, which are presented in detail in Appendix C of this document.

A rapid social assessment is effectively a desktop study with limited field investigations; it does not include the rigorous field data gathering activities – door by boor interviews with potentially affected persons and such, but primarily relies on the use of census data from the governmental statistical department databases.

2.6.3 Rapid Social Assessment

4.12.1.1 Potentially Affected Communities

Two methods were used to collect social information on the communities likely to be affected by the project. Google Earth was first used to identify and characterize communities and social amenities surrounding the development site. This was followed by a drive through of the areas immediately surrounding the site to ground truth the information collected via Google Earth. The communities identified were Charnocks, Coverley, Fairy Valley, the airport and its immediate surroundings.

To better understand the social structure within the identified communities, social data were sourced from the Barbados 2010 census dataset. A shapefile (Census_ED_Boundary_2010) with enumeration districts (EDs) for the entire country was opened using ArcMap 10.5.1. This shapefile consisted of an attribute table which contained information on population size, gender, education, employment, the number and type of houses in a given area and the number of individuals within each household. Using 'Open Street Map' as a base layer in ArcMap, EDs for the potentially affected communities were identified using the identification tool. These EDs were manually selected and the social data for each community was extracted. There were limitations to data sets examined; these limitations are detailed in Section 3 of the social assessment study in Appendix C.

The demographic profiles of the communities in closest proximity to the proposed project location based on the 2010 data are presented in section 3 of the social assessment study in Appendix C; these communities are:

- Charnocks (Enumeration District- ED 391) - with a 2010 population of 345 persons.
- Seawell, Coverley, and Fairy Valley (ED519/520) – with a 2010 population of 599 persons.
- Grantley Adams Airport (ED518) – with a 2010 population of 511 persons.

In the past ten years there is likely to have been some in and out migration, and since the population of Barbados is confirmed to be aging, it is likely that the percentage of persons in the older age ranges would have increased. The areas are characterized by a diverse mix of communities, including low, low-middle, middle and upper-middle income households. There is a diversity of social amenities including churches, pre- and primary schools, old people's homes, playing fields and pavilions. There are several small bars, variety shops and other micro and small businesses such as hairdressers, mechanics and body works, and cupboard makers. In each community a number of persons with disabilities were reported. According to the 2010 census, disability include persons with deafness, significant hearing impairment, blindness, significant vision impairment, who are unable to speak, significant speech impediment, severe arthritis, who are unable to walk, who are unable to climb stairs and who are unable to take care of themselves.

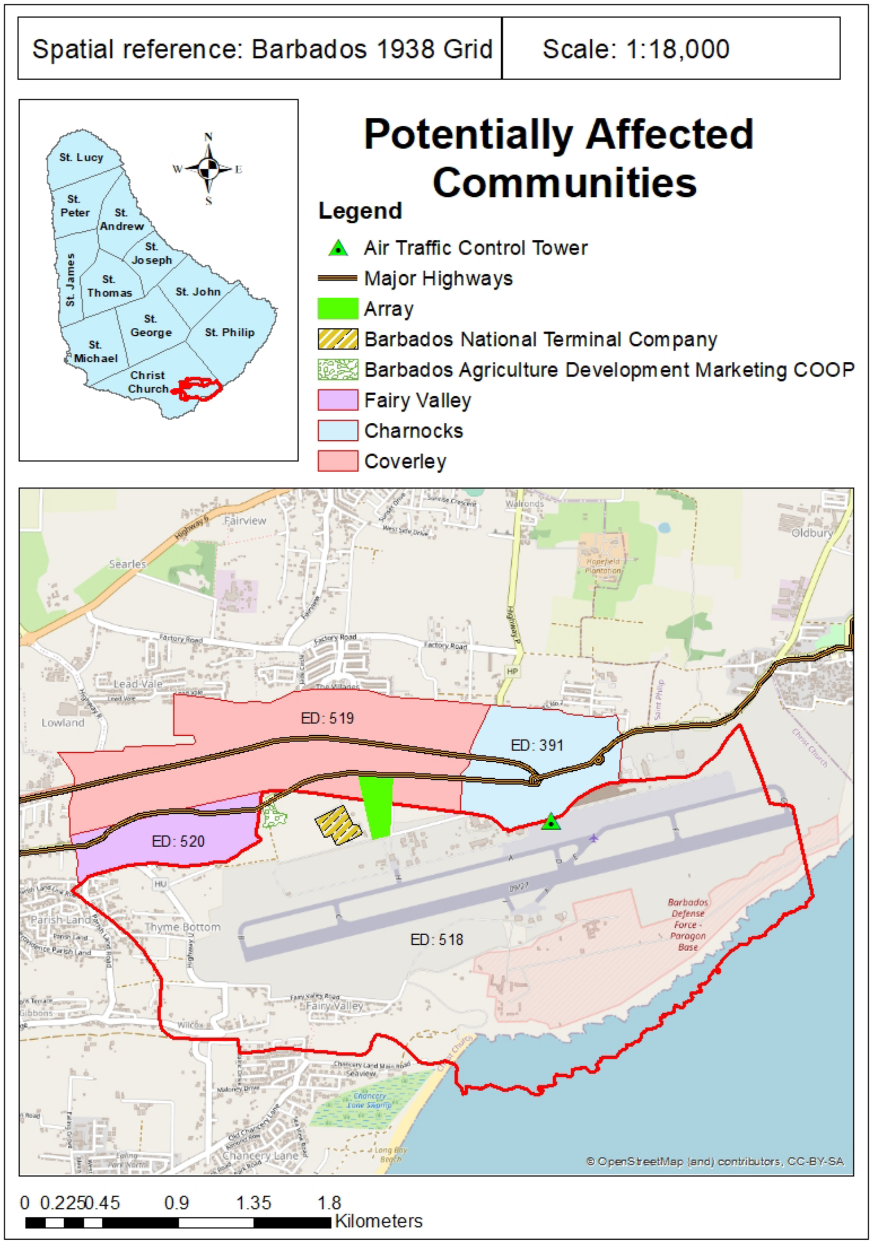

Figure 13 - Potentially affected communities

4.12.1.2 Valued Social Components and Potential Impacts

Based on the information obtained from google maps, the drive-through and the 2010 census data, the valued social components (VSC), i.e. the significant elements in the social environment that may be impacted by the project's activities during the construction and operational phases were determined - see Table 1 below. Justification for each VSC is provided.

Table 1: Valued Social Components

Social components	Justification
Residents, businesses and social amenities in close proximity to, as well as down-wind of the project's activities.	Noise, dust, odours and vibrations from the construction activities as well as other activities during the operations phase could affect the residents, businesses and users of social amenities in adjacent communities. Potential concerns about the impacts of the array on the aesthetics of the area.
Residents, businesses and social amenities along the routes to be traversed by the construction vehicles.	Noise, dust, odours and vibrations from construction vehicles could affect the residents, businesses and users of social amenities.
Worker health and safety.	There is always a risk associated with work on construction sites, e.g. falls, chemical spills, accidents with equipment etc. In addition, there are several pollutants occurring in solar cells and parts which include arsenic, chrome, lead and cadmium in batteries[23].
Public health and safety.	There is always a risk to adjacent communities and the general public with respect to construction sites.

The proposed construction of a photo voltaic "solar farm" by the BNTCL provides the opportunity to produce a clean, reliable, environmentally friendly and infinite source of energy in comparison to traditional fossil fuels. By so doing, it can contribute to an increase in national energy independence and promote the diversification and security of the energy supply. Thus, it is consistent with the goal of the Barbados National Energy Policy 2019 – 2030 which is to transition the island to being 100% renewable energy and carbon-neutral by 2030.

The proposed solar farm can facilitate job creation during both the construction and operational phases of the project. During construction, there will be work for skilled and semi-skilled labour as well as support for local businesses that provide supplies for the renewable energy sector. The construction phase can also be a boost for the persons operating small retail businesses in the area, especially food and beverage, because the construction workers will provide them with additional customers. The project therefore can be a boost to the economy and have a positive effect on local livelihoods. This is a

[23]Kumarankandath, A. (2016, July 8). What about recycling for solar PV? Down to Earth. Retrieved from https://www.downtoearth.org.in/news/energy/whatabout-recycling-for-solar-pv—54797

particularly positive impact in the current economic context, where the prolonged Covid-19 pandemic has resulted in a decline in tourism arrivals, the closure of many businesses and the loss of several jobs.

There are also positive health benefits from improved air quality compared to the emissions from fossil fuel sources of energy.

However, it is not necessarily a completely green source of energy, as there are potential environmental and socio-economic impacts associated with solar power. From a health and safety perspective, the effects of noise dust and vibrations during construction from vehicles and machinery can be psychologically stressful as well as physically problematic to individuals with a sensitivity to dust. There are also potential negative visual impacts if persons or groups perceive the arrays to negatively affect the aesthetic of the existing landscape. Sometimes, there can be initial opposition to projects from residents and businesses in close proximity to the project site. Persons can be concerned, for example, about the effects of the project on their property values. The suspicions and objections can often be the result of insufficient information sharing and stakeholder engagement by the project proponents during the initial stages of the project before construction commences.

During construction there are risks associated with worker health and safety on the site such as falls, and injuries that might arise from the inappropriate use of machinery, and the storage and handling of chemicals or flammable substances. There is also the potential for chemical spills, accidents with equipment etc. It is noted that there are several pollutants occurring in solar cells and parts which include arsenic, chrome, lead and cadmium in batteries. There are also potential risks to adjacent communities and the general public. For example, from the public gaining unauthorised entry to the site and getting hurt.

Table 2 summarises the potential positive and negative effects that the construction and operational phase activities are likely to have on the valued social components.

Table 2: Project activities and potential effects

Project effects - negative	Project effects- positive
CONSTRUCTION PHASE	
• Noise and vibrations from construction vehicles and equipment • Impaired air quality from dust and other emissions from construction vehicles and equipment • Health and safety risks to on-site workers • Health and safety risks to adjacent communities and general public • Perceived negative aesthetic impacts from the array • Suspicion or objection towards the project.	• Construction related jobs will be created for skilled labour • Increased retail business, primarily food related from construction workers
OPERATIONAL PHASE	
• Potential health and safety impacts on workers and adjacent communities • Accidents (non-routine) events • Perceived negative aesthetic impacts from the array	• Employment opportunities for skilled labour. • Advances the renewable energy policy to increase energy conservation and efficiency, and contribute to mitigation efforts in reducing GHG emissions.

4.12.1.3 Recommended mitigation measures – Rapid Social Assessment

The solar farm will be a new addition to an existing industrial estate. However, some residents could be concerned about the potential change to the aesthetics of the area. This should be addressed through a carefully planned and implemented public awareness campaign, that addresses the typical concerns raised in relation to the construction of a solar farm. The campaign should clearly explain the design of the farm, as well as the potential benefits that could accrue to Barbados.

Potentially adverse effects from the construction of the farm must be minimized and mitigated to the extent feasible to reduce impacts on the residents, and users of social amenities and commercial enterprises. It is also essential to ensure that the project is compliant with the legal and statutory labour requirements, to safeguard Community and Worker Health and Safety.

Construction should therefore be based on an approved construction management plan that includes measures to reduce the impacts of noise, dust and vibrations. Details for the management of noise, dust and vibrations should be included in the contractor's Environmental Management Plan. However, at a minimum, these measures should include:

- Dust management measures such as:
  - Fitting machinery with emission control devices compliant with International Design Standards.
  - Using waterproof boxes to minimize spillage along roadways
  - Covering all trucks that are hauling material
  - Washing truck tyres before exiting the construction site onto existing paved roads
  - Construction vehicles traversing the adjacent areas should strictly observe the speed limit

  - Cleaning spillages on roadways and property accesses promptly to minimize spread of sediment and dust
  - Reducing or eliminating stockpiles as much as practical

- Noise management measures such as:
  - Installation of mufflers and appropriate sound attenuation devices on construction equipment
  - Conducting work onsite within specifically set times
  - Switching off construction equipment and vehicles when not in use
  - Construction vehicles traversing the adjacent areas should strictly observe the speed limit, and horns should be minimally used (only as necessary)

- With respect to vibrations, it is expected that the Contractor would have the required insurance policies to cover any legitimate claims made as a result of any damage that may occur during the construction phase.

There should also be an approved Traffic Management Plan (which should be submitted by the Contractor) to control on-site traffic as well as the practices of construction drivers to and from the construction site.

Contractors should be required to operate approved occupational health and safety plans which detail the safety provisions according to the type of machinery and materials being utilized. Workers should be required to use protective gear to guard against on-the-job injuries. Ergonomic devices should be available, e.g., for lifting and carrying. Only trained and/or certified persons should use specialized equipment and handle dangerous chemicals. There should be appropriate supervision to ensure that workers do not cause harm to themselves or others on the site.

There should be adequate 24-hour security to prevent curious onlookers from wandering into the construction zones. As required, sufficient and appropriate lighting, clearly visible signage that meets the universal design environmental access requirements/standards for persons with disabilities, and open and unobstructed passageways should be installed to enforce safety in and around the construction zone.

Public service announcements should be provided to ensure that commercial operators, residents, and the public are updated on the construction activities, especially those that could be disruptive, e.g., construction activities planned outside of typical work hours such as late evening or night.

When operational, the solar farm should meet the highest of international and national standards to ensure the health and safety of workers, passengers, and the surrounding communities.

The environmental management plan (provided by the contractor of the works) will address all impacts associated with noise, air quality, vibrations, and worker health and safety and general public health and safety. However, the Social Management Plan detailed in Section 5 of Appendix C, comprises a stakeholder engagement plan and a grievance redress mechanism to ensure that the best interest of all the relevant stakeholders is taken into account during the project. It will also identify critical aspects for mainstreaming of gender equality.

2.6.4 Social Engagement Plan

The majority of the potential social impacts may result from the effects of the noise, dust and vibrations associated with construction vehicles and equipment. There are also potential impacts associated with occupational health and safety and public health and safety. The social management plan focuses on the engagement of the stakeholders to ensure that there is a mechanism in place to provide information on the project to the public and to encourage participation of all affected groups in a consultation process. The social management plan comprises two components: 1) the social engagement plan which facilitates open and continuous communication and consultation between various groups including construction contractors, stakeholders, and the general public; and 2) the grievance redress process which ensures that legitimate concerns of the stakeholders are recorded, investigated and addressed.

There are four critical steps in a stakeholder engagement process:

1. Identification of required resources.
2. Identification and analysis of the stakeholders.
3. Developing key messages and selecting appropriate engagement channels.
4. Implementing, reviewing and revising the engagement plan.

Details of the various steps as well as the identification of key stakeholders are presented in Section 5 of the social assessment study in Appendix C.

2.6.5 Grievance Redress Mechanism

People adversely affected by a project will complain about actual or perceived impacts in order to find a satisfactory solution. Affected persons (APs) must be able to raise their grievances and be given an adequate hearing, and satisfactory solutions should be found that mutually benefit both the APs and the project. It is therefore very important that APs have access to legitimate, reliable, transparent, and efficient institutional mechanisms that are responsive to their complaints[24] (Asian Development Bank, 2010).

Several benefits are derived to the project and to the APs from grievance redress mechanisms (GRM). Within affected groups, GRMs provide cost-effective ways to report complaints and grievances. They establish a forum whereby APs can report their concerns with dignity and with access to a fair hearing and remedy. They allow APs to negotiate and influence decisions of the projects that could adversely affect them and they facilitate access to information. From the project's perspective, GRMs provide a structured and systematic way of resolving grievances and disputes relatively quickly before they escalate to an unmanageable level. They facilitate effective communication between the project and affected persons and can help to win the trust and confidence of community members thereby creating productive relationships between the parties. GRMs aid in ensuring equitable and fair distribution of benefits, costs,

[24] Asian Development Bank. 2010. Designing and Implementing Grievance Redress Mechanisms. A Guide for Implementers of Transport Projects in Sri Lanka. Available online: https://www.adb.org/sites/default/files/institutional-document/32956/files/grievance-redress-mechanisms.pdf. Assessed April 2020.

and risks, especially amongst vulnerable groups such as women, children, the disabled and the elderly. These mechanisms ultimately can mitigate or prevent adverse impacts of the project on communities and produce appropriate corrective or preventive action, thereby avoiding project delays and cost increases, and also improving the quality of work (Asian Development Bank, 2010).

Based on the rapid social assessment, it can be anticipated that there will likely be complaints about the dust and noise from the project, especially from the residents and businesses in closest proximity to, and downwind of the construction zone. The GRM provides guidance to the BNTCL to be able to address these and any other concerns that might arise during the project. It recommends a procedure that should be followed for the management of complaints and grievances that arise during the project. It describes the scope and procedural steps and specific roles and responsibilities of the parties involved. It should be revised and updated based on the experience and feedback from the stakeholders.

Further details on the GRM and implementing a GRM for this project are presented in Section 5.2 of the social assessment report in Appendix C.

2.6.6 Social Monitoring Plan

The tasks outlined in Section 6 of Appendix C are to be undertaken by the Contractors to ensure that any negative social and gender impacts during the construction works for the 5MW PV Power Plant Project are minimised or eliminated and positive impacts enhanced. Tasks include public communication through public service announcements and precautionary signage, mitigation of noise dust and vibration impacts by maintaining a register of sensitive receptor locations, compliance with the GRM through Complaints Record and Grievance Complaint Form, promotion of site safety through health and safety incident report forms, and confirming gender equity with employment by maintaining a full list of employees. Reporting documents are to be submitted on a monthly basis to facilitate the monitoring process.

4.13 ANALYSIS OF ALTERNATIVES

The alternatives for this development are to do nothing or to consider another form of renewable energy solution on the site.

4.13.1 Do Nothing

To do nothing would result in the site continuing to be vacant with a running cost for maintenance - debushing etc. The site is zoned for developments that promote employment, so it is a possible the land could be used for the construction of office buildings or similar that could permit employment.   To not build the PV would eliminate the possible contribution of the site towards reducing Barbados's fossil fuel bill and carbon footprint would be not be attained. In addition, the potential of the site to contribute to Barbados' green energy policy mandate of 100% renewable sources of energy by 2030 would not be realized.

4.13.2 Alternative Renewable Energy Solution

The production of wind energy via the erection of wind turbines on the site is an alternative renewable energy solution that could be considered. It may be possible to erect several smaller turbines or possibly two or three larger turbines on the site.

Given the height of turbines, they would pose a visual impact to surrounding communities and may cause shadow flicker impacts to the same communities. Noise may also be a possible impact of this option. Turbines are also known to cause bird and bat kills. Also the positioning of wind turbines is normally a function of the natural wind regime of a site; wind studies would have to be done to determine whether the proposed site is suited for the development of a wind turbine solution. There would also be a height restriction to the turbines given the site's proximity to GAIA.

The development of a PV solar farm as proposed by the Developer would definitely be much less environmentally impactful than a proposal to erect and operate a wind farm at the BNTCL site.

4.14 CONCLUSION

It is hereby concluded that if all the recommendations of the scoping study are implemented then it is unlikely that the development of the proposed PV farm on lands leased and maintained by the BNTCL will have an adverse impact on nearby human receptors and the surrounding environment.

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See ***Appendix C*** for references reviewed for the rapid social impact assessment study.

APPENDICES

Appendix Subtitle

Appendix A

DRAFT TERMS OF REFERENCE

5MW Photovoltaic Power Plant, Barbados National Oil Terminal, Christ Church

Draft Terms of Reference for Environmental Scoping Study

TCDPO Appl# - 0858/06/2019E

Prepared for:
Chief Executive Officer, BNOCL,
Barbados National Oil Company Ltd (BNOCL)
Woodbourne, St. Philip

Prepared by:
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Project#128020094

March 30, 2021

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1.0 TERMS OF REFERENCE

1.1 BACKGROUND

1.1.1 Site Description

The Barbados National Oil Company Ltd (BNOCL) – hereafter termed the "Developer" – proposes the construction of a photovoltaic (PV) solar farm on a 57,000 m^2 (14 acre) parcel of leased and managed land at Fairy Valley, Christ Church, Barbados.

The site for development is currently vacant land with regularly maintained low-cut grass. The site is in the Coral Region of Barbados. Examination of the Geology Map of Barbados reveals that groundwater exists beneath the site for development. There are no natural watercourses traversing the site for development.

Land use within the environs of the site is predominantly industrial and commercial with some residential properties (Fairy Valley) near the West and North West of the northern site boundary. The Barbados National Terminal Limited (BNTL) is located immediately west and adjacent to the site; the Barbados Light & Power (BL&P) Seawell natural gas power generation plant is located just over 300m East of the Eastern site boundary. The Grantley Adams International Airport (GAIA) is located immediately South of the PV farm site. The Air Traffic Control tower (ATCT) is located close to 1km due East of the PV farm site. To the immediate West of the

1.1.2 Proposed Development

The Client proposes the construction of a solar farm on lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados. The farm shall generate power to be sold to Barbados Light & Power Ltd. The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. These 14,520 panels are expected to produce approximately 5MW AC of renewable energy electricity. The proposed layout of the facility is attached in Appendix A.

The overall intent is to supply electricity – from a renewable energy source - to the Barbados Light & Power national grid.

The Developer applied to the Town & Country Development Office (TCDPO)for permission to develop the PV farm. It is understood that the submission of an environmental scoping study (ESS) for the development is to accompany the application. This document presents the draft terms of reference for an ESS for the proposed 5MW photovoltaic farm.

1.2 ENVIRONMENTAL SCOPING STUDY

An ESS provides information on the proposed development and its likely effects on the environment. Potential negative impacts on the environment are identified and measures to mitigate recommended. Positive impacts are also identified. The ESS enables "Developers" to comply with their own environmental standards and minimize environmental impacts, where necessary. An ESS assesses a proposed development and makes recommendations, which should be taken into consideration and incorporated during the detailed design phase of a project to mitigate environmental impacts; an ESS is not meant to present detailed design solutions for mitigation measures.

1.3 ENVIRONMENTAL ISSUES OF CONCERN

There are potential construction and operational environmental impacts due to the development of the proposed PV Farm. The following are noted:

- There may be land use impacts due to the development of the PV farm, which may not be in line with the Physical Development Plan for Barbados.
- There may be visual impacts to nearby land users.
- Noise emanating from inverters installed as a component of the facility may impact nearby receptors.
- The impervious surface of PV panels combined with ground improvement works below the panels could result in higher runoff volumes and potential downstream flooding impacts.
- Glint and Glare originating from the panels may impact on adjacent land users. Of particular concern are potential impacts to the air traffic controllers in the ATCT and pilots of landing aircraft at GAIA.
- There is the potential for transient impacts – dust, noise, traffic etc. during the construction stage of the project.
- There may the generation of liquid and solid waste during the construction and operations phases of the development, which could have an impact on nearby receptors as wells as the natural environment.
- There may be potential social impacts to nearby land users due to the development of the farm.

On the basis of the above, there appears to be the potential for environmental impacts due to: land use, noise, drainage, glint and glare, solid waste, wastewater, and construction. Visual impacts due to the development are also a possibility, as well as potential social impacts.

1.4 TERMS OF REFERENCE FOR ESS

1.4.1 Legislative and Regulatory Framework

Describe relevant local and international policies, standards, legal and administrative frameworks pertaining to the protection of the environment, and health and safety. Identify relevant international agreements to which Barbados is a party.

1.4.2 Site & Project Description

1.4.2.1 Site Description

Define the study area and describe the existing physical and biological environment within the environs that is likely to be significantly impacted by the proposed development - including the geology and soil conditions, drainage, ground water, residential settlements, and other nearby land uses.

1.4.2.2 Project Description

Describe the process design, construction, and operations stages of the development. Description via the design stage shall include location; raw materials required; general layout; capacity; size; and Best Available Technologies (BAT) in use where relevant. Description via the construction stage shall include procedures, equipment etc anticipated to be used. For the operations stage, staffing, operations, and maintenance activities – over the life of the project - are to be described.

1.4.3 Environmental Assessments

1.4.3.1 Land Use Assessment

Analyse the current use of the site and proposed land use with consideration of relevant land use policies. Determine the suitability of the development proposal from a land use planning perspective. Assess possible impacts on existing land use within the environs of the project site. Recommend mitigation measures where applicable.

1.4.3.2 Noise Impact Assessment

Inverters may be a consistent source of noise from the proposed PV solar farm. Taking into consideration the locations of inverters, conduct a qualitative noise assessment utilising established principles of sound attenuation with distance from source of noise. Recommend measures to mitigate any identified noise impacts.

1.4.3.3 Drainage Assessment

Conduct hydrological and hydraulic investigations to enable a description of the existing drainage condition within and surrounding the site. Taking into consideration the proposed development and a 1 in 25yr return storm criterion, determine any increase in runoff and potentials for post development flooding - on site and downstream of the site. Recommend measures to mitigate potential drainage impacts.

1.4.3.4 Glint and Glare Study

Conduct a study of potential glint and glare impacts to nearby receptors over the course of a year. Assessment to be done with an internationally recognised and accepted glint and glare computer modelling software. Assessment to consider landing flight path of aircraft at GAIA and potential glint and glare impacts to air traffic controllers of the ATCT. Recommend measures to mitigate any identified glint and glare impacts from the development.

1.4.3.5 Solid Waste & Wastewater Assessment

Assess sources, types, and quantities of liquid and solid waste generation during the construction and operation stages of the development. Recommend measures to mitigate any potential impacts from these wastes.

1.4.3.6 Construction Impact Assessment

Taking into consideration construction activities, identify potential transient impacts – traffic, noise, dust, construction debris etc that can be expected during construction. Recommend measures to mitigate potential impacts.

1.4.3.7 Visual Impact Assessment

Conduct a visual impact assessment - utilising photographic techniques - from various vantage points, particularly at locations of the nearest sensitive human receptors. Recommend measures to mitigate any identified potential impacts.

1.4.3.8 Rapid Social Impact Assessment

Conduct a rapid social impact assessment (SIA); rapid assessments eliminate residential and commercial field surveys that normally form a part of the traditional social impact assessment process.

Two methods should be used to collect social information on the communities with the potential to be affected by the project. Satellite imagery should first be used to identify and characterize communities and social amenities surrounding the PV farm. This should be followed by a ground truthing exercise.

To better understand the social structure within the identified communities, social data should be sourced from the Barbados Statistical Department. Information on population size, gender, education, employment, the number, and type of houses in each area and the number of individuals within each household should be obtained.

The rapid SIA should include the identification of valued social components and potential impacts as well as a social management plan (SMP). The SMP should include a stakeholder engagement plan and grievance redress mechanism.

1.4.4 Alternatives Analysis

Alternatives to the proposed site are to be qualitatively compared to the current proposal – taking into consideration:

- Their environmental impacts
- Their feasibility of mitigating impacts

The "Do Nothing" option is to also be considered.

1.4.5 Report Outline

The report of findings is to be concise and limited to significant environmental issues. The main text should focus on findings, conclusions and recommended actions – supported by summaries of data collected and citations for references used in data interpretation. The report on findings should be presented in the following or similar manner:

Main Report

- Executive Summary
- Policy, Legal & Administrative Framework
- Description of Project
- Description of Environment
- Environmental Assessments
- Rapid Social Impact Assessment
- Analysis of Alternatives

Appendices

- References
- Tables presenting relevant data referred to or summarized in the main text
- Other relevant data

Appendix B

GLINT & GLARE STUDY

Stantec

BNTCL Solar Photovoltaic Farm

Glint and Glare Study

June 14, 2022

Prepared for:

Barbados National Oil Company Ltd.
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Prepared by:

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St. Michael, Barbados

Revision	Description	Author		Quality Check		Independent Review	
1	Included results for FP2	TT					

Sign-off Sheet

This document entitled BNTCL Solar Photovoltaic Farm – Glint & Glare Study was prepared by Stantec Consulting Caribbean Ltd. (“Stantec”) for the account of Barbados National Oil Corporation Ltd. (the “Client”). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec’s professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____

(signature)

Reviewed by ____

(signature)

Approved by ____

(signature)

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Executive Summary

The Developer proposes the construction of a Photo Voltaic "solar farm" on the lands of the Barbados National Terminal Corporation Ltd. (BNTCL), Fairy Valley, Christ Church, Barbados. The farm will occupy an approximate area of 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. This system is proposed to produce 5MW AC of renewable energy for integration in the Barbados Light & Power Co. Ltd's (BL&P) electricity grid. The farm is near to the Grantley Adams International Airport (GAIA). There are two (2) existing roof top mounted and one ground mounted PV array installations in the vicinity of the proposed BNTCL PV farm development.

Glare is generally described as direct sunlight or reflected sunlight from a surface for an extended duration. Glint is a momentary flash of light from a reflective surface, which can cause discomfort to those impacted. Solar panels are designed to absorb as much light/solar energy as possible to attain maximum efficiency; they are designed to absorb light and not reflect it. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow and steel (metal sheeted roofs etc). PV panels usually reflect 2% of incident sunlight.

SGHAT – a glare modelling software – was used to estimate the potential glare at eleven (11) observation/receptor points (OPs) - including the Air Traffic Control Tower- ATCT at GAIA, three (3) route (public roadway) receptors and two (2) flight path receptors (pilot landing an aircraft at GAIA) – all points within sight of the solar farm. The SGHAT model defines and models glare as follows:

Green	**Low Potential Hazard**: Glare present with a low potential for a temporary after-image (a lingering image of the glare in the field of view). This hazard is shown green on the glare potential plots.
Yellow	**Moderate Potential Hazard**: Glare present with the potential to leave a temporary after-image of the glare. This hazard is shown yellow on the glare potential plots.
Red	**High Potential Hazard**: Glare present with the potential for permanent eye damage if observed. This hazard is shown red on the glare potential plots.

An important limitation of the SGHAT software is that it does not take into consideration natural or artificial obstructions buildings, trees etc. between a receptor (OP) and the potential source of glare.

The model indicates that there is potential for glare impacts at receptors predominantly to the East and West; the model also predicts that receptors OP2 *(first floor BNTCL office)* and OP9 *(first floor of GAIA Engineering building)* may be exposed to the most prevalent glare received by building receptors, while the road along the southern boundary of the PV site (Fairy Valley Road) may experience glare from panels throughout most of the year. Glare when it is predicted to occur does so within discrete hours of a given day – not exceeding a period of 3 hours on the days with the longest duration of glare. Note the following model results:

- Based on model results, glare may be experienced at receptors West of the site and via commuters along the roads to the north and south of the site between 5:45am and 7:00am from March to October.

- Glare was not predicted to occur at receptors South of the site, except via the use of Deeply Textured PV panels; when occurring, glare was predicted between 3:00pm and 6:00pm from April until September.

- Glare was predicted at the receptors to the East of the sites, but more predominantly to the South-East, between 5:00pm and 6:00pm from March to October.

- To the North of the site in the Fairy Valley community, little to no glare was predicted; predicted glare occurred between 5:45am and 6:30am during March, September, and October.

- In the airport, at the ATCT, the model predicted that glare may occur during the evening, between the hours of 5:30pm and 6:00pm from March to mid-May, and from August to mid-October. The glare predicted was predominantly "yellow" glare defined as a ***Moderate Potential Hazard*** – glare with potential to leave an after-image.

- "Green" glare, defined as a ***Low Potential Hazard*** – glare with low potential to leave an after-image, was also predicted at the ATCT, the road along the southern boundary of the PV site and along the flight path of aircrafts landing at GAIA from both the West and the East.

Impacts to the receptors identified may be less than predicted, or in some cases eliminated, due to existing partial to full obstructions within the vicinity of the receptors and the site. All the OPs had clear lines of sight to at least a portion of the PV array, except for OP4 *(farm west of solar farm)* and OP8 *(Seawell power generating station)*. The earth berms lined with trees to the West and North-West of the site obscure a significant portion of the site from OP4; latter said, the northern section of the PV site would be visible and has been predicted to be a source of glare. Similarly, for OP8 *(Seawell power generating station)*, lands are heavily vegetated between the site and the receptor; the vegetation would obstruct the line of sight between the Seawell plant and the PV plant almost entirely. Notwithstanding, this receptor point OP8 was retained, given the potential for the future clearance of these vegetated lands.

The United States (US) Department of Energy in collaboration with the US Federal Aviation Administration (FAA) has determined that glare from PV farms in the vicinity of airports can impact air traffic controllers and pilots of aircraft. The FAA has set the following acceptance criteria for farms in the vicinity of airports:

- No potential for glare at cabin level (where air traffic controllers work).

- Glare impacting pilots during last two miles of standard straight in landing approach to have a low potential for after image.

The (FAA, 2016) study on the hazards of glare impacting pilots on final approach in aircraft recommends that design of solar installations at an airport consider pilot approach and ensure that installation does not result in pilot facing glare that is straight ahead or within 25 degrees of straight ahead during final approach. The existing PV installations introduced earlier and the proposed BNTCL PV farm altogether fall within 25 degrees of the final 2-mile final approach of landing aircraft - from the East and West. Latter said, the USDE/FAA acceptance criteria listed above does permit glare to landing pilots if it is predicted as having a low potential for after image.

The results of the glint and glare study indicate potential glint and glare impacts to air traffic controllers at the ATCT receptor location and green glare impacts (low potential for after image) to landing pilots. Therefore, FAA acceptance criteria were not met for the GAIA Air Traffic Control Tower but for the Eastern and Western landing approaches, the results were acceptable.

Stemming from this glint and glare study the following are recommended.

Pre-Construction Stage

- Consideration could be given to optimizing the panel angles (and possibly removal of some panels) – via consultation with panel system supplier - to minimize glare impacts; the focus of the optimization should be to eliminate the potential glare effects at the cabin level of the ATCT. Note that this action could result in a reduction in the solar conversion efficiency of the PV farm.
- A tree screen of height not less than 3m (10 feet) should be constructed along the northern, southern and eastern site boundaries. There is an existing partial screen along the western boundary of the site in the form of an earthen berm with tree line atop; the southern section of this existing screen should be extended in the form of a 3m (10ft) high tree screen towards the site's southern boundary. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors to the North, East, South and West and by extension mitigate – if not eliminate - the potential for glare impacts. The implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm.
- Along the line of sight of two-storey buildings, tree screens should be grown to a minimum height of 6m. The implementation of this recommendation would block the line of sight of PV panels to receptors in targeted two-storey buildings.
- Consideration could be given to utilizing smooth panels without ARC coating.

Post-Construction Stage

If there are reports of impacts from residents or other land users near the development, then consideration should be given to the following:

- Replacing offending panels with a deep textured panel – to reduce glare intensity.
- Removing the offending solar panels.

The above recommendations would also apply to any reports of glare from pilots of approaching aircraft or air traffic controllers in the ATCT.

1.0 INTRODUCTION

1.1 DEVELOPMENT PROPOSAL

The Client proposes the construction of a solar farm on lands of the Barbados National Terminal Co. Ltd. (BNTCL) at Fairy Valley, Christ Church, Barbados. The farm shall generate power to be sold to Barbados Light & Power Ltd. The area slated for development occupies a total footprint of approximately 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. These 14,520 panels are expected to produce approximately 5MW AC of renewable energy electricity for integration into the national power grid.

The specific location and site surroundings of the PV farm are shown below:

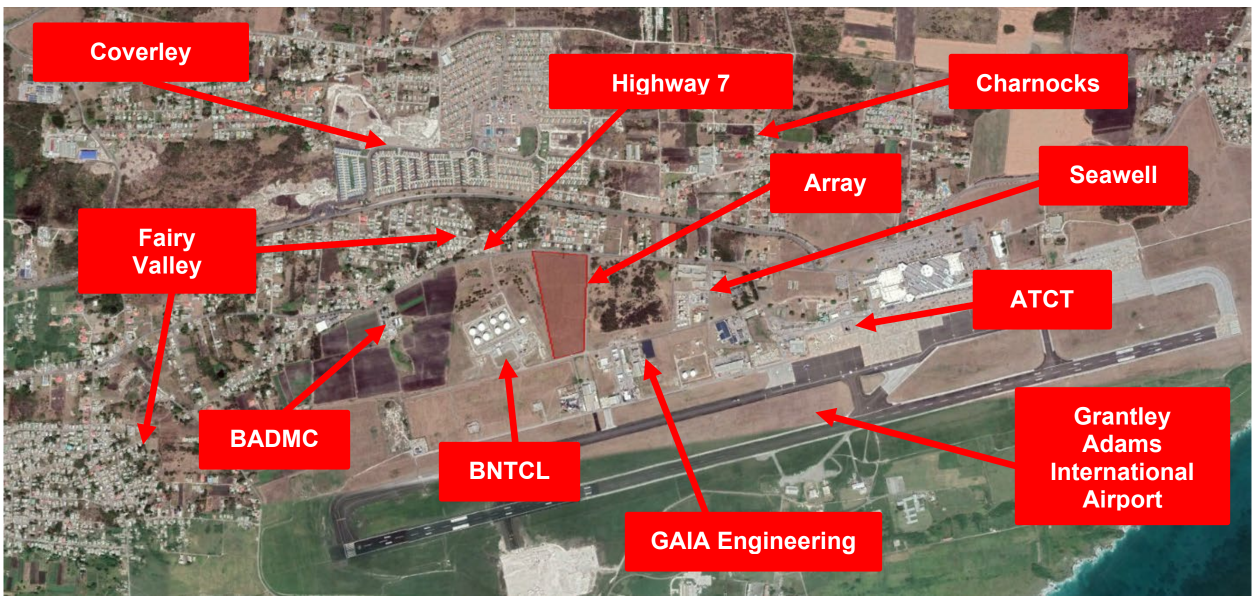


Figure 1 – Site Location and Surroundings

The PV site is situated on the lands of BNTCL, adjacent and to the east of existing BNTCL buildings. To the North and West of the site was the residential development of Fairy Valley, and to the immediate East was “rab”/vegetated land. The Grantley Adams International Airport (GAIA) was located to the east and south of the array; the Air Traffic Control Tower (ATCT) of GAIA was located 950m South East of the PV farm. To the immediate west of the PV site were office buildings of the BNTCL including other mass storage fuel infrastructure including several large fuel tanks and a water storage tank. Further East of the BNTCL compound were other lands under agriculture/cultivation.

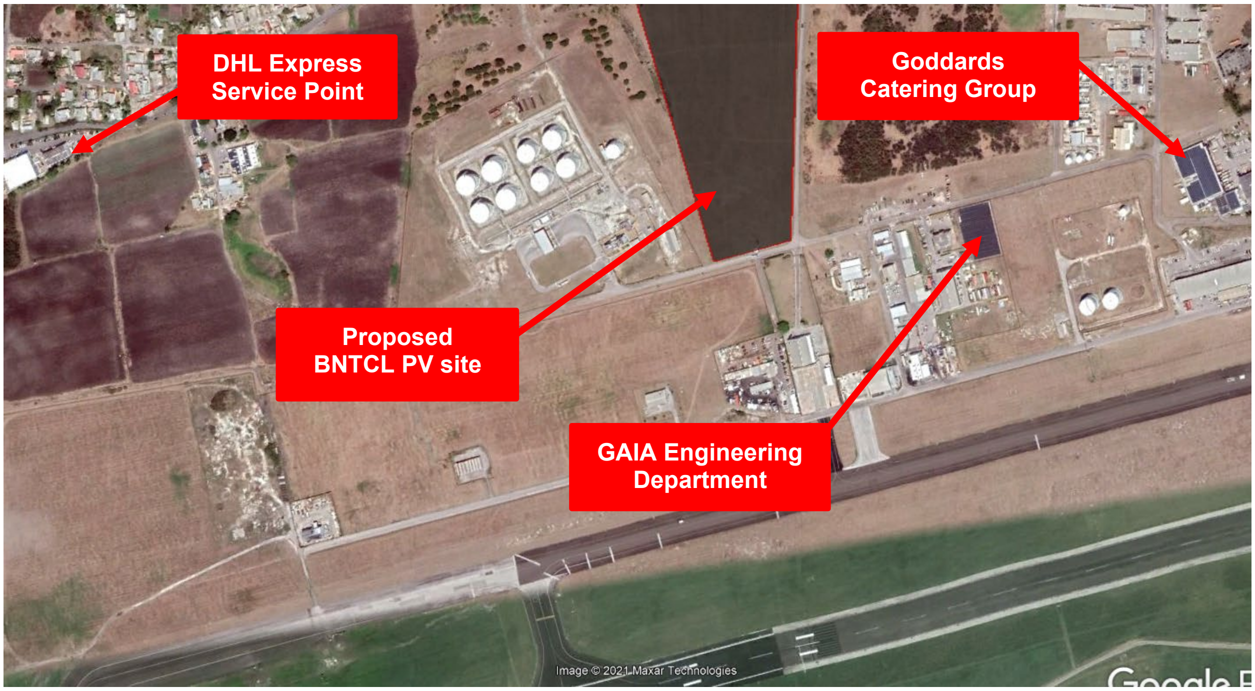


Figure 2 - Existing PV Installations within site environs

With respect to existing installations of solar PV facilities there are three facilities within the environs of the proposed site and the GAIA facility (see Figure 2.0 above):

- Roof top PV system at DHL Express Service Point.
- Ground mounted PV system on lot of land to the immediate East of GAIA's Engineering Office.
- Roof top PV system – Goddards Catering Group building.

Primary access to the proposed PV site shall be from Fairy Valley Road in the South that currently provides access to the BNTCL compound. Access into the fenced and gated PV farm compound shall be from the South; upon entry there shall be a vehicle parking area, control room and equipment storage container (see Figure 3.0 below)

The proposed PV site has been maintained to prevent any overgrowth of vegetation, and as such there is a clear view of the surrounding developments and businesses from the site. To the West and North-West of the site a tree lined earthen berm was observed; the berm followed a Westerly path to the North of the BNTCL facility, almost to the Western extent of the facility.

The proposed PV farm site layout can be seen below:

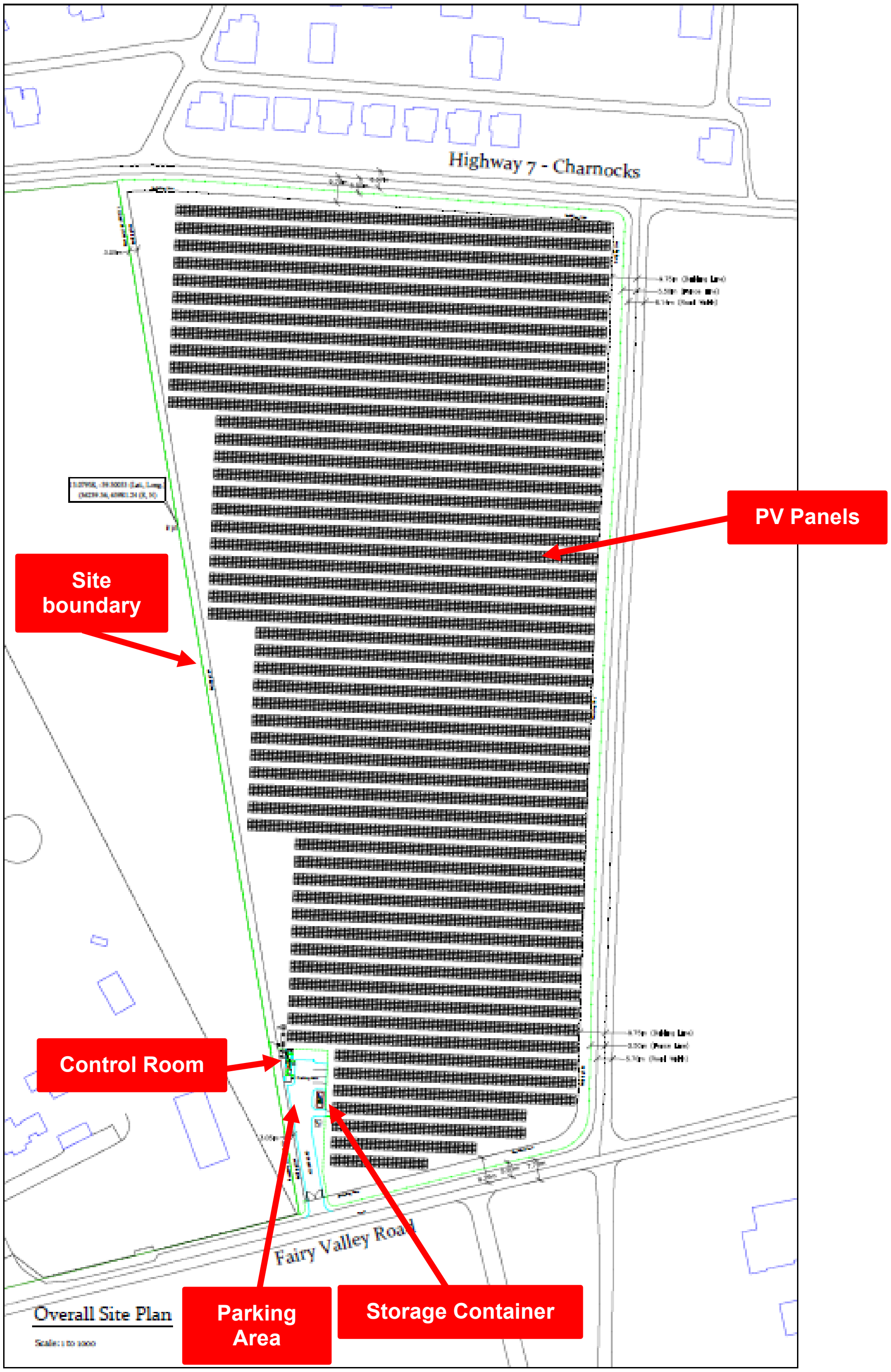


Figure 3 – Site Layout

1.2 STUDY PURPOSE

There is a concern that the development of the solar farm may result in glint and glare impacts to other adjacent and nearby land users including the ATCT and landing aircraft. The purpose of this report is to assess the potential for glint and glare impacts to nearby land users, and to recommend measure(s) to mitigate these impacts.

The report continues with a description of glint and glare, its potential impacts, methodology for assessment, the presentation of results, and conclusions and recommendations.

1.3 PV PANELS

Photovoltaic panels usually consist of several layers. The top layer is typically glass with a high transmissivity and low reflectance[1] values. The glass layer is typically followed by a structural layer - usually the back sheet. The solar cells along with electrical circuitry are usually between the glass and the back sheet; they are normally bound together by encapsulating materials on the front and back of the PV cell layer. To further stabilize and protect the edges of a panel, a frame - usually made from aluminum - is used.

With respect to the top glass layer, this layer can be specially treated to lower the reflectance of the panel and improve its efficiency. An Anti-Reflective Coating (ARC) can be applied to the glass layer to increase the amount of light absorbed into the cell; the ARC can be applied to smooth or textured glass of a panel. The vast majority of glare observed by human receptors is produced when the sun is low in the sky; ARC does not appear to significantly reduce glare produced at these low angles.

Textured glass was predominantly used to reduce the reflectivity of solar panels before AFCs became more affordable. On clean surfaces textured glass improves the efficiencies of solar devices; incoming light is reflected off the raised surface of textured glass and is re-directed to other portions of the surface improving the solar energy capture efficiency. Another benefit of textured glass surfaces is that they reduce PV panel glare. Drawbacks with textured solar PV glass structures are:

- Higher cost due to the additional material required to create the textured surface
- Textured surfaces may trap dirt left behind by evaporation in the small grooves or low spots of the textured surface. That dirt can reduce the amount of transmitted energy and thus reduce the device's efficiency.

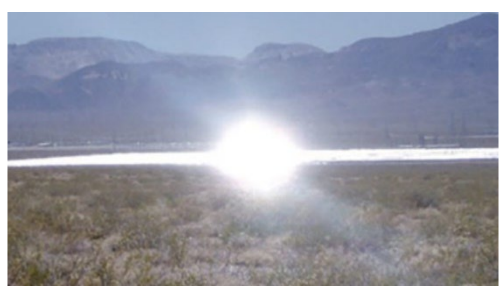


Figure 4 – Glint from Solar Farm

[1] Reflectance of the surface of a material is its effectiveness in reflecting radiant energy.

1.4 PANEL ORIENTATION AND TILT

Solar PV panels work best when their absorbing surface is perpendicular to the rays of the sun. As well as moving across the sky, the sun moves up and down the sky throughout a given year.

A panel's orientation is its horizontal angle relative to North; a panel facing Southwards – for example – would have an orientation of 180 degrees from North. To maximize exposure to the direct sun rays, panels should be oriented towards the terrestrial equator. Thus, in the Northern hemisphere (where Barbados is) panels should face Southwards; in the Southern hemisphere panels should be face Northwards.

The tilt of a PV panel is the angle between the panel surface and the earth' surface. The existing and proposed tilt of the PV panels for the BNTCL Solar PV farm is 15 degrees.

1.5 GLINT AND GLARE

1.5.1 What is Glint and Glare?

Figure 5 – Glare from Panels

Glare is generally described as direct sunlight or reflected sunlight from a surface for an extended duration. Glint is a momentary flash of light from a reflective surface, which can cause discomfort to those impacted.

Reflections from a smooth surface are dependent on the angle of incidence of the light and surface conditions; as the angle of incidence increases, the amount of reflected light increases. Solar panels are designed to absorb as much light/solar energy as possible to attain maximum efficiency; they are designed to absorb light and not reflect it. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow and steel. Because of the solar panel's smooth surface, incident light is re-radiated in a specific direction, typically resulting in reflections that are considerably less than direct sunlight. It is reported that PV panels usually reflect 2% of incident sunlight[2].

The primary impact of glint and glare from solar panels is nuisance to the receptor. Glare from panels can also impact the vision of pilots flying airplanes.

[2] FAA, November 2010, Technical Guidance for Evaluating Selected Solar Technologies on Airports

1.5.2 Measures to mitigate impacts of Glint and Glare

Typical measures to mitigate glint and glare impacts from solar farms include:

- Choosing a panel with a rougher surface
- Reorienting the panels
- Shielding offending panels so they cannot be seen – via the used of screened fences or tree screens
- Changing the panel layout to reduce visibility
- Removing offending panels

2.0 PV ARRAYS NEAR AIRPORTS

The United States (US) Department of Energy (USDE) in collaboration with the US Federal Aviation Administration (FAA) has determined that glare from PV farms in the vicinity of airports can impact air traffic controllers and pilots of aircraft. The FAA has set the following acceptance criteria for farms in the vicinity of airports (NREL, 2016):

- No potential for glare at cabin level (where air traffic controllers work).
- Glare impacting pilots during last two miles of standard straight in landing approach to have a low potential for after image.

A (FAA, 2016) report that investigated glare as a hazard for general aviation pilots on final approach concluded the following:

- Presence of glare contributed to the impairment of a pilot's ability to see his instruments and fly the aircraft when glare was straight ahead as well as slightly to the side.
- More forward the glare, the longer the glare duration and impact to pilot.
- Mitigation: recommended that design of solar installation at an airport consider pilot approach and ensure that installation does not result in pilot facing glare that is straight ahead or within 25 degrees of straight ahead during final approach.

As depicted in Figure 6.0, all existing PV installations introduced in section 1.1 and the proposed BNTCL PV farm fall within 25 degrees of the final 2-mile final approach of landing aircraft - from the West. Latter said, the USDE/FAA acceptance criteria listed above does permit glare to landing pilots if it is predicted as having a low potential for after image.

Figure 6 - 2-mile Western runway approach with 25-degree view angles shown

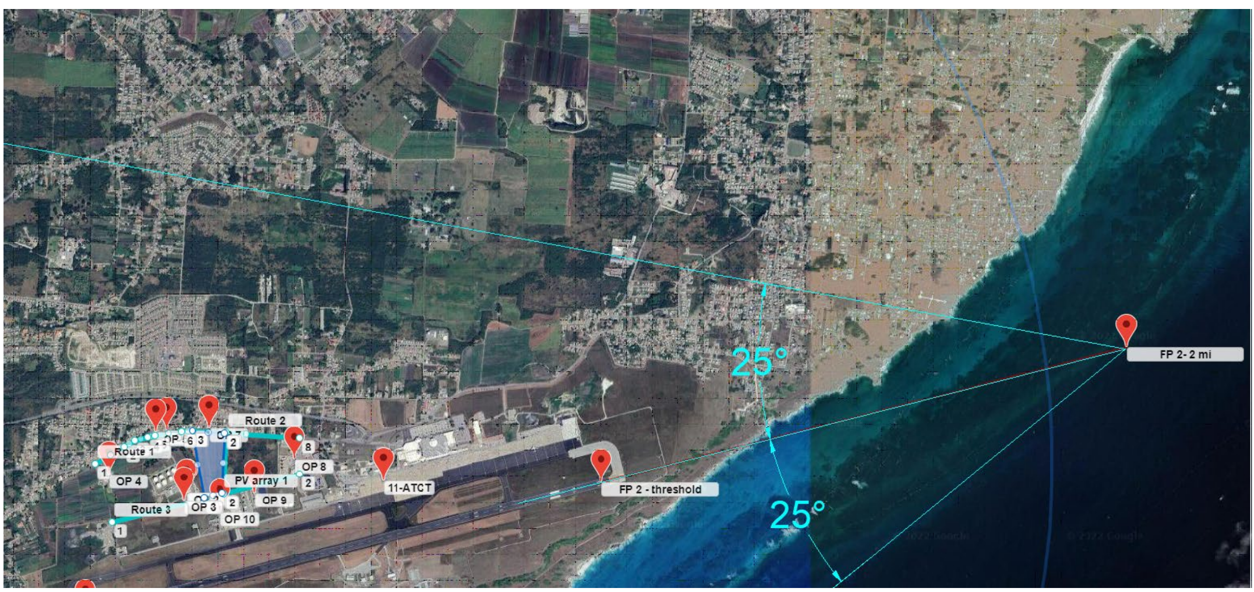


Figure 7 - 2-mile Eastern runway approach with 25-degree view angles shown

3.0 GLINT AND GLARE MODELLING

3.1 GENERAL

The general objective of the modelling operation is to identify the time and day within a year when glare and glint from a fixed tilt solar PV farm may impact identified receptors (at selected observation points).

3.2 GLARE MODELLING TOOL

A web based Solar Glare Hazard Analysis Tool (SGHAT) – developed by Sandia National Laboratories and currently licensed to ForgeSolar – was used to conduct solar glare analyses for this assignment. Most importantly, the tool provides a quantitative assessment of:

- When and where glare will occur throughout the year due to a proposed PV array
- Potential effects on the human eye at locations where glare occurs

A Google Map interface is used to position and size the PV array; information on the orientation and tilt of panels, reflectance, environment, and ocular factors – for example – can be entered by the user.

Once glare is found, SGHAT calculates the retinal irradiance and size/distance of the source of glare; the software also predicts ocular hazards ranging from temporary after-image to retinal burn.

3.3 MODEL INPUTS

Several model runs were done with different panel textures and finishes. Key data inputted into the model for the BNTCL Solar farm were as follows:

- Time Zone: UTC -4
- Peak Direct Normal Irradiance[3] (DNI) – 1000 W/m^2
- PV Panel tilt – 15 degrees (fixed – no tracking)
- PV Panel orientation – 180 degrees (facing South)
- PV panel height above ground level – 1460mm
- Panel material – various options (smooth glass with/without ARC; light textured panels with/without ARC, deep textured panels)

[3] Radiant flux (power) received by a surface per unit area30.31

3.4 OBSERVATION POINT LOCATIONS

Eleven (11) observation/receptor points, three (3) route receptors and two (2) flight path receptors were determined based on locations where glint and glare could impact sensitive receptors. Satellite photography from Google Earth® was examined to determine the appropriate location and number of Observation Points that could possibly be affected by glint or glare emanating from the array. A field visit was then conducted to determine whether observation points could be clearly seen from the PV sites (see Photographs in Appendix 1). The eleven (11) observation points (OPs 1 to 11), the route receptors (R1 to R3) and the flight path receptors (FP1 and FP2) are detailed in the table below. Note that the ground elevation of the array ranges from 56m to 66m AMSL. Also note that the elevations indicated in the table below are the ground elevations of the receptors.

Table 1 - Observation Locations

Number	Latitude (deg)	Longitude (deg)	Elevation (m)	Remarks
OP 1	13.0775	-59.501	57.30	Ground Floor of the BNTCL Office Building to the West of the Solar Farm
OP 2	13.07751	-59.5011	57.37	First Floor of the BNTCL Office Building to the West of the Solar Farm
OP 3	13.07711	-59.5012	56.95	Guard Hut at entrance of the BNTCL complex to the West of the Solar Farm
OP4	13.07848	-59.5054	66.60	Farm in Fairy Valley to the West of the Solar Farm
OP5	13.08072	-59.5028	69.48	Two-storey residence to the North-West of the Solar Farm
OP6	13.08083	-59.5022	69.03	Single-storey residence to the North-West of the Solar Farm
OP7	13.08094	-59.4998	65.40	Single-storey residence to the North of the Solar Farm
OP8	13.07926	-59.4952	62.01	BL&P Seawell Power generation plant - to the East of the Solar Farm
OP9	13.07748	-59.4974	57.46	First floor of the GAIA Engineering Office to the South-West of the Solar Farm
OP10	13.07648	-59.4992	57.87	Commercial complex to the South of the Solar Farm
OP11-ATCT	13.07813	-59.4903	56.37	ATCT on the airside section of GAIA to the South-West of the Solar Farm
R1	Start: 13.07902 End: 13.08042	Start: -59.50606 End: -59.49489	Start: 72.47 End:61.43	The road running along the northern boundary of the Solar Farm
R2	Start: 13.08068 End: 13.07744	Start: -59.49893 End: -59.49903	Start: 63.60 End: 58.00	The road running along the eastern boundary of the Solar Farm

Number	Latitude (deg)	Longitude (deg)	Elevation (m)	Remarks
R3	Start: 13.07594 End: 13.07847	Start: -59.50516 End: -59.49488	Start: 59.58 End: 59.60	The road running along the southern boundary of the Solar Farm
FP1	Start: 13.07714 End: 13.06442	Start: -59.50663 End: -59.53354	Start: 55.44 End: 24.28	The western approach path for planes landing at GAIA
FP2	Start: 13.07805 End: 13.08523	Start: -59.47834 End: -59.44956	Start: 50.40 End: 0.00	The eastern approach path for planes landing at GAIA

It was assumed that the height of a human receptor from ground level was 1.8m; the height from ground level to a human receptor in a first-floor building was set as 4.8m. The height from ground level to the cabin level in the ATCT was set as 22m. For the route receptors, it was assumed that the height of a receptor from ground level was 1.2m, and for the flight path receptor, the threshold height was set as 15.24m from ground level (based on guidance from the SGHAT manual). Flight receptor paths were modelled for both eastern and western landing approaches.

Figure 8 – PV Array Outline and Monitoring Locations

Figure 9 –2-mile Flight Path in SGHAT

3.5 ASSUMPTIONS AND LIMITATIONS OF SGHAT

The following standard assumptions have been made through the course of the analysis; these are sourced from the SGHAT user manual[4]:

Assumptions:

- Ocular transmission coefficient[5] - 0.5
- Pupil diameter[6] – 0.002m

[4] Solar Glare Hazard Analysis Tool (SGHAT) User's Manual Version 3
[5] Ocular Transmission Coefficient – radiation that is absorbed in the eye before reaching the retina; value of 0.5 is typical
[6] Pupil diameter – the larger the diameter, the greater the amount of light entering the eye and reaching the retina. Typical values 0.002m for daylight adjusted eyes

- Eye focal length[7] - 0.017m
- Sun subtended angle[8] – 9.3 mrad

Limitations

- Software only applies to flat reflective surfaces (as proposed at the BNTCL PV development).
- The detailed geometry of a solar array system is not represented, such as – gaps between modules, variable height of PV arrays and support structures that may impact glare results.
- **The software does not consider man-made or natural obstacles in the path between the solar installation and observation points.**

3.6 GLARE HAZARD DEFINITIONS IN SGHAT

Three levels of ocular (eye) hazard as a result of glare are defined in SGHAT. These are as follows:

Green	**Low Potential Hazard**: Glare present with a low potential for a temporary after-image (a lingering image of the glare in the field of view). This hazard is shown green on the glare potential plots.
Yellow	**Moderate Potential Hazard**: Glare present with the potential to leave a temporary after-image of the glare. This hazard is shown yellow on the glare potential plots.
Red	**High Potential Hazard**: Glare present with the potential for permanent eye damage if observed. This hazard is shown red on the glare potential plots.

3.7 BNTCL SOLAR FARM MODELLING RESULTS

The SGHAT model was run a total of five times under various configurations. These configurations were as follows:

- **Config. 1:** 15-degree tilt with a smooth PV panel surface with no Anti Reflective Coating (ARC)
- **Config. 2:** 15-degree tilt with a smooth PV panel surface with Anti Reflective Coating (ARC)
- **Config. 3**: 15-degree tilt with lightly textured PV panel surface with no Anti Reflective Coating (ARC)
- **Config. 4**: 15-degree tilt with lightly textured PV panel surface with Anti Reflective Coating (ARC)
- **Config. 5**: 15-degree tilt with deeply textured PV panel surface with no Anti Reflective Coating (ARC)

Modelling results are shown on the following pages.

[7] Eye focal length – Distance between nodal point (where ray intersects the eye) and the retina. Typical value 0.017m.
[8] Subtended angle of the sun – average subtended angle of the sun as viewed from the earth

Table 2 - Key Results

Configuration	1	2	3	4	5
Description	**Smooth, without ARC**	**Smooth, with ARC**	**Lightly Textured, without ARC**	**Lightly Textured, with ARC**	**Deeply Textured**
Total Annual Glare	3,051 minutes (50.85 hours) 34,104 minutes (568.4 hours) Total: 619.25 hours	4,452 minutes (74.20 hours) 38,161 minutes (636.02 hours) Total: 710.22 hours	5,415 minutes (90.25 hours) 41,035 minutes (683.92 hours) Total: 774.17 hours	5,186 minutes (86.43 hours) 39,633 minutes (660.55 hours) Total: 746.98 hours	348,811 minutes (5,813.52 hours) Total: 5,813.52 hours
OP1	1,669 minutes from April to mid-September, between 6:00am and 6:30am.	1,894 minutes from April to mid-September, between 6:00am and 6:30am.	2,012 minutes from April to mid-September, between 6:00am and 6:30am.	1,969 minutes from April to mid-September, between 6:00am and 6:30am.	734 minutes from April to September between 6:00am and 6:30am
OP2	3,345 minutes from April to mid-September, between 6:00am and 6:30am.	3,977 minutes from March to mid-October, between 6:00am and 7:00am.	4,416 minutes from March to mid-October, between 5:45am and 7:00am.	4,228 minutes from March to mid-October, between 5:45am and 7:00am.	33,152 minutes year-round from 5:45am and 9:00am
OP3	8 minutes from May to mid-August around 6:00am	4 minutes from late May to mid-July around 6:00am.	7 minutes from May to August around 6:00am.	9 minutes from May to August around 6:00am.	No glare
OP4	2,604 minutes from March to October between 6:00am and 7:00am	2 minutes in mid-September around 6:00am 3,213 minutes from March to mid-October between 5:45am and 7:00am.	31 minutes in mid-March and mid-September around 6:00am 3,600 minutes from March to mid-October between 5:45am and 7:00am.	23 minutes in mid-March and mid-September around 6:00am 3,429 minutes from March to mid-October between 5:45am and 7:00am.	14,757 minutes year-round between 5:45am and 9:00am

Note: Green highlight denotes 'green level' glare, yellow highlight denotes 'yellow level' glare, and red highlight denotes 'red level' glare.

Configuration	**1**	**2**	**3**	**4**	**5**
Description	**Smooth, without ARC**	**Smooth, with ARC**	**Lightly Textured, without ARC**	**Lightly Textured, with ARC**	**Deeply Textured**
OP5	604 minutes during March, and from mid-September to mid-October between 5:45am and 6:30am	811 minutes during from late February to March, and from mid-September to mid-October between 5:45am and 6:30am	962 minutes during March, and from mid-September to mid-October between 5:45am and 6:30am	896 minutes during March, and from mid-September to mid-October between 5:45am and 6:30am	27,191 minutes year-round between 6:00am and 8:00am
OP6	188 minutes from March to mid-March, and from late September to mid-October between 5:45am and 6:30am	311 minutes from March to mid-March, and from late September to mid-October between 5:45am and 6:30am	410 minutes from March to mid-March, and from late September to mid-October between 5:45am and 6:30am	368 minutes from March to mid-March, and from late September to mid-October between 5:45am and 6:30am	13,537 minutes from September to April between 6:00am and 8:00am
OP7	No glare	No glare	No glare	No glare	3 minutes in April and September around 6:00am
OP8	49 minutes from March to mid-May and from August to October between 5:30pm and 6:00pm	52 minutes from March to mid-May and from August to October between 5:15pm and 6:00pm	52 minutes from March to mid-May and from August to October between 5:15pm and 6:00pm	52 minutes from March to mid-May and from August to October between 5:15pm and 6:00pm	44 minutes from March to mid-April, and from late August to November between 3:30pm and 4:30pm
OP9	2,742 minutes from March to October between 5:00pm and 6:00pm	3,345 minutes from March to October between 5:00pm and 6:00pm	3,777 minutes from March to October between 5:00pm and 6:15pm	3,597 minutes from March to October between 5:00pm and 6:15pm	23,250 minutes year-round between 3:00pm and 6:00pm
OP10	No glare	No glare	No glare	No glare	8,540 minutes from mid-April to late September between 3:00pm and 6:00pm

Note: Green highlight denotes 'green level' glare, yellow highlight denotes 'yellow level' glare, and red highlight denotes 'red level' glare.

Configuration	1	2	3	4	5
Description	Smooth, without ARC	Smooth, with ARC	Lightly Textured, without ARC	Lightly Textured, with ARC	Deeply Textured
OP11-ATCT	37 minutes in mid-March, and in late September around 6:00pm	193 minutes in March, and in September around 6:00pm	653 minutes from March to mid-April, and from late August to early October between 5:30pm and 6:15pm	567 minutes from March to mid-April, and from late August to early October between 5:30pm and 6:15pm	20,310 minutes year-round between 3:30pm and 6:00pm
	1,598 minutes from March to mid-May, and from August to October between 5:30pm and 6:15pm	1,850 minutes from March to mid-May, and from August to October between 5:30pm and 6:15pm	1,686 minutes from March to mid-May, and from August to October between 5:30pm and 6:15pm	1,646 minutes from March to mid-May, and from August to October between 5:30pm and 6:15pm	
R1	2,284 minutes from late February to late May, and from late July to mid-October between 5:45am to 7:00am; from March to April, and from September to October between 5:30pm and 6:00pm	2,937 minutes from mid-February to late May, and from mid-July to late October between 5:45am to 7:00am; from March to April, and from September to mid-October between 5:30pm and 6:15pm	2 minutes in late March, and in September around 6:00pm 3,422 minutes from mid-February to late May, and from mid-July to late October between 5:45am to 7:00am; from March to mid-April, and from September to mid-October between 5:30pm and 6:00pm	3,209 minutes from mid-February to late May, and from mid-July to late October between 5:45am to 7:00am; from March to April, and from September to mid-October between 5:30pm and 6:00pm	56,165 minutes year-round between 6:00am and 8:30am, and between 4:00pm and 6:00pm

Note: Green highlight denotes ‘green level’ glare, yellow highlight denotes ‘yellow level’ glare, and red highlight denotes ‘red level’ glare.

Configuration	**1**	**2**	**3**	**4**	**5**
Description	**Smooth, without ARC**	**Smooth, with ARC**	**Lightly Textured, without ARC**	**Lightly Textured, with ARC**	**Deeply Textured**
R2	No glare	No glare	No glare	No glare	2,048 minutes from late April to mid-August between 5:30pm and 6:00pm
R3	121 minutes from June to July around 4:00pm	750 minutes from mid-May to August between 3:30 and 4:00pm	791 minutes from mid-May to August between 3:30 and 4:00pm	841 minutes from mid-May to August between 3:30 and 4:00pm	115,300 minutes year-round between 4:00pm to 6:00pm, from mid-February to November starting from 6:00am increasing throughout the year and peaking from mid-May to mid-July. Glare during peak months is between 6:00am and 12:00pm, and between 1:00pm and 6:00pm
	19,013 minutes from mid-April to late August between 6:00am and 7:00am; from March to mid-October between 3:45pm and 6:00pm	19,767 minutes from mid-April to late August between 6:00am and 7:15am; from March to mid-October between 3:45pm and 6:00pm	20,691 minutes from mid-April to late August between 6:00am and 7:30am; from late February to mid-October between 3:45pm and 6:15pm	20,230 minutes from mid-April to late August between 6:00am and 7:00am; from March to mid-October between 3:45pm and 6:00pm	
FP1	2,113 minutes from May to early August between 6:00am and 7:00am	2,504 minutes from May to early August between 6:00am and 7:00am	2,772 minutes from May to early August between 6:00am and 7:00am	2,659 minutes from May to early August between 6:00am and 7:00am	19,680 minutes from March to October between 6:30am and 9:00am
FP2	780 minutes from March to mid-April and from late August to mid-October between 5:30pm and 6:15pm	1,003 minutes from March to mid-April and from late August to mid-October between 5:30pm and 6:15pm	1,166 minutes from late February to mid-April and from late August to mid-October between 5:30pm and 6:15pm	1,096 minutes from late February to mid-April and from late August to mid-October between 5:30pm and 6:15pm	14,095 minutes year-round between 3:45pm and 6:00pm

Note: Green highlight denotes 'green level' glare, yellow highlight denotes 'yellow level' glare, and red highlight denotes 'red level' glare.

Key Observations

- Glare predicted by the model was the most prevalent during the summer months; glare was not present during the balance of the year.
- Building receptors (OPs 1 to 10) were a combination of single-story and two-story buildings, as well as an Air Traffic Control Tower in GAIA (OP11-ATCT). Receptors located to the West at BNTCL (OPs 1 & 2), BADMC leased farmlands (OP4), and to the south-east at GAIA's Engineering Office (OP9) had significant 'yellow level' predicted glare, particularly amongst the first-floor receptors (OPs 2 & 9). 'Yellow level' glare has the potential to leave temporary after-images of the glare.
- 'Yellow level' glare was predicted at OPs 1 to 6 in the morning, from March to mid-October, just after sunrise between the hours of 5:45am and 7:00am.
- 'Yellow level' glare was also predicted at OPs 8, 9 and 11-ATCT in the evening, from March to mid-October between 5:00pm and 6:00pm.
- The receptors in Charnocks to the north-west (OPs 5 to 7) were not predicted to have significant glare, with OP7 having no predicted glare in any configuration except Config 5: Deeply Textured Panels, which was exclusively 'green level' glare. 'Green level' glare has low potential to leave temporary after-images of the glare.
- The BL&P Seawell power generation station (OP8) – to the East - was not predicted to be impacted by glare from the PV farm.
- The commercial buildings and aircraft hangar at (OP10) due south of the proposed array were not predicted to be impacted by glare from the farm, except via Configuration 5: Deeply Textured Panels, which was exclusively 'green level' glare.
- Route (roadway) receptor R1, heading west to east from OP4 along Highway 7 – north of the site, was predicted to experience 'yellow level' glare during the morning and evening, between 5:45am and 7:00am and between 5:30pm to 6:00pm, during the spring to fall months. The most predominant locations where glare was predicted along the route were by OPs 4, 5 and 6.
- Route receptor R2, heading north to south along roadway adjacent to the eastern boundary of the proposed site, was not predicted to experience any glare, except via Configuration 5: Deeply Textured Panels, which was exclusively 'green level' glare.
- Route receptor R3, along Fairy Valley Road adjacent to the southern boundary of the proposed site, was predicted to experience significant 'yellow level' glare along the length of the entire route. The model indicates that glare would be experienced during the morning and evening, between 6:00am and 7:00am and between 3:45pm and 6:00pm, peaking in midsummer and tapering off during the spring and fall months.

- Pilots in aircraft along the 2-mile (3.2km) western approach flight path FP1 were predicted to experience ‘green level’ glare during the summer months from May to August, with predicted observations between 6:00am and 7:00am from the 3.2km mark to the 1.3km mark – approaching the runway.
- Pilots in aircraft along the 2-mile (3.2km) eastern approach flight path FP2 were predicted to experience significantly less glare than those along FP1 with a more than 50% reduction in the number of glare-minutes for all configurations except deeply textured panels. Glare experienced along FP2 was solely ‘green level’ glare with low potential to leave temporary after-images for all configurations.
- Glare was predicted along the full 2-mile length of FP2 around March and September just before sunset between 5:30pm and 6:15pm for smooth and lightly textured panels, and year-round in the late afternoon between 3:45pm and 6:00pm for deeply textured panels.
- Anti-reflective coating had a slightly detrimental effect on smooth panels and a slightly beneficial effect on textured panels.
- The configuration that predicted the least total amount of glare was Configuration 1: Smooth Panels without Anti-Reflective Coating (ARC). This configuration also predicted the least number of hours of ‘yellow level’ glare.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Land use in the environs of the proposed BNTCL solar farm is a mixture of residential, agricultural, commercial and industrial land use. The most vulnerable receptors are: the Fairy Valley community to the north, the BNTL complex including offices to the West, the BADMC leased farmlands – also to the West, the GAIA Engineering office to the South East, GAIA equipment maintenance facility and aircraft hangers (operated by others) to the South, the BL&P Seawell power station and offices to the East, other commercial buildings in the GAIA complex to the South East, the GAIA Air Traffic Control Tower , and pilots in aircrafts landing from the West and occasionally, the East. Access to the future PV site shall be via Fairy Valley Road, which runs along the southern boundary of the site. While the proposed site itself is clear of bush and tall vegetation, natural obstructions exist either on the boundary of the PV site or nearer to the receptors themselves, which can act as a partial or complete screen for the site.

SGHAT – a glare modelling software – was used to estimate the potential glare at eleven (11) observation/receptor points, three (3) route receptors and two (2) flight path receptors within sight of the solar farm. The model indicates that there is potential for glare impacts from March to October (spring to fall) at the receptors predominantly to the East and West; the model also predicts that receptors OP2 and OP9 (*first floor of the office buildings*) may be exposed to the most prevalent glare for the building receptors, while commuters along Fairy Valley Road along the southern boundary of the PV site may experience glare throughout most of the year. Glare when it is predicted to occur does so within discrete hours of a given day – not exceeding a period of 3 hours on the days with the longest duration of glare.

Based on model results, glare may be experienced at receptors West of the site and along the roads to the north and south of the site between 5:45am and 7:00am from March to October. Glare was not predicted to occur South of the site, except via the use of Deeply Textured PV panels; when occurring glare was predicted between 3:00pm and 6:00pm from April until September. Glare was predicted at receptors to the East of the sites, but more predominantly to the South-East, between 5:00pm and 6:00pm from March to October. To the north of the site in the Fairy Valley community, little to no glare was predicted; predicted glare occurred between 5:45am and 6:30am during March, September and October. In the airport, at the ATCT, the model predicted that glare may occur during the evening, between the hours of 5:30pm and 6:00pm from March to mid-May, and from August to mid-October. The glare predicted was predominantly "yellow" glare defined as a ***Moderate Potential Hazard*** – glare with potential to leave an after-image. "Green" glare, defined as a ***Low Potential Hazard*** – glare with low potential to leave an after-image, was also predicted at the ATCT, the road along the southern boundary of the PV site and along the flight path of aircrafts landing at GAIA from the West and East.

Impacts to the receptors identified may be less than predicted, or in some cases completely eliminated, due to existing partial to full obstructions within the vicinity of the receptors and site. All the OPs had clear lines of sight to at least a portion of the PV array, with the exception of OP4 (*farm in Fairy Valley*) and OP8 (*BL&P Seawell Power generation plant*). The earthen berms lined with trees to the West and North-West of the site obscure a significant portion of the site from OP4; latter said, the northern section of the PV site would be visible and has been predicted to be a source of glare. Similarly, for OP8, lands are heavily vegetated between the site and the receptor; the vegetation would obstruct the line of site between the Seawell plant and the PV plant almost entirely. Notwithstanding, this receptor point (*OP8 - BL&P Seawell Station*) was retained, given the potential for the future clearance of these vegetated lands.

The results of the glint and glare study indicate potential glint and glare impacts to air traffic controllers at the ATCT and green glare impacts (low potential for after image) to landing pilots. The potential impact to ATCT air traffic controllers does not meet FAA acceptance criteria introduced in section 2.0 of this report.

Generally, smooth panels with no Anti-Reflective Coating (ARC) when modelled predicted the least overall exposure time to glare, however almost exclusively 'yellow level' glare was predicted. Adding ARC to the smooth panels or substituting for lightly textured panels increased the predicted 'yellow level' glare notably, with a lesser increase in 'green level glare'.

The deeply textured panel surface eliminated the more intense 'yellow level' glare to the more tolerable 'green level' glare, but at the cost of increasing the total predicted exposure time by a rough factor of eight (8) when compared to the average of the other panels. This increased exposure time results in year-round predicted exposure for multiple OPs and Routes and the Eastern Flight Path, as well as almost continual glare throughout the day during the peak summer months for R3.

4.2 RECOMMENDATIONS

The following measures are recommended to mitigate potential glare impacts.

4.2.1 Pre-construction

- Consideration could be given to optimizing the panel angles and eliminating some panels – via consultation with panel system supplier - to eliminate glare impacts at the ATCT; note that this action could result in a reduction in the solar conversion efficiency of the PV farm.
- A tree screen of height not less than 3m (10 feet) should be constructed along the northern, southern and eastern site boundaries. There is an existing partial screen along the western boundary of the site in the form of an earthen berm with tree line atop; the southern section of this existing screen should be extended in the form of a 3m (10ft) high tree screen towards the site's southern boundary. During the growing in period of the tree screen, the perimeter fencing of the complex should be fitted with an opaque privacy screen. The implementation of this recommendation would block the line of sight of the panels of the farm from receptors to the North, East, South and West and by extension mitigate – if not eliminate - the potential for glare impacts. The implementation of this recommendation would also block the line of sight of PV panels from roadway commuters travelling on the roads in the vicinity of the farm.
- Along the line of site of two-storey buildings, tree screens should be grown to a minimum height of 6m. The implementation of this recommendation would block the line of sight of PV panels to receptors in targeted two-storey buildings.
- Consideration could be given to utilizing smooth panels without ARC coating.

4.2.2 Post construction

If there are reports of impacts from residents or other land users near the development, then consideration should be given to the following:

- Replacing offending panels with a deep textured panel – to reduce glare intensity.
- Removing the offending solar panels.

The above recommendations would also apply to any reports of glare from pilots of approaching aircraft or air traffic controllers in the ATCT.

5.0 REFERENCES

Federal Aviation Administration (FAA). 2016, Evaluation of Glare as a Hazard for General Aviation Pilots on Final Approach.DOT/FAA/AM-15/12. Office of Aerospace Medicine Washington, DC 20591

Ho, Clifffford K; Sims, Cianan A.; Yellowhair, Julius E., (Sandia National Laboratories) 2016 – Solar Glare Hazard Analysis Tool (SGHAT) Users Manual v. 3.0

National Renewable Energy Laboratory (NREL). 2016. Analysing Glare Potential of Solar Photovoltaic Arrays. NREL/FS-6A10-67250. https://www.osti.gov/servlets/purl/1336899

APPENDICES

Appendix A

PHOTOGRAPHS

APPENDIX A – PHOTOGRAPHS

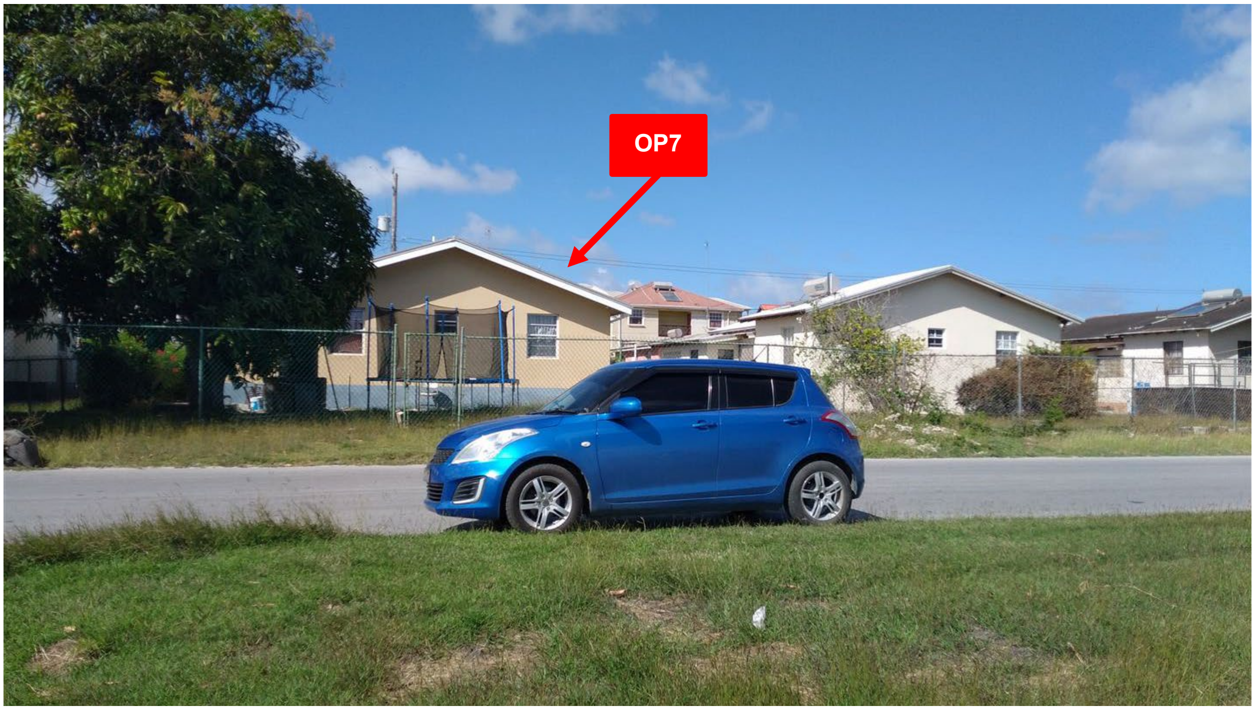


Image 1 – View to the North of the Farm

Image 2 – View to the East of the Farm

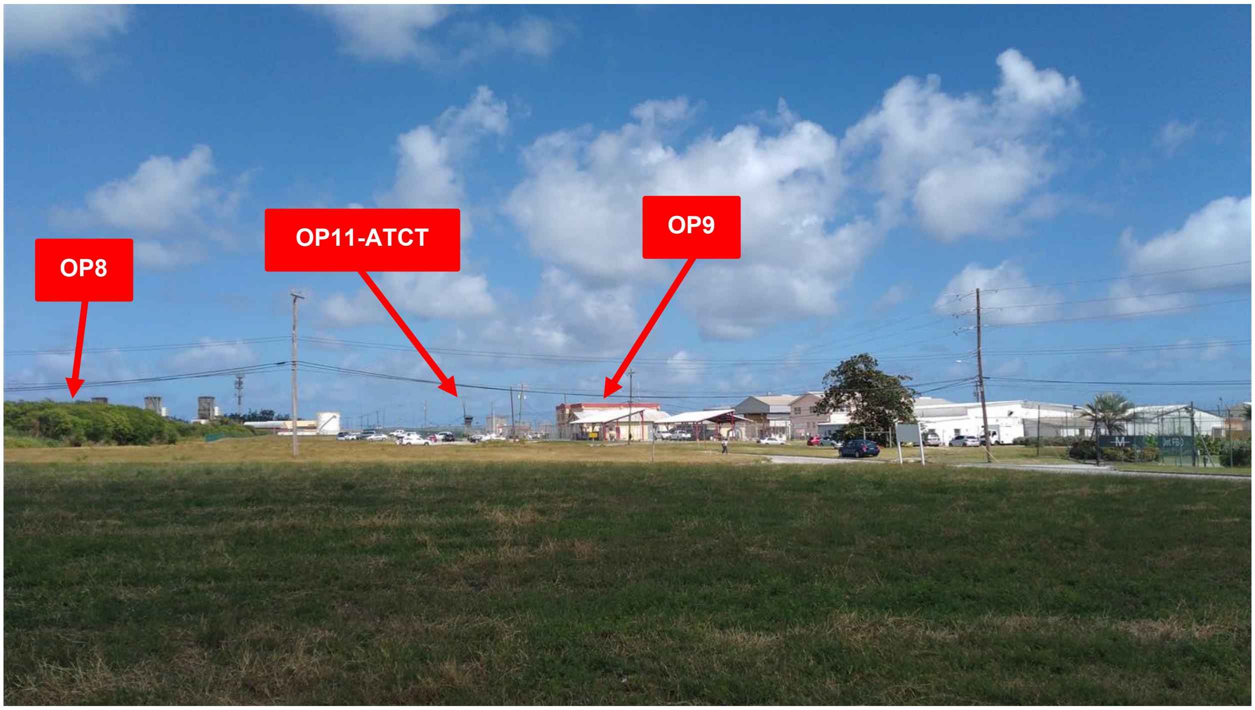


Image 3 – View to the South-East of the Farm

Image 4 – View to the South of the Farm

Image 5 – View to the West of the Farm, towards BNTCL

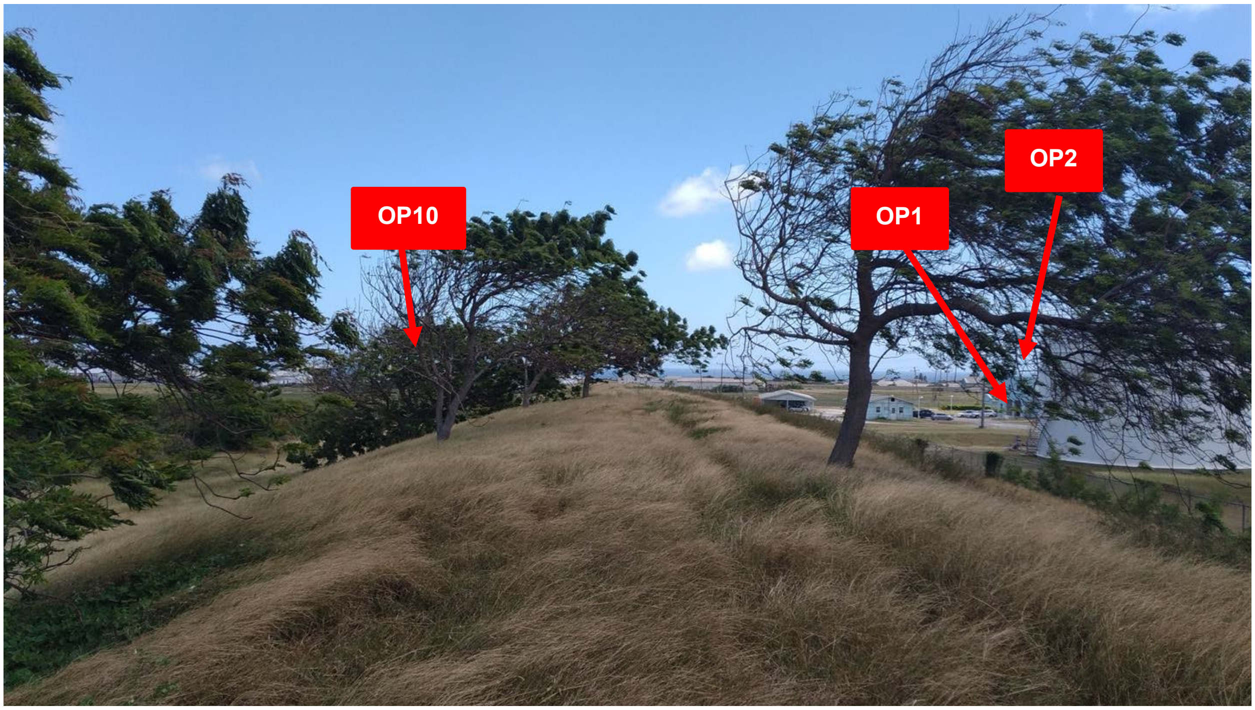


Image 6 – Earth Berm lined with trees to the West of the Farm

Appendix B

SGHAT RESULTS

ForgeSolar

BNTCL 5MW PV Farm

BNTCL Smooth_ARC_2FP

Client: BNOCL

Created May 12, 2022
Updated May 12, 2022
Time-step 1 minute
Timezone offset UTC-4
Site ID 68998.9238

Project type Advanced
Project status: active
Category 500 kW to 1 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

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

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	15.0	180.0	4,452	38,161	-

Component Data

PV Array(s)

Total PV footprint area: 55,735 m^2

Name: PV array 1
Footprint area: 55,735 m^2
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Smooth glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 8.43 mrad

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.077475	-59.499126	58.00	1.46	59.46
2	13.080642	-59.498997	63.41	1.46	64.87
3	13.080757	-59.500772	66.29	1.46	67.75
4	13.077224	-59.500113	56.11	1.46	57.57

2-Mile Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height : 15 m
Direction: 76.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	13.071136	-59.506635	55.44	15.24	70.68
2-mile point	13.064416	-59.535538	24.28	215.08	239.36

Name: FP 2
Description:
Threshold height : 15 m
Direction: 255.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
Threshold	13.078052	-59.478343	50.40	15.24	65.64
2-mile point	13.085227	-59.449555	0.00	234.33	234.33

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.079016	-59.506061	72.47	1.20	73.67
2	13.079935	-59.504484	71.15	1.20	72.35
3	13.080259	-59.503947	70.90	1.20	72.10
4	13.080458	-59.503196	70.27	1.20	71.47
5	13.080531	-59.502821	68.56	1.20	69.76
6	13.080730	-59.501351	67.09	1.20	68.29
7	13.080792	-59.500707	66.37	1.20	67.57
8	13.080416	-59.494892	61.43	1.20	62.63

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.080677	-59.498926	63.60	1.20	64.80
2	13.077438	-59.499033	58.00	1.20	59.20

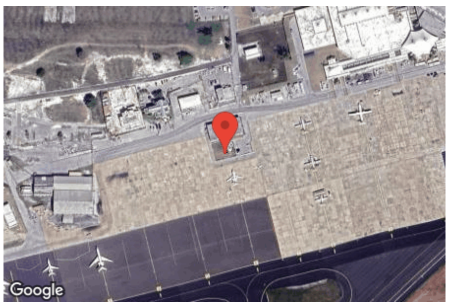
Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.075943	-59.505159	59.58	1.20	60.78
2	13.078472	-59.494881	59.60	1.20	60.80

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.077496	-59.501009	57.30	1.80	59.10
OP 2	13.077512	-59.501075	57.37	4.80	62.17
OP 3	13.077115	-59.501228	56.95	1.80	58.75
OP 4	13.078485	-59.505356	66.60	1.80	68.40
OP 5	13.080724	-59.502755	69.48	4.80	74.28
OP 6	13.080834	-59.502181	69.03	1.80	70.83
OP 7	13.080938	-59.499847	65.40	1.80	67.20
OP 8	13.079259	-59.495156	62.01	1.80	63.81
OP 9	13.077482	-59.497366	57.46	4.80	62.26
OP 10	13.076482	-59.499246	57.87	1.80	59.67
11-ATCT	13.078125	-59.490296	56.37	22.00	78.37

11-ATCT map image



Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	15.0	180.0	4,452	38,161	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	95	417	238	0	0	0	0	0
pv-array-1 (yellow)	0	72	1524	2824	4197	4514	4495	3379	2062	402	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

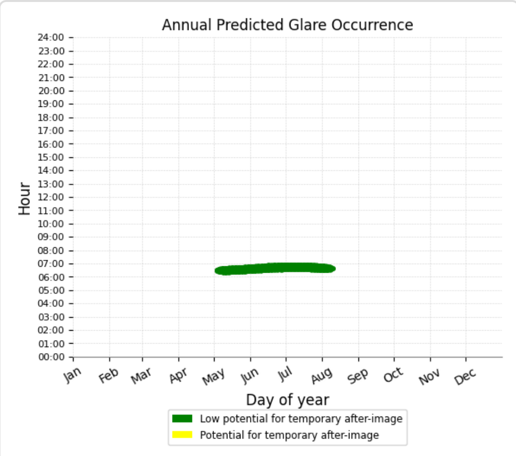
PV array 1 potential temporary after-image

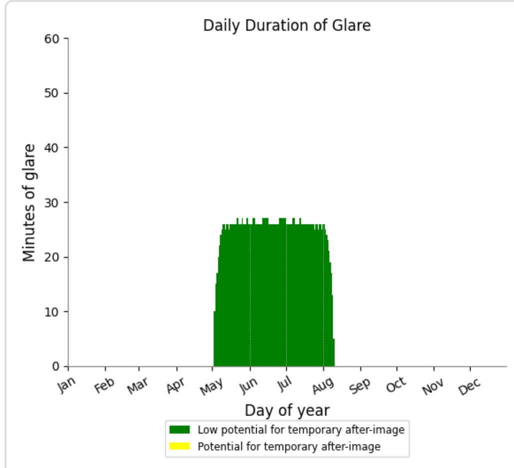
Component	Green glare (min)	Yellow glare (min)
FP: FP 1	2504	0
FP: FP 2	1003	0
OP: OP 1	0	1894
OP: OP 2	0	3977
OP: OP 3	0	4
OP: OP 4	2	3213
OP: OP 5	0	811
OP: OP 6	0	311
OP: OP 7	0	0
OP: OP 8	0	52
OP: OP 9	0	3345
OP: OP 10	0	0
OP: 11-ATCT	193	1850
Route: Route 1	0	2937
Route: Route 2	0	0
Route: Route 3	750	19767

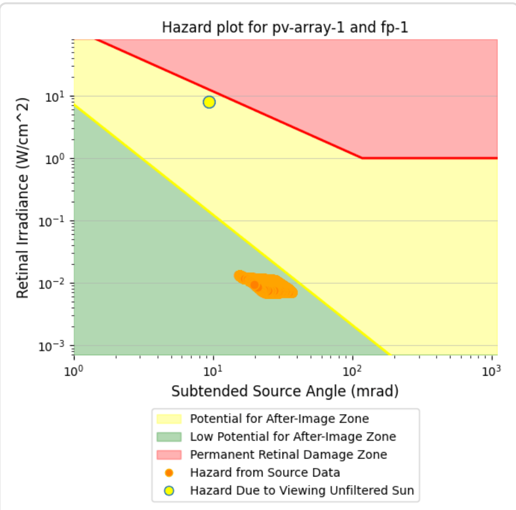
PV array 1 - Receptor (FP 1)

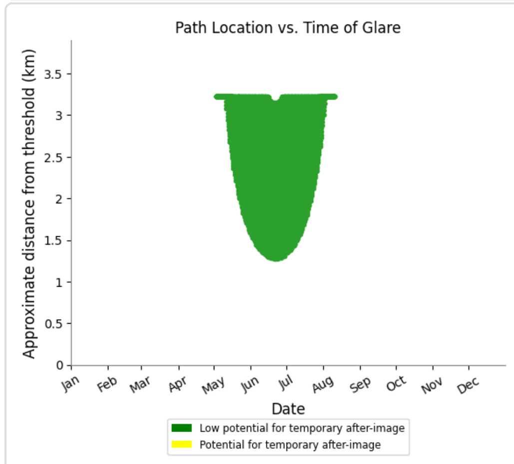
PV array is expected to produce the following glare for observers on this flight path:

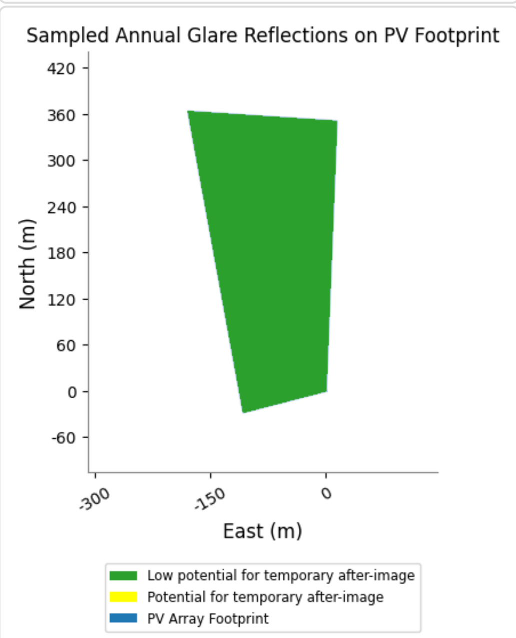
- 2,504 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

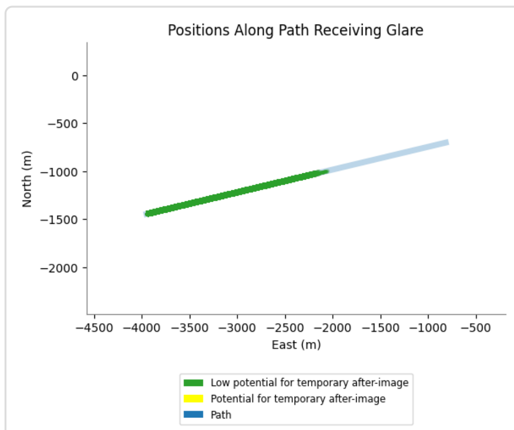








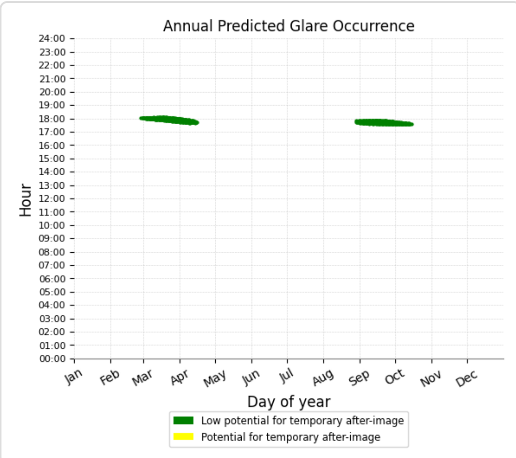


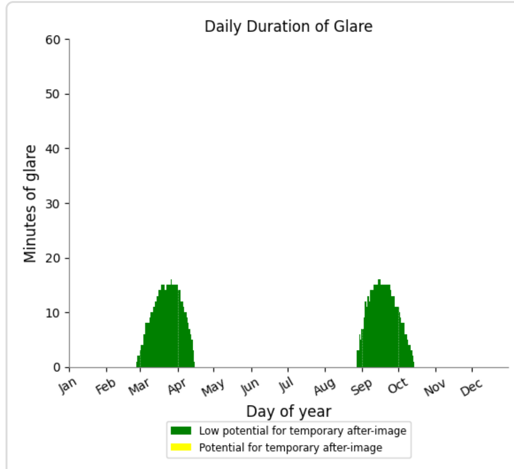


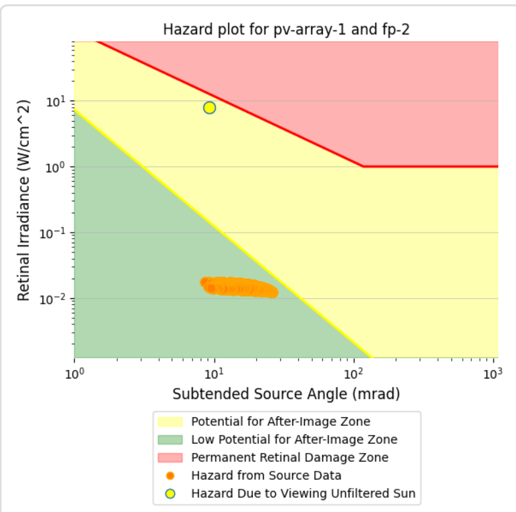
PV array 1 - Receptor (FP 2)

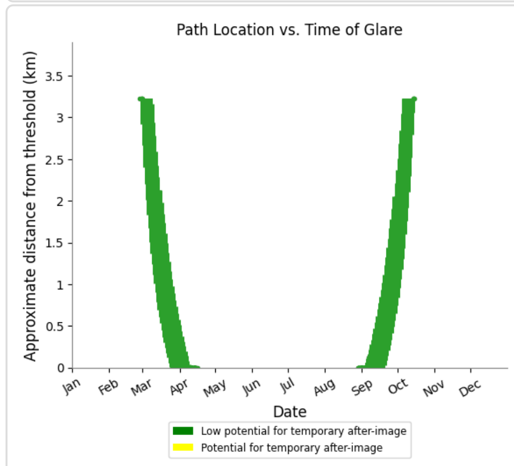
PV array is expected to produce the following glare for observers on this flight path:

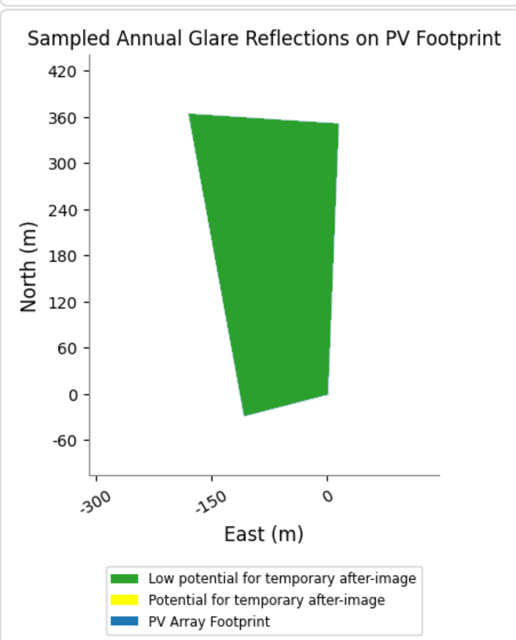
- 1,003 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

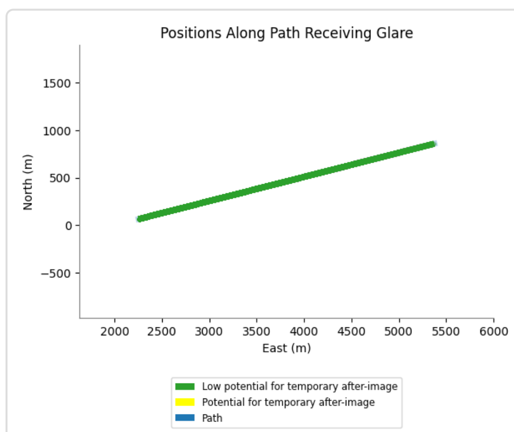








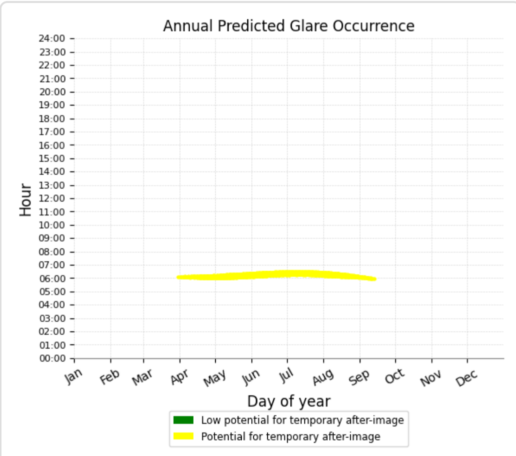


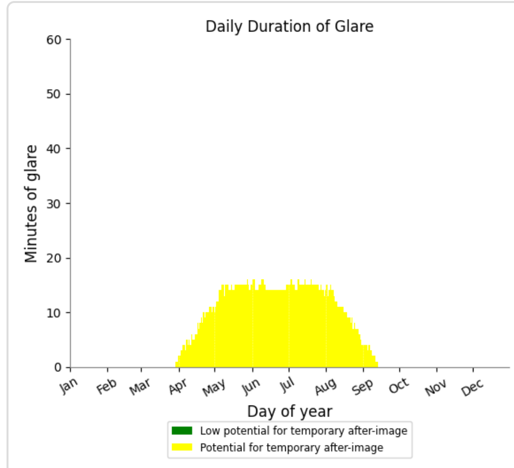


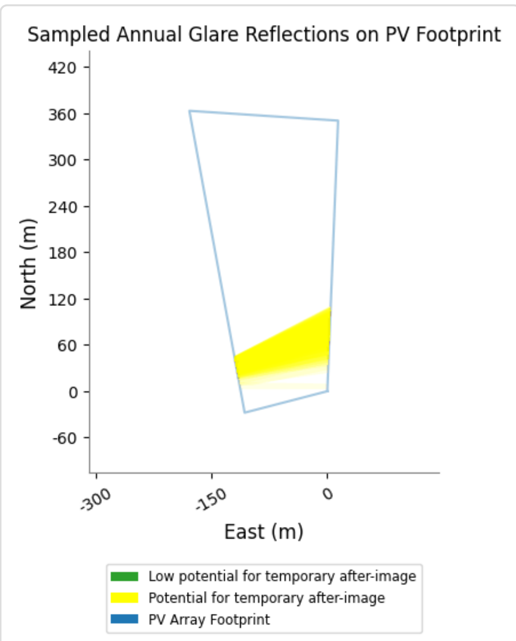
PV array 1 - OP Receptor (OP 1)

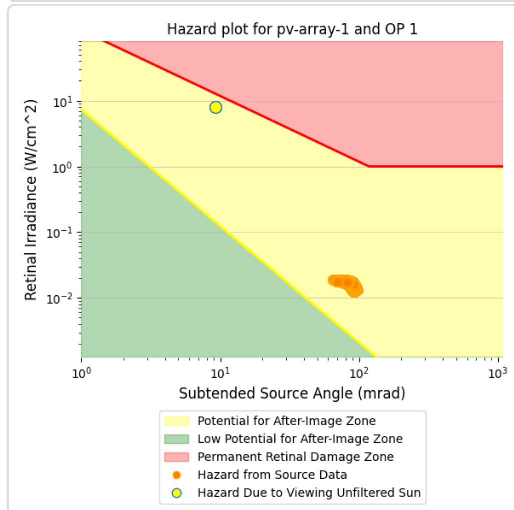
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,894 minutes of "yellow" glare with potential to cause temporary after-image.





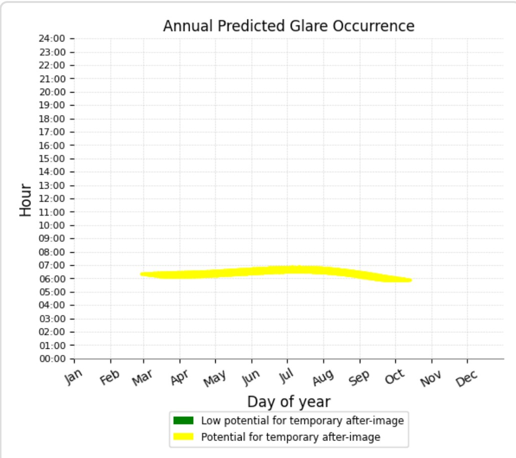


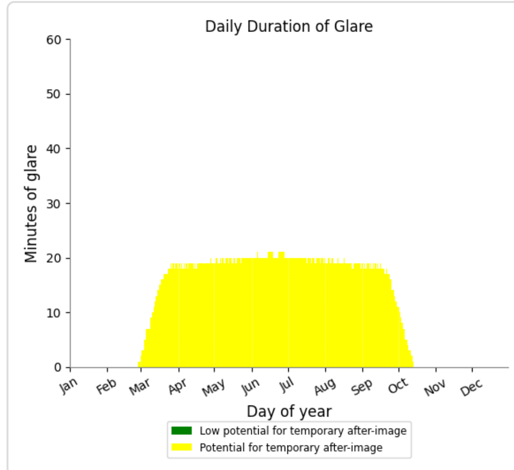


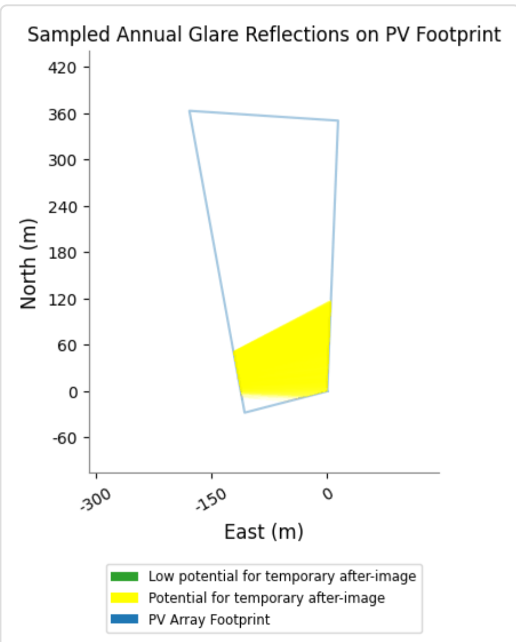
PV array 1 - OP Receptor (OP 2)

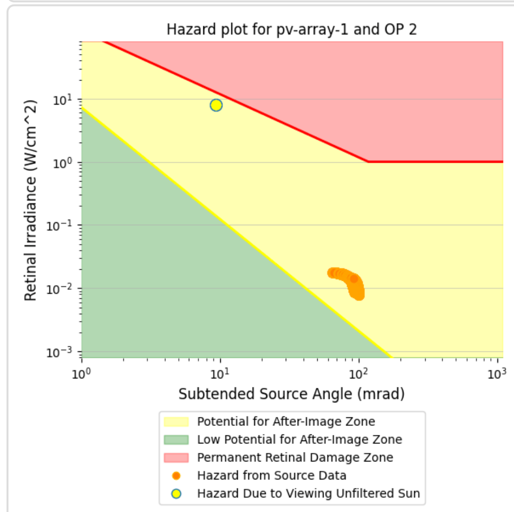
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,977 minutes of "yellow" glare with potential to cause temporary after-image.





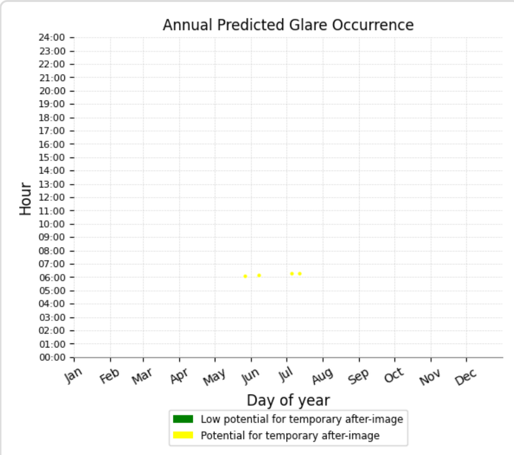


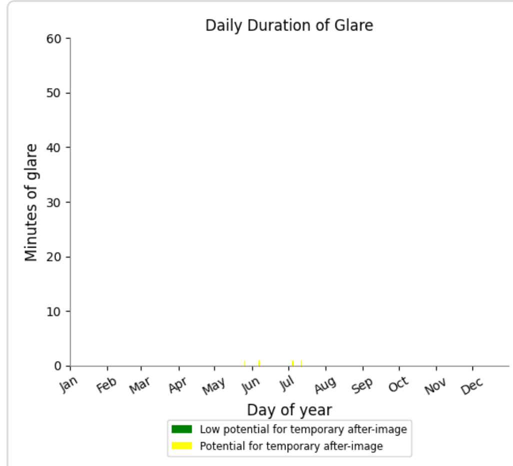


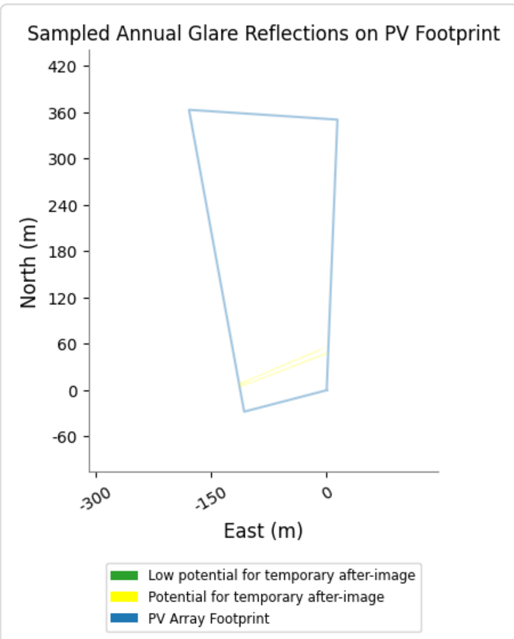
PV array 1 - OP Receptor (OP 3)

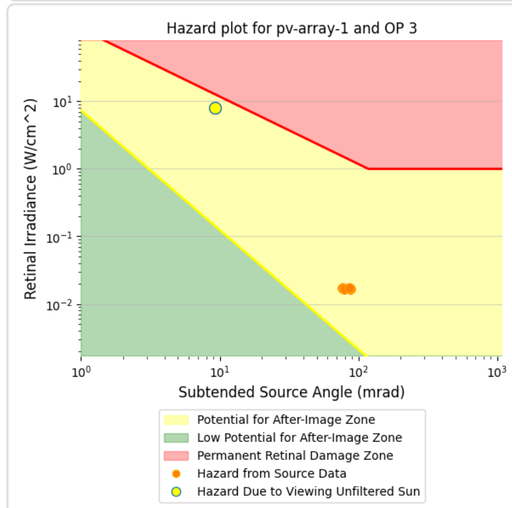
PV array is expected to produce the following glare for receptors at this location:

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





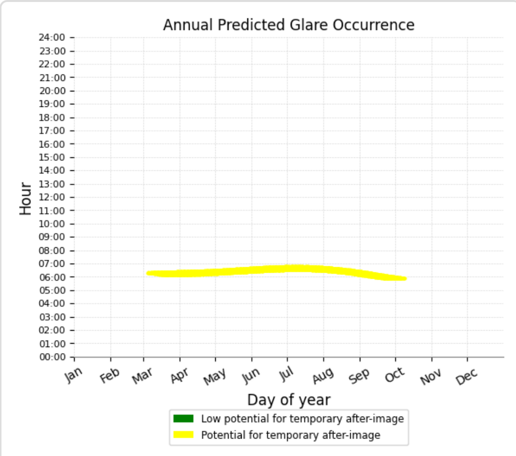


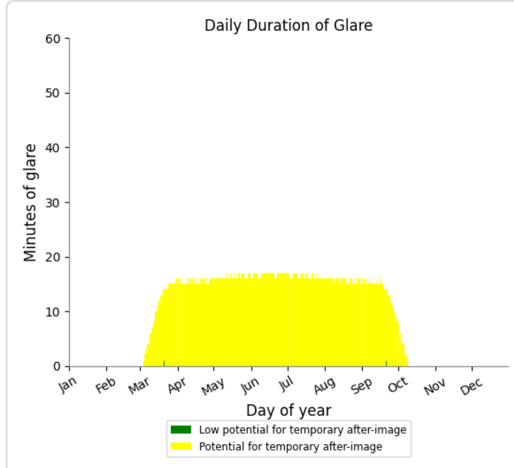


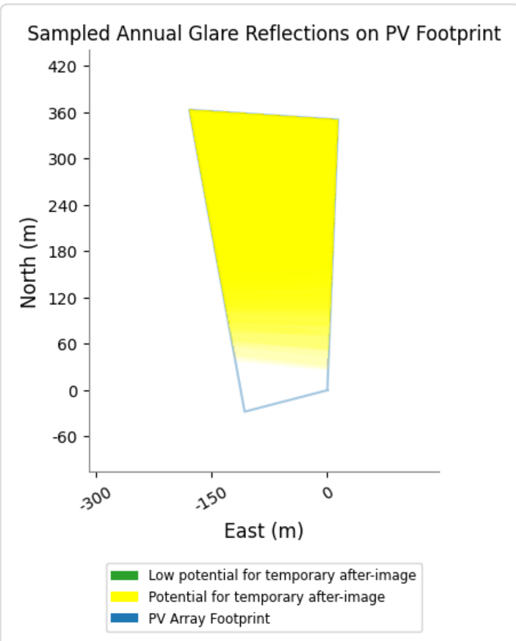
PV array 1 - OP Receptor (OP 4)

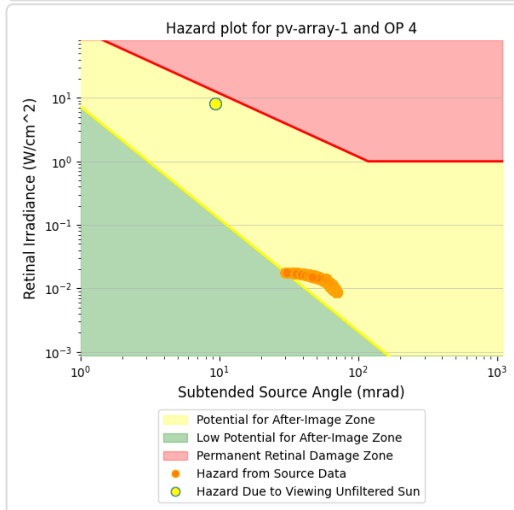
PV array is expected to produce the following glare for receptors at this location:

- 2 minutes of "green" glare with low potential to cause temporary after-image.
- 3,213 minutes of "yellow" glare with potential to cause temporary after-image.





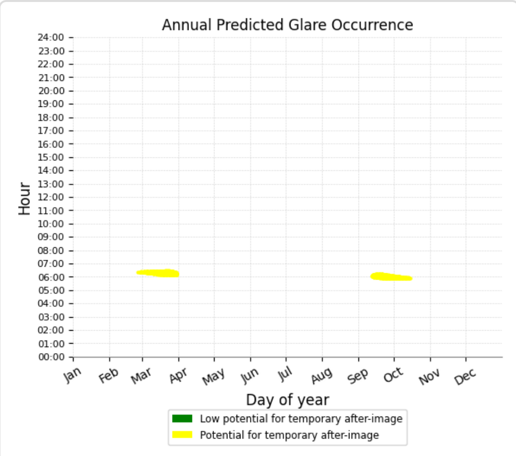


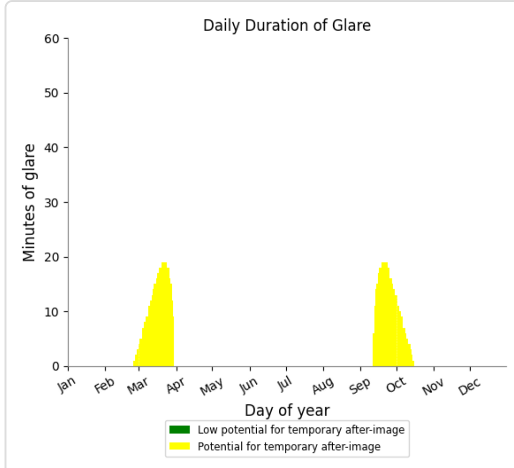


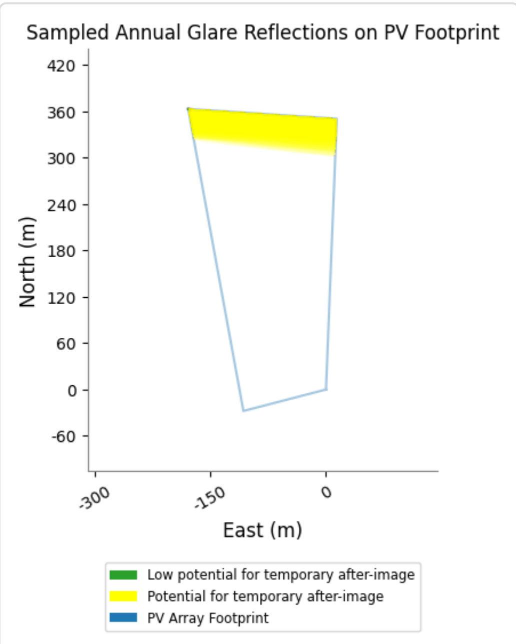
PV array 1 - OP Receptor (OP 5)

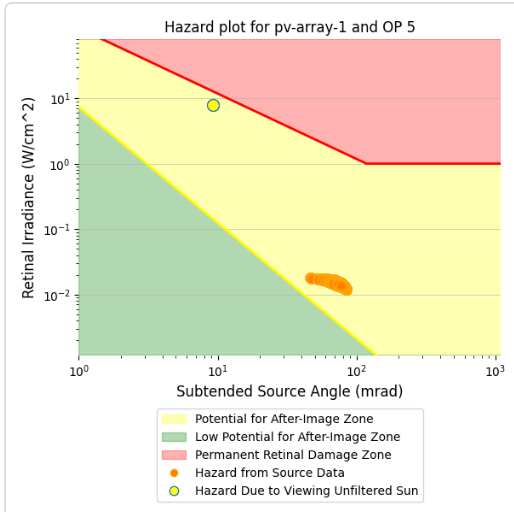
PV array is expected to produce the following glare for receptors at this location:

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





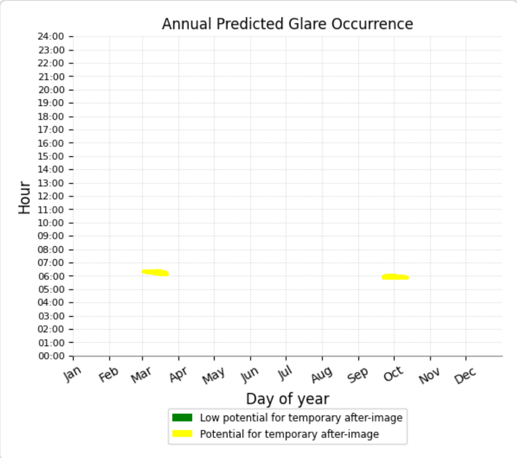


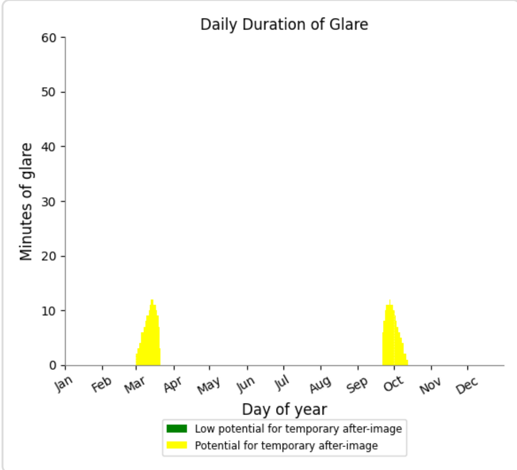


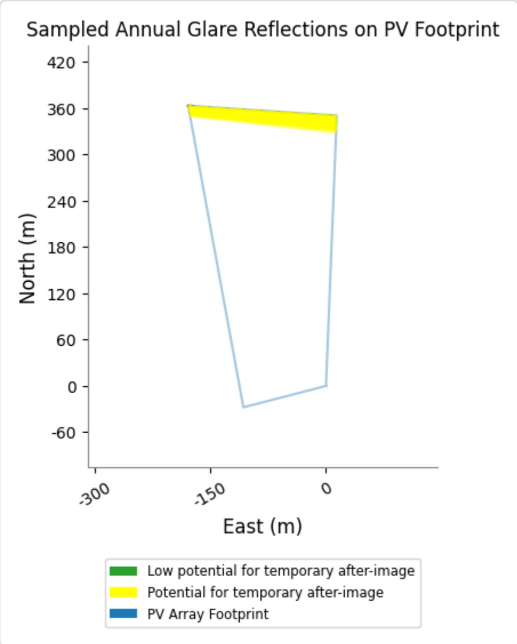
PV array 1 - OP Receptor (OP 6)

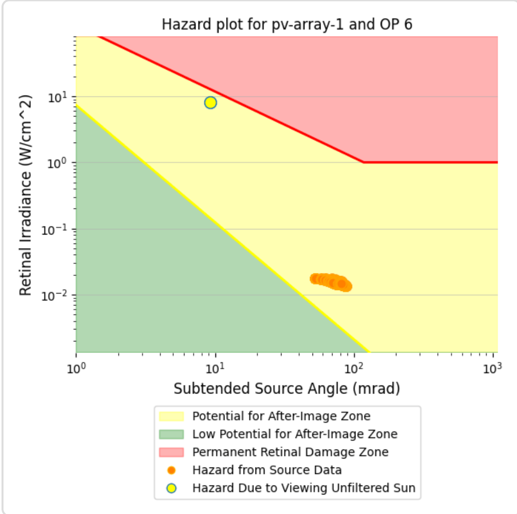
PV array is expected to produce the following glare for receptors at this location:

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









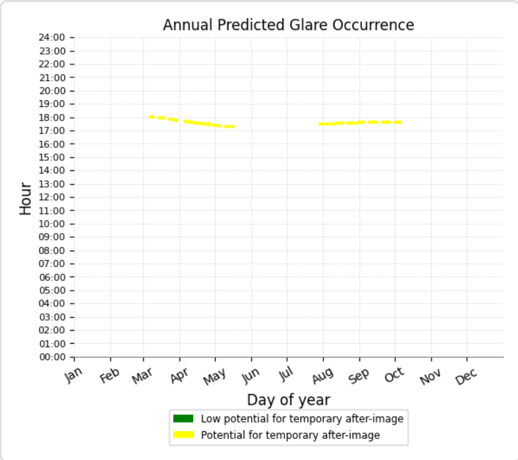
PV array 1 - OP Receptor (OP 7)

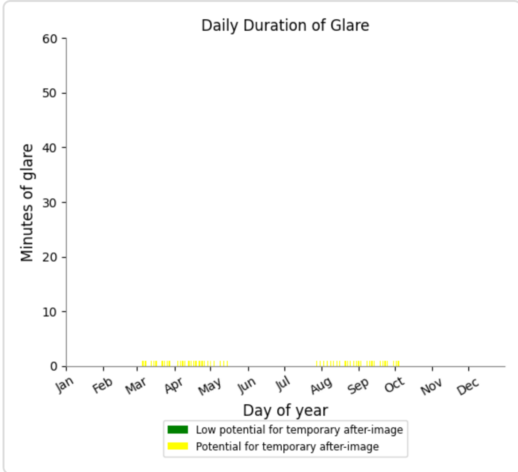
No glare found

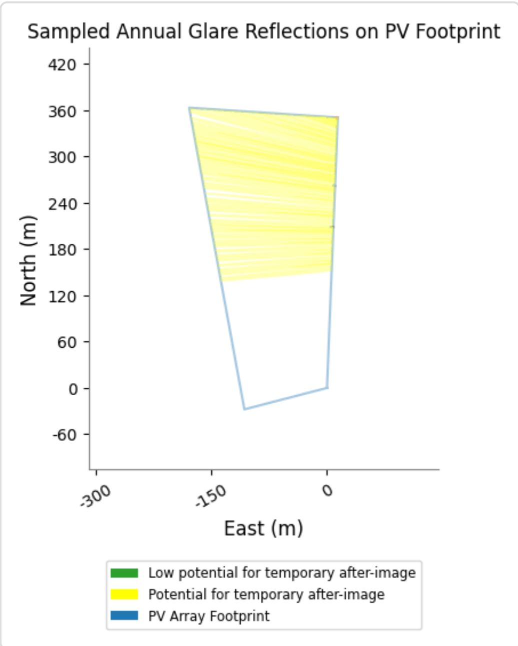
PV array 1 - OP Receptor (OP 8)

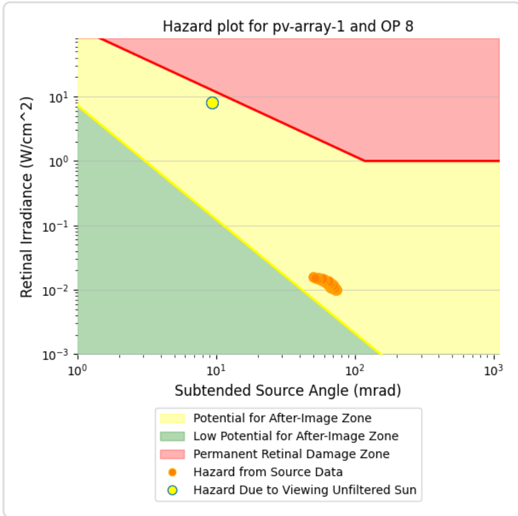
PV array is expected to produce the following glare for receptors at this location:

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





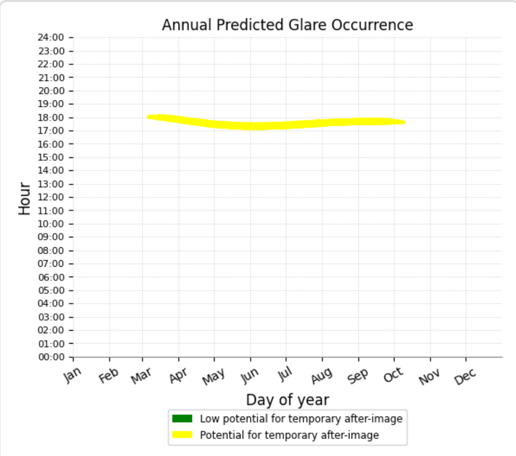


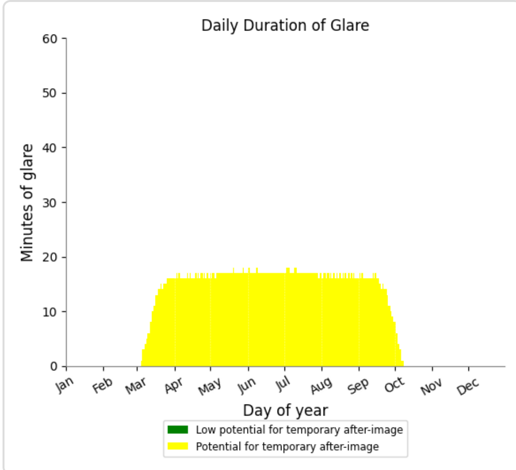


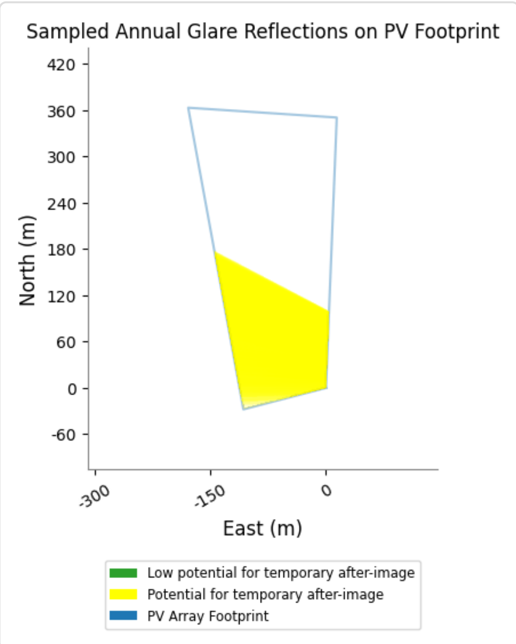
PV array 1 - OP Receptor (OP 9)

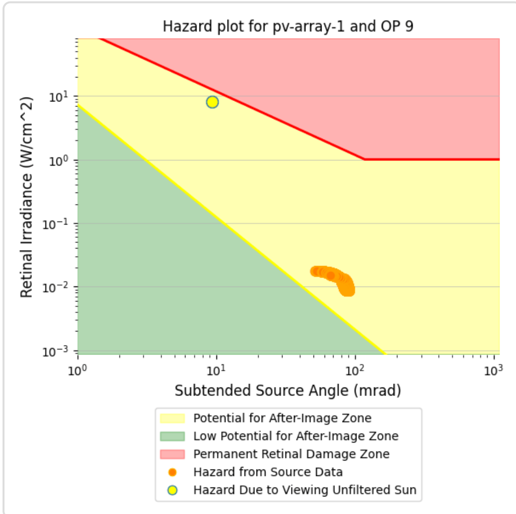
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,345 minutes of "yellow" glare with potential to cause temporary after-image.









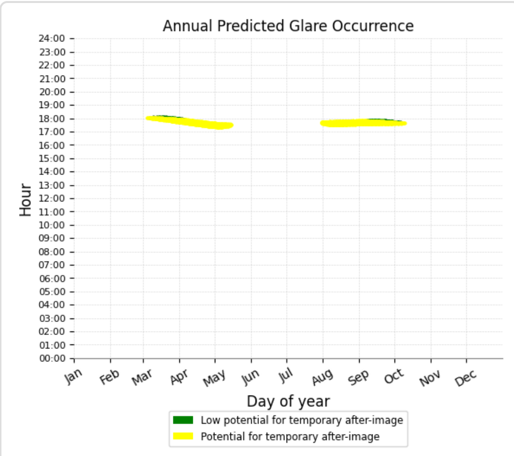
PV array 1 - OP Receptor (OP 10)

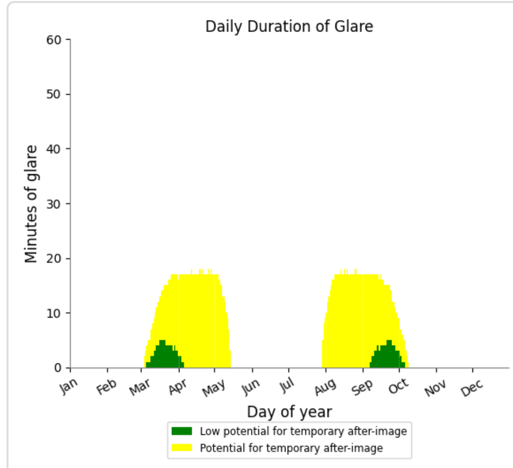
No glare found

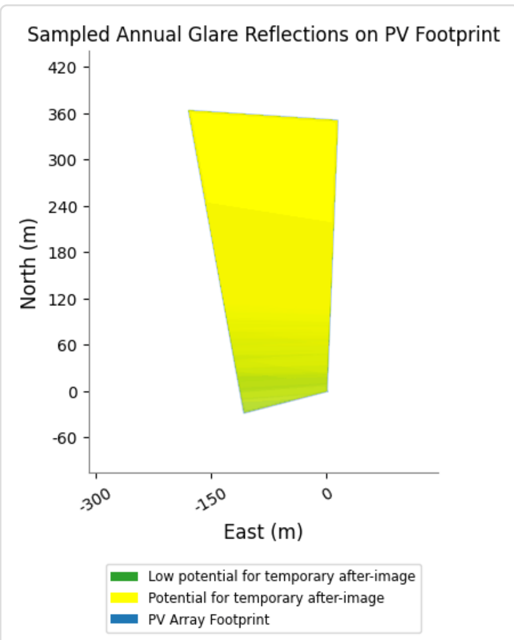
PV array 1 - OP Receptor (11-ATCT)

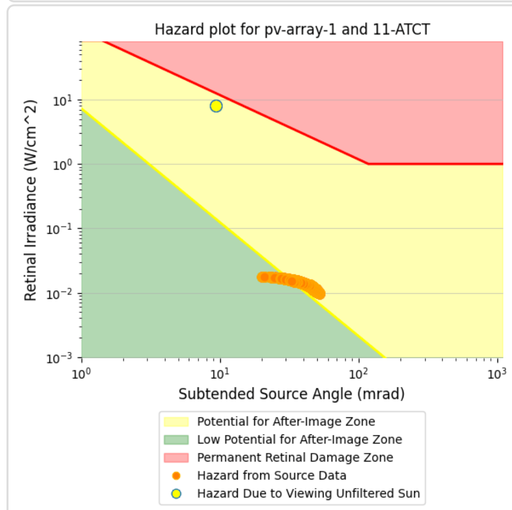
PV array is expected to produce the following glare for receptors at this location:

- 193 minutes of "green" glare with low potential to cause temporary after-image.
- 1,850 minutes of "yellow" glare with potential to cause temporary after-image.





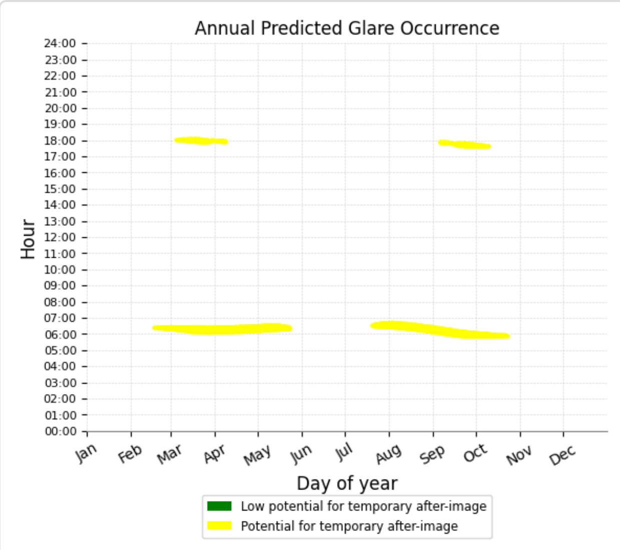


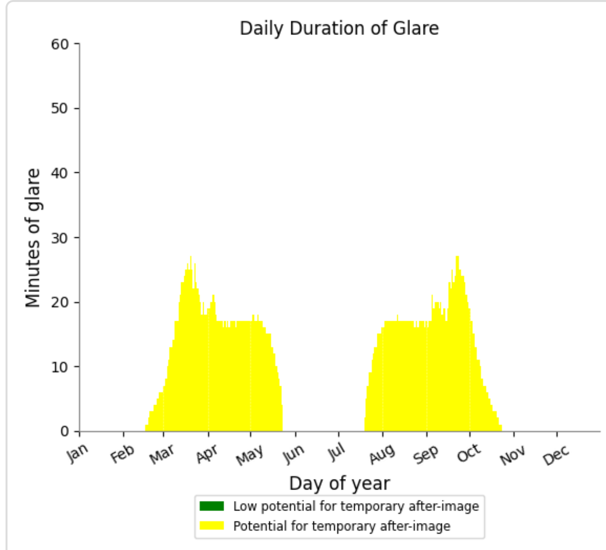


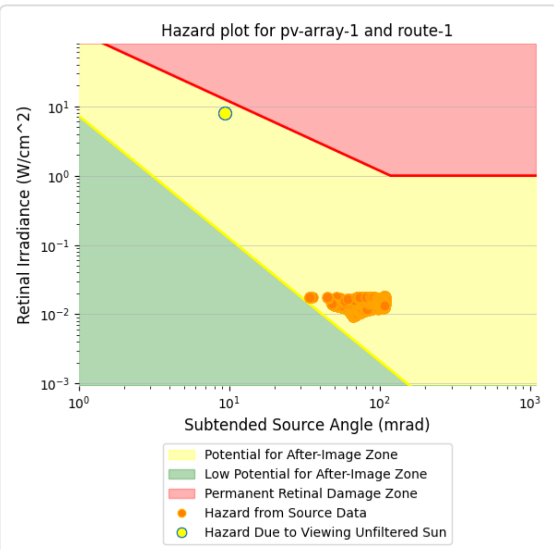
PV array 1 - Route Receptor (Route 1)

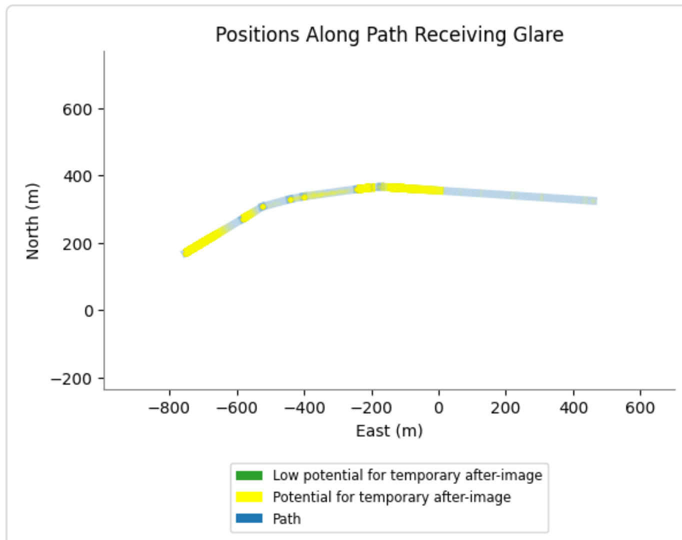
PV array is expected to produce the following glare for receptors at this location:

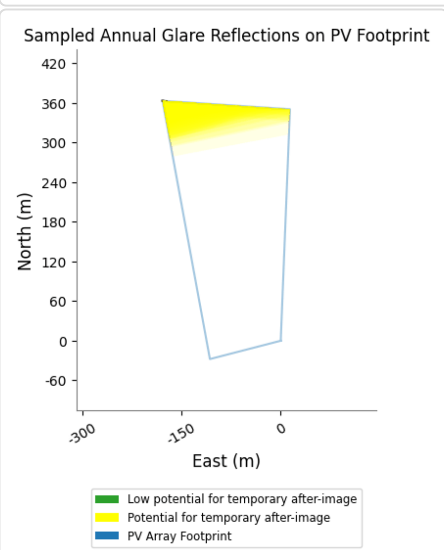
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,937 minutes of "yellow" glare with potential to cause temporary after-image.











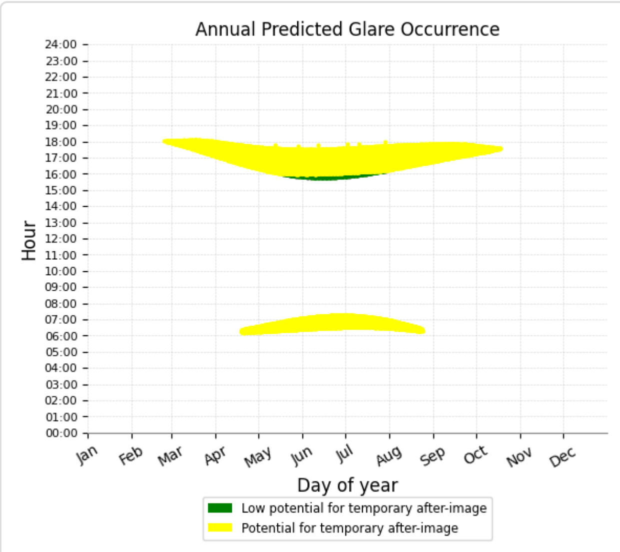
PV array 1 - Route Receptor (Route 2)

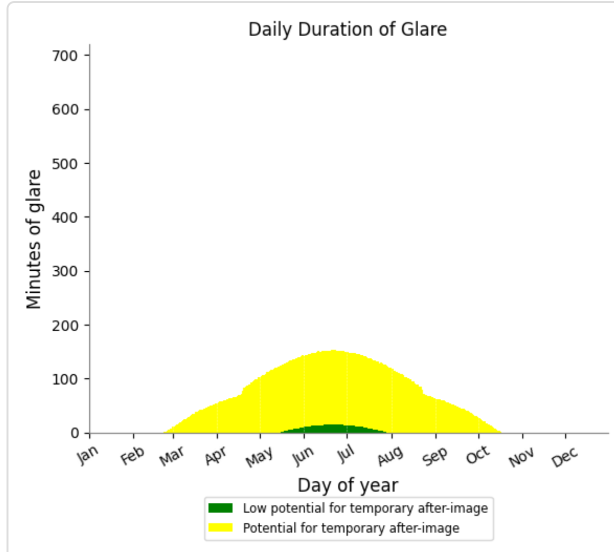
No glare found

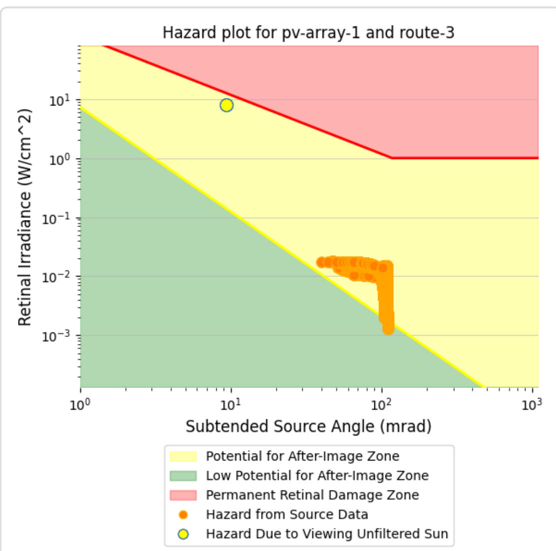
PV array 1 - Route Receptor (Route 3)

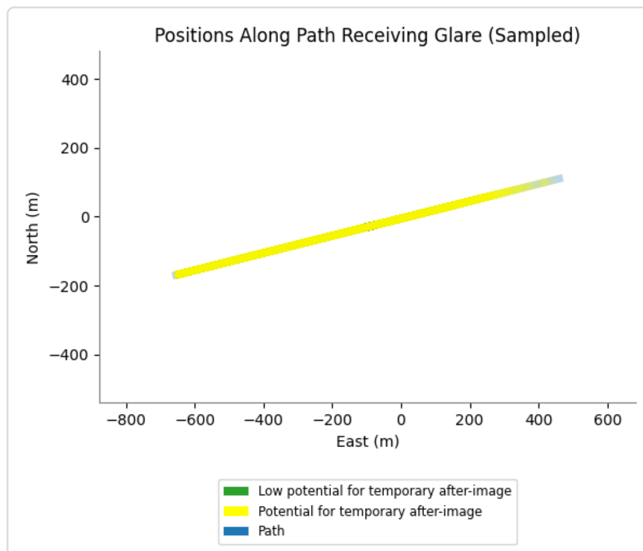
PV array is expected to produce the following glare for receptors at this location:

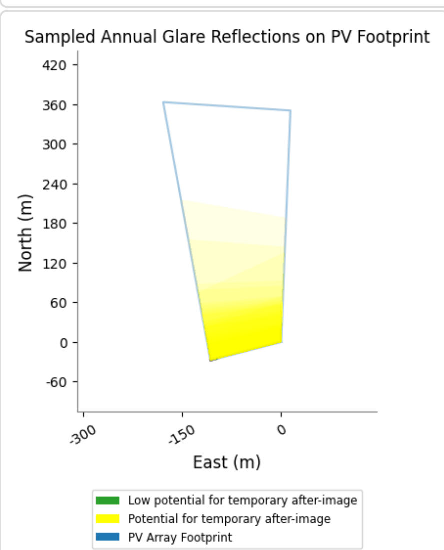
- 750 minutes of "green" glare with low potential to cause temporary after-image.
- 19,767 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

BNTCL 5MW PV Farm

BNTCL_Smooth_no ARC_2FP

Client: BNOCL

Created May 12, 2022
Updated May 12, 2022
Time-step 1 minute
Timezone offset UTC-4
Site ID 68999.9238

Project type Advanced
Project status: active
Category 500 kW to 1 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

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

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	15.0	180.0	3,051	34,104	-

Component Data

PV Array(s)

Total PV footprint area: 55,735 m^2

Name: PV array 1
Footprint area: 55,735 m^2
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Smooth glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 6.55 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.077475	-59.499126	58.00	1.46	59.46
2	13.080642	-59.498997	63.41	1.46	64.87
3	13.080757	-59.500772	66.29	1.46	67.75
4	13.077224	-59.500113	56.11	1.46	57.57

2-Mile Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height : 15 m
Direction: 76.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.071136	-59.506635	55.44	15.24	70.68
2-mile point	13.064416	-59.535538	24.28	215.08	239.36

Name: FP 2
Description:
Threshold height : 15 m
Direction: 255.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.078052	-59.478343	50.40	15.24	65.64
2-mile point	13.085227	-59.449555	0.00	234.33	234.33

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.079016	-59.506061	72.47	1.20	73.67
2	13.079935	-59.504484	71.15	1.20	72.35
3	13.080259	-59.503947	70.90	1.20	72.10
4	13.080458	-59.503196	70.27	1.20	71.47
5	13.080531	-59.502821	68.56	1.20	69.76
6	13.080730	-59.501351	67.09	1.20	68.29
7	13.080792	-59.500707	66.37	1.20	67.57
8	13.080416	-59.494892	61.43	1.20	62.63

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.080677	-59.498926	63.60	1.20	64.80
2	13.077438	-59.499033	58.00	1.20	59.20

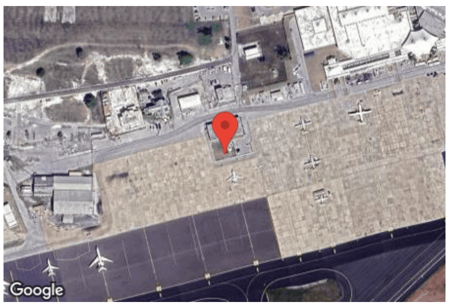
Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.075943	-59.505159	59.58	1.20	60.78
2	13.078472	-59.494881	59.60	1.20	60.80

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.077496	-59.501009	57.30	1.80	59.10
OP 2	13.077512	-59.501075	57.37	4.80	62.17
OP 3	13.077115	-59.501228	56.95	1.80	58.75
OP 4	13.078485	-59.505356	66.60	1.80	68.40
OP 5	13.080724	-59.502755	69.48	4.80	74.28
OP 6	13.080834	-59.502181	69.03	1.80	70.83
OP 7	13.080938	-59.499847	65.40	1.80	67.20
OP 8	13.079259	-59.495156	62.01	1.80	63.81
OP 9	13.077482	-59.497366	57.46	4.80	62.26
OP 10	13.076482	-59.499246	57.87	1.80	59.67
11-ATCT	13.078125	-59.490296	56.37	22.00	78.37

11-ATCT map image



Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	15.0	180.0	3,051	34,104	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	0	98	23	0	0	0	0	0
pv-array-1 (yellow)	0	26	1337	2640	3987	4511	4380	3159	1874	292	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

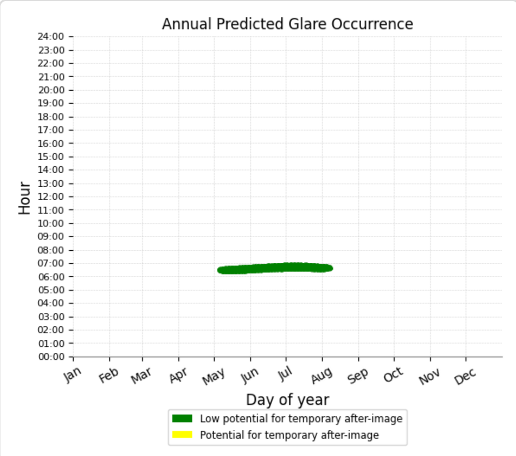
PV array 1 potential temporary after-image

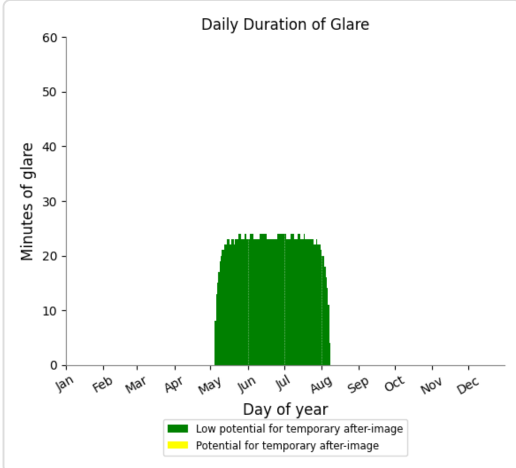
Component	Green glare (min)	Yellow glare (min)
FP: FP 1	2113	0
FP: FP 2	780	0
OP: OP 1	0	1669
OP: OP 2	0	3345
OP: OP 3	0	8
OP: OP 4	0	2604
OP: OP 5	0	604
OP: OP 6	0	188
OP: OP 7	0	0
OP: OP 8	0	49
OP: OP 9	0	2742
OP: OP 10	0	0
OP: 11-ATCT	37	1598
Route: Route 1	0	2284
Route: Route 2	0	0
Route: Route 3	121	19013

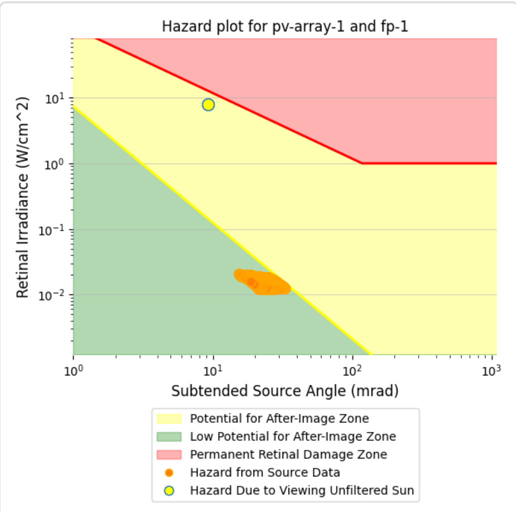
PV array 1 - Receptor (FP 1)

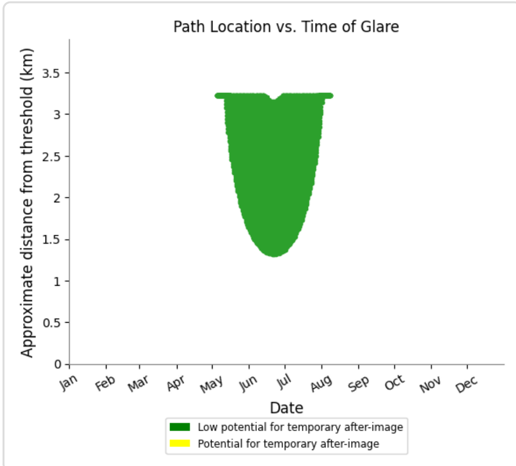
PV array is expected to produce the following glare for observers on this flight path:

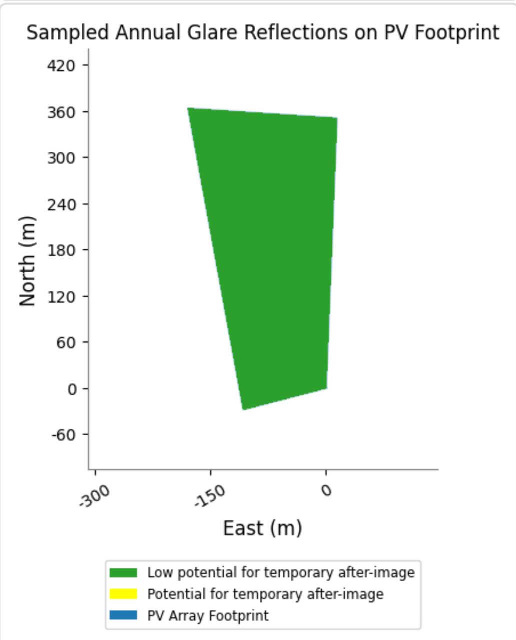
- 2,113 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

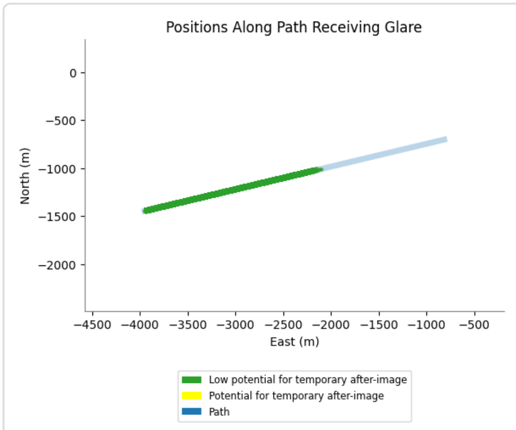








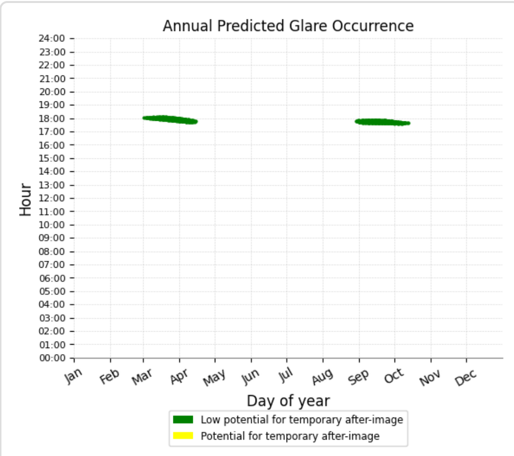


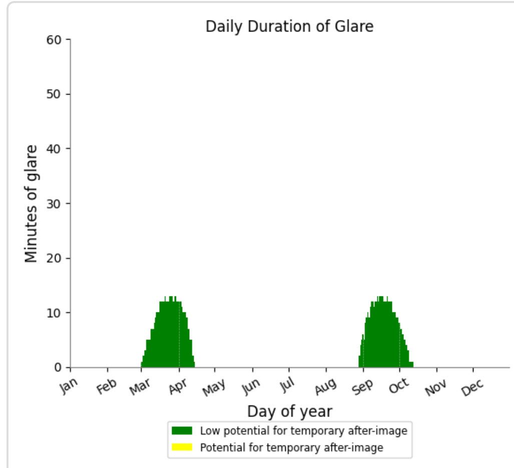


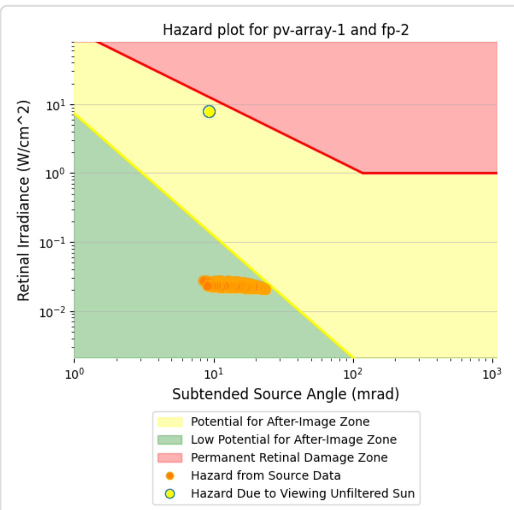
PV array 1 - Receptor (FP 2)

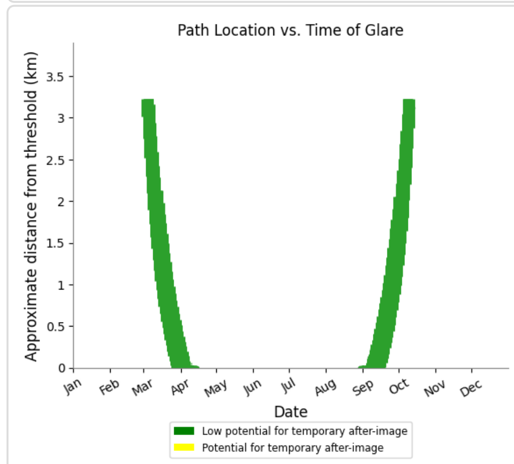
PV array is expected to produce the following glare for observers on this flight path:

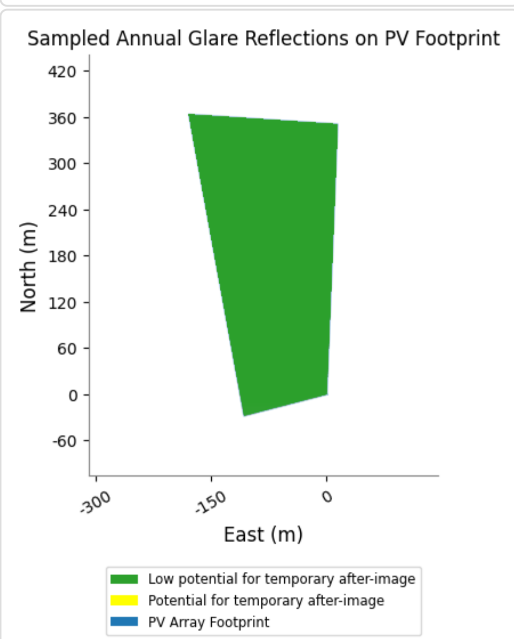
- 780 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

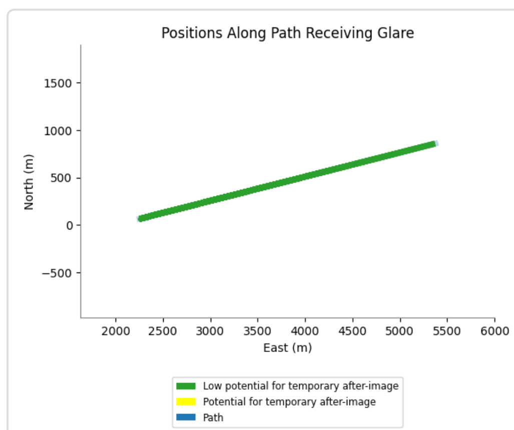








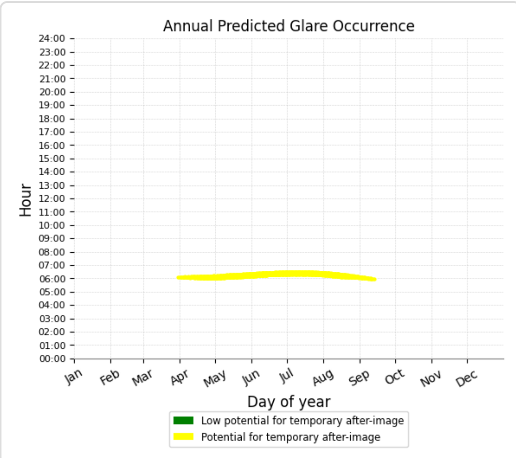


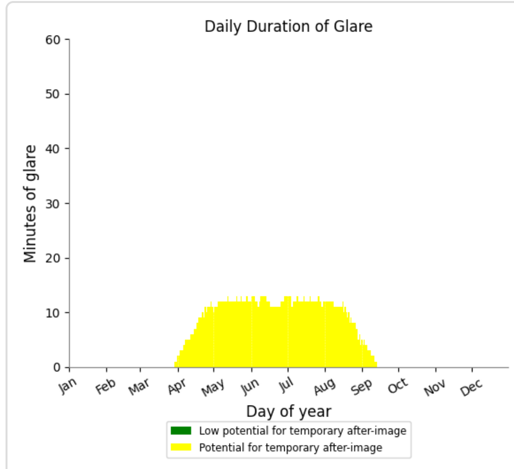


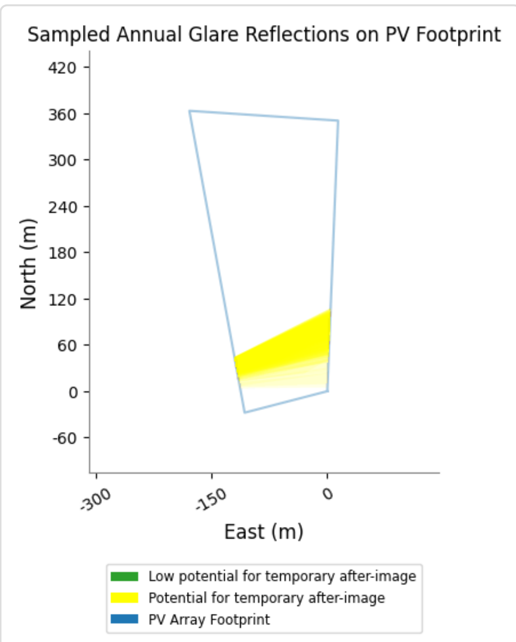
PV array 1 - OP Receptor (OP 1)

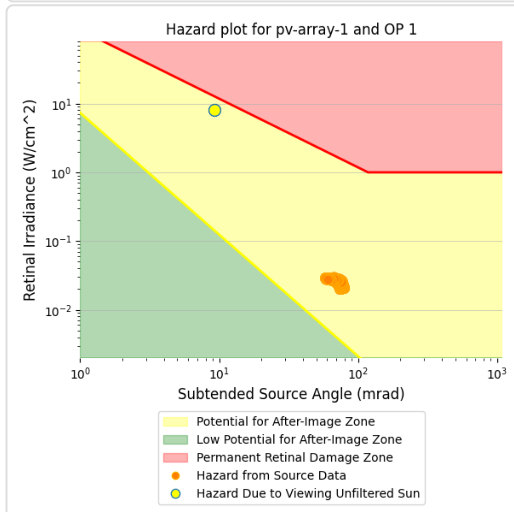
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,669 minutes of "yellow" glare with potential to cause temporary after-image.





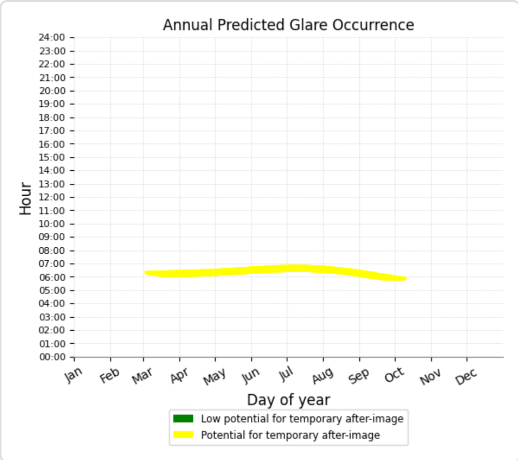


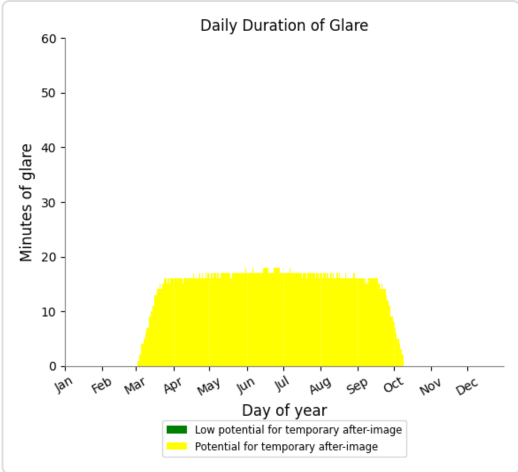


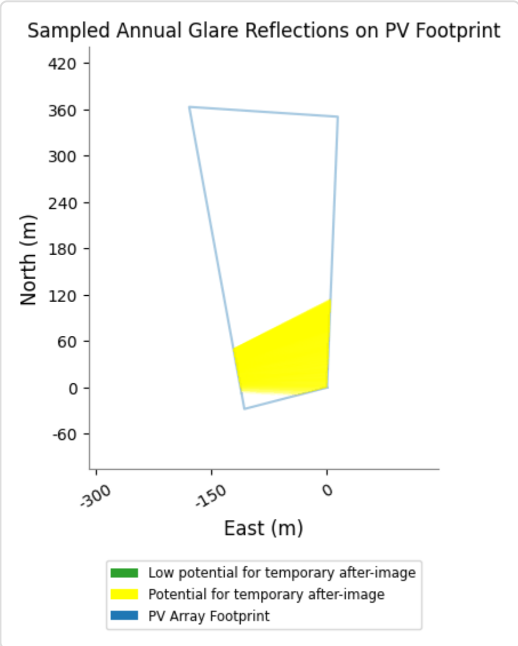
PV array 1 - OP Receptor (OP 2)

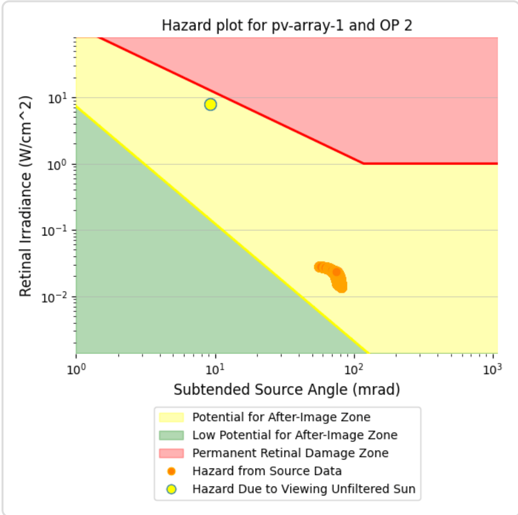
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,345 minutes of "yellow" glare with potential to cause temporary after-image.





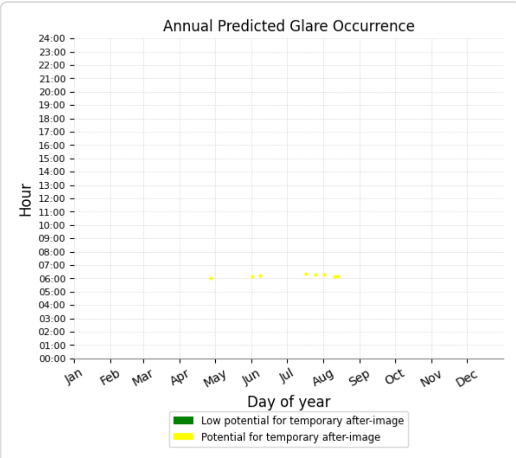


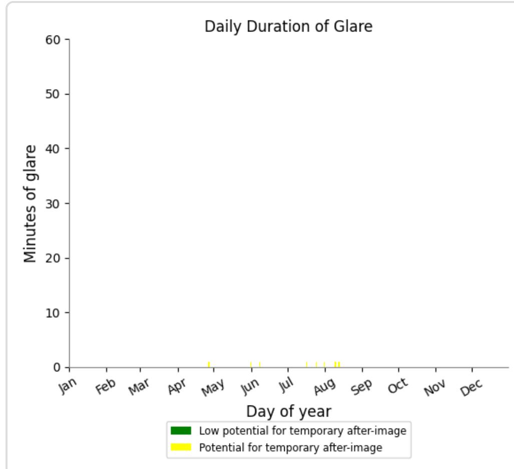


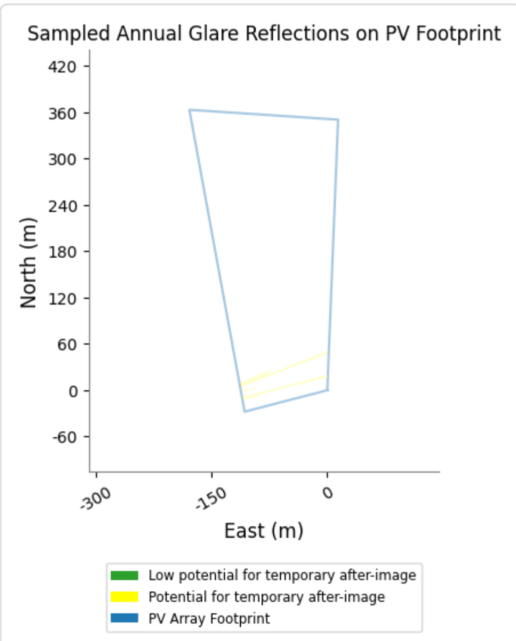
PV array 1 - OP Receptor (OP 3)

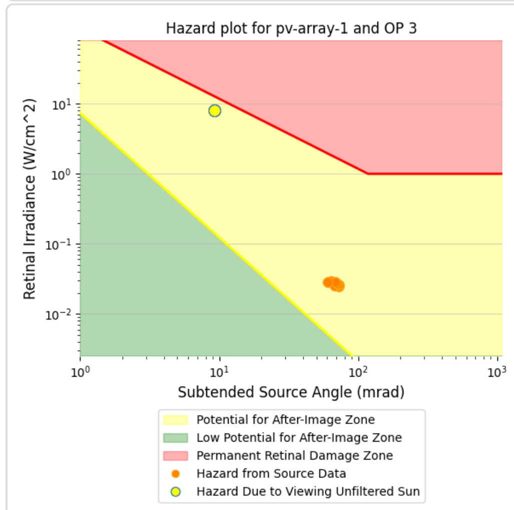
PV array is expected to produce the following glare for receptors at this location:

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





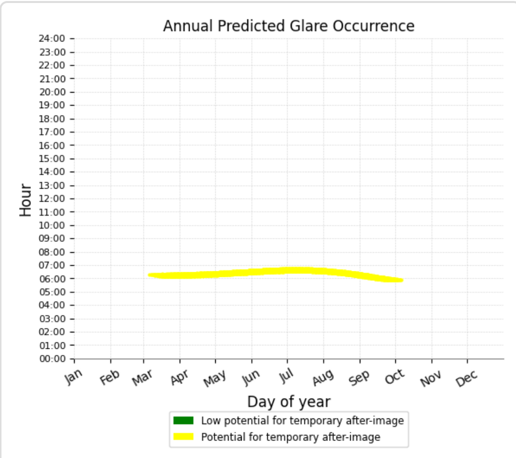


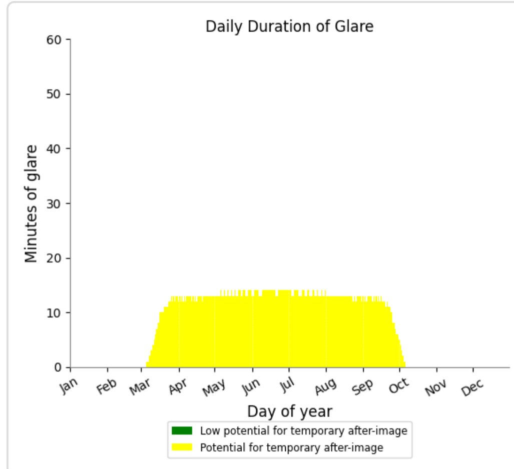


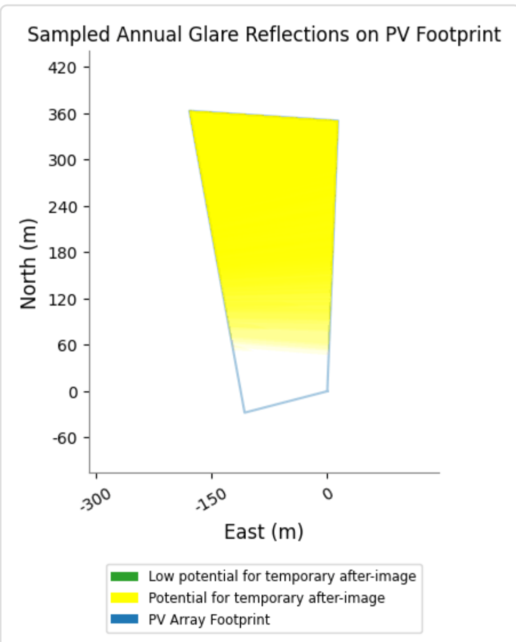
PV array 1 - OP Receptor (OP 4)

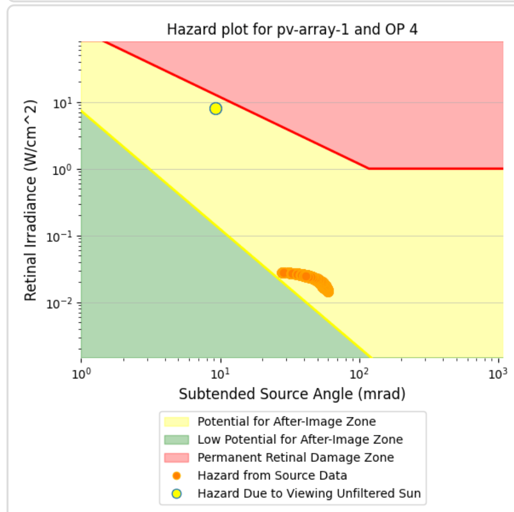
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,604 minutes of "yellow" glare with potential to cause temporary after-image.





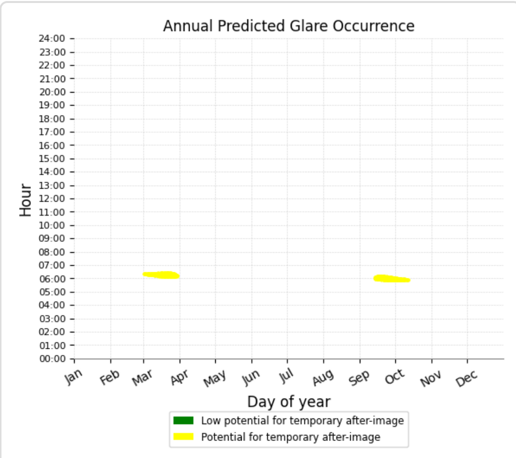


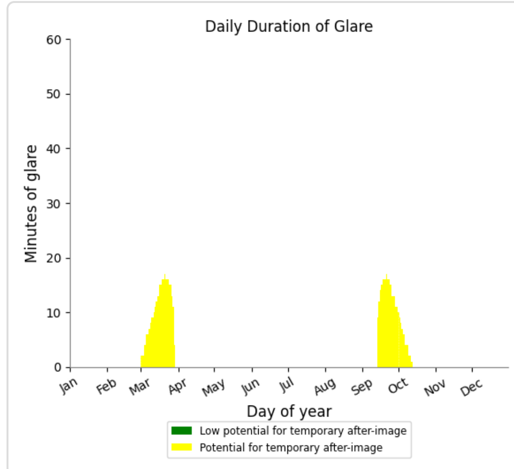


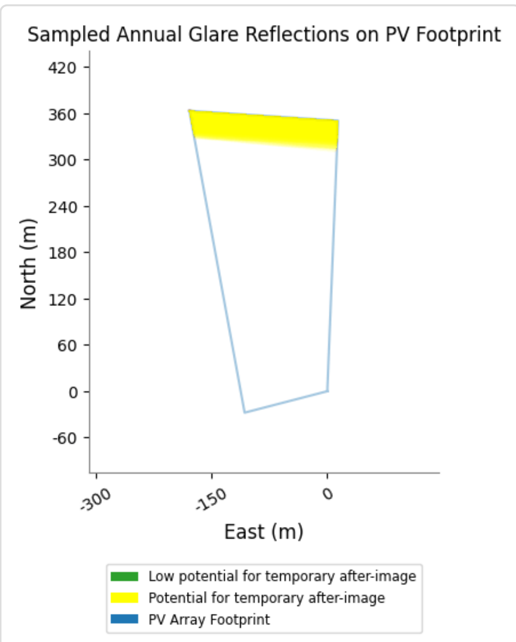
PV array 1 - OP Receptor (OP 5)

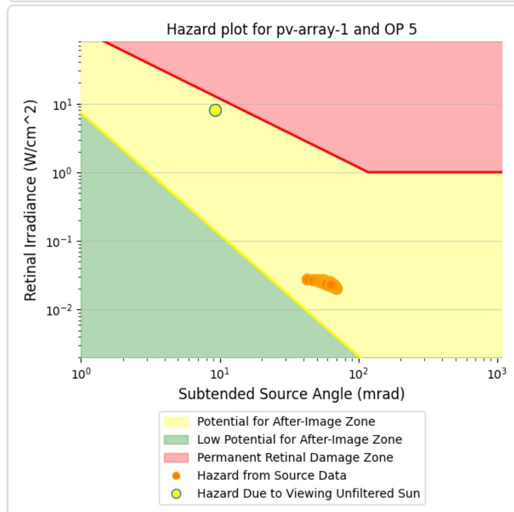
PV array is expected to produce the following glare for receptors at this location:

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





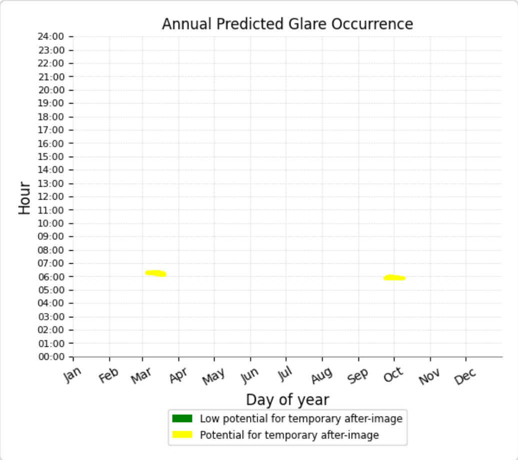


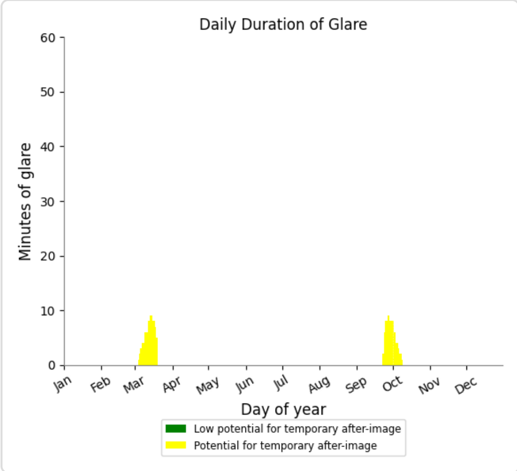


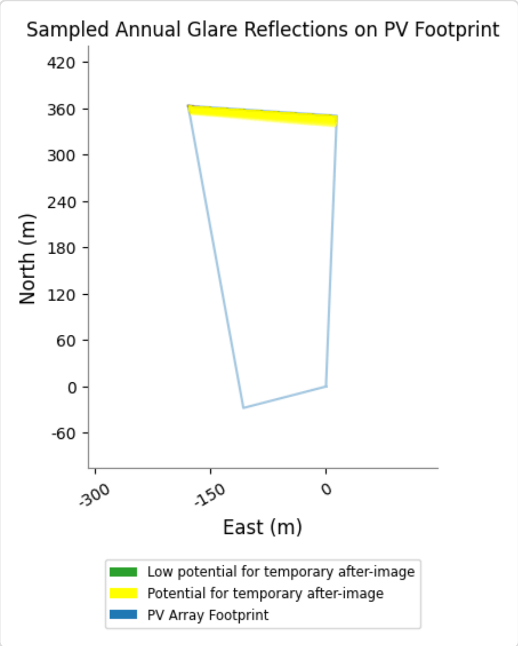
PV array 1 - OP Receptor (OP 6)

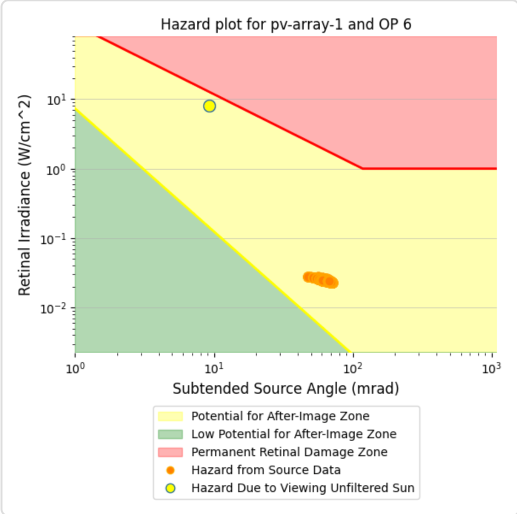
PV array is expected to produce the following glare for receptors at this location:

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









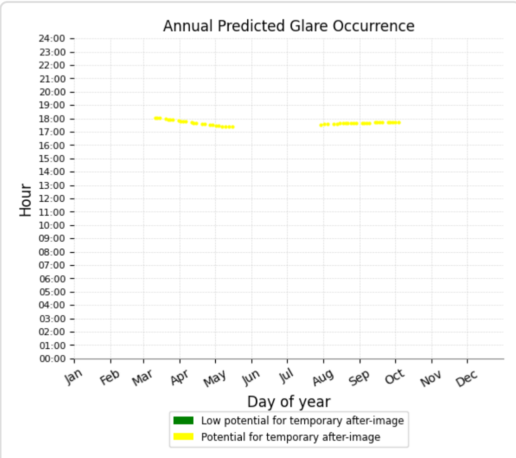
PV array 1 - OP Receptor (OP 7)

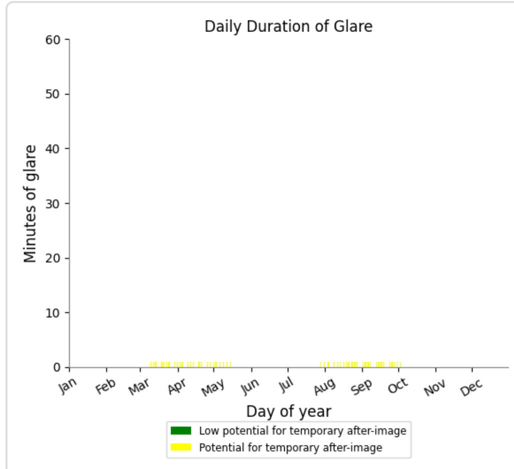
No glare found

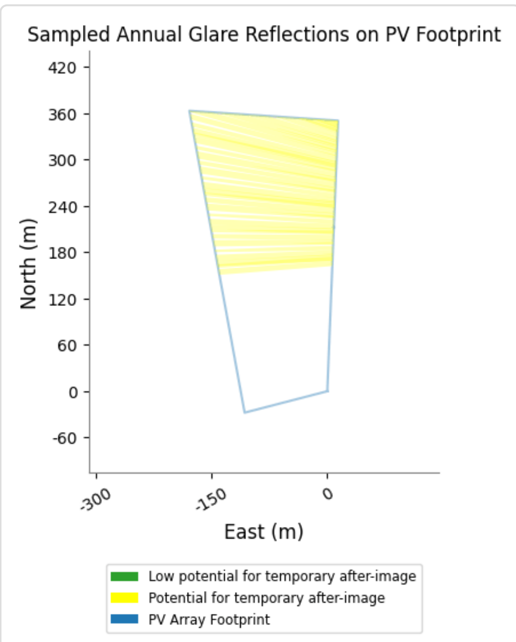
PV array 1 - OP Receptor (OP 8)

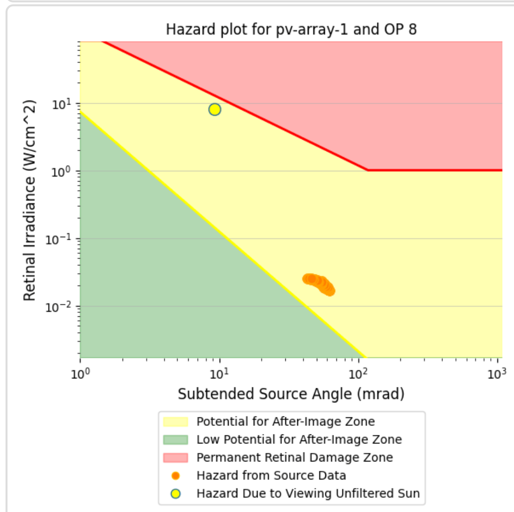
PV array is expected to produce the following glare for receptors at this location:

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





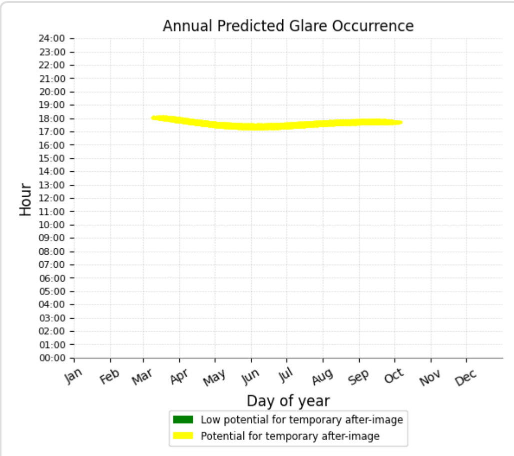


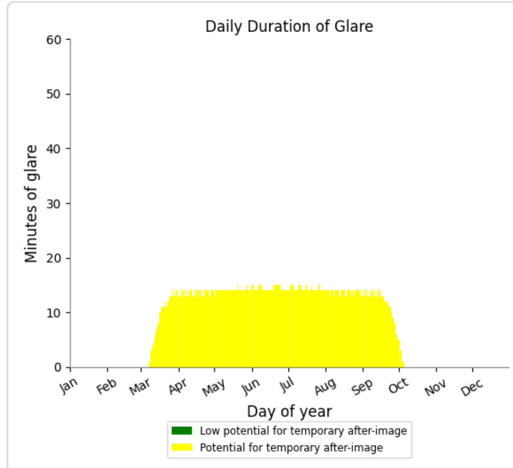


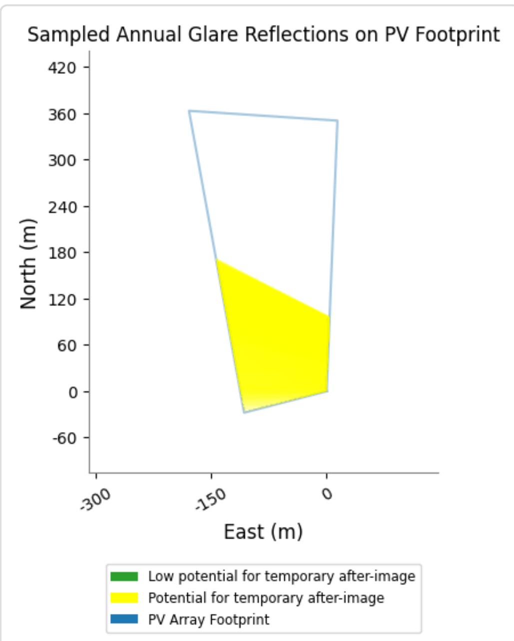
PV array 1 - OP Receptor (OP 9)

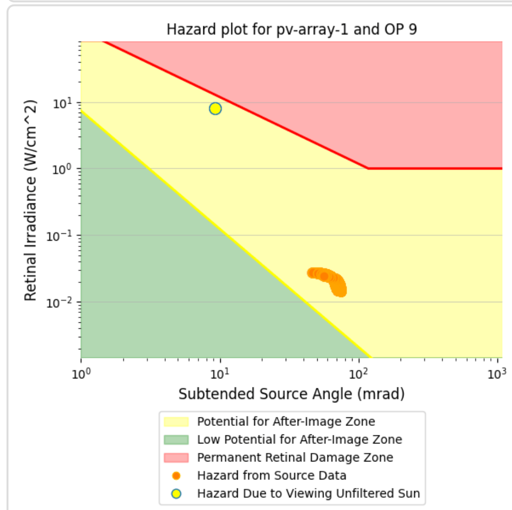
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,742 minutes of "yellow" glare with potential to cause temporary after-image.









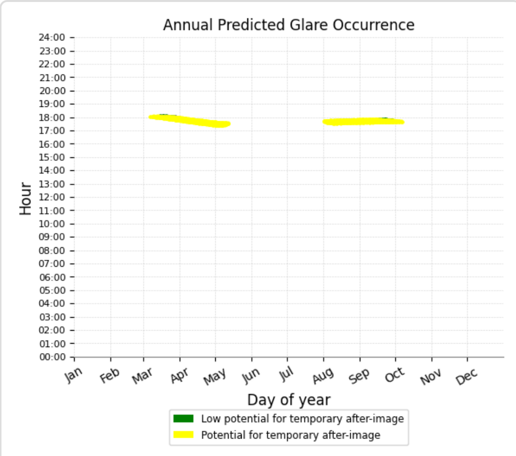
PV array 1 - OP Receptor (OP 10)

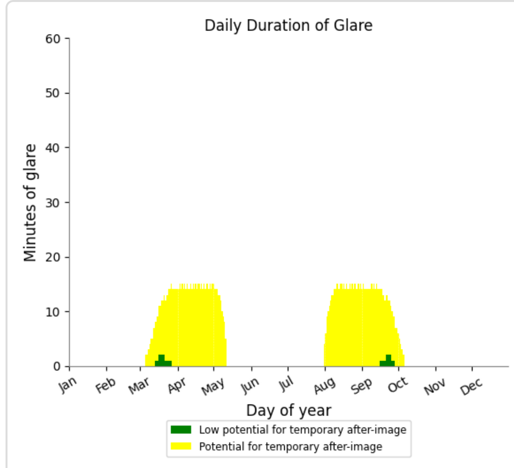
No glare found

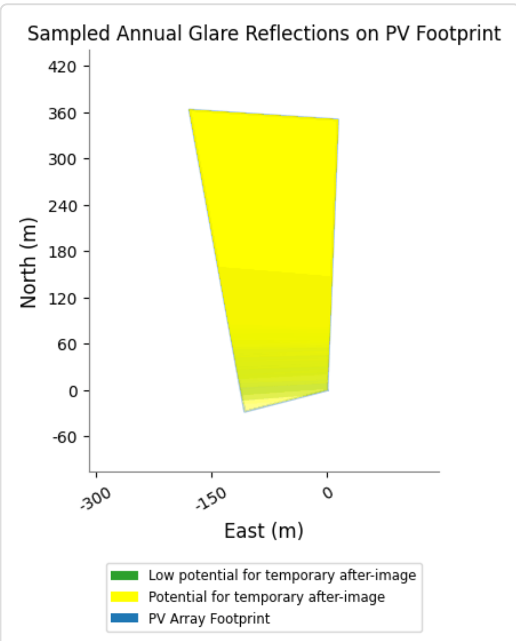
PV array 1 - OP Receptor (11-ATCT)

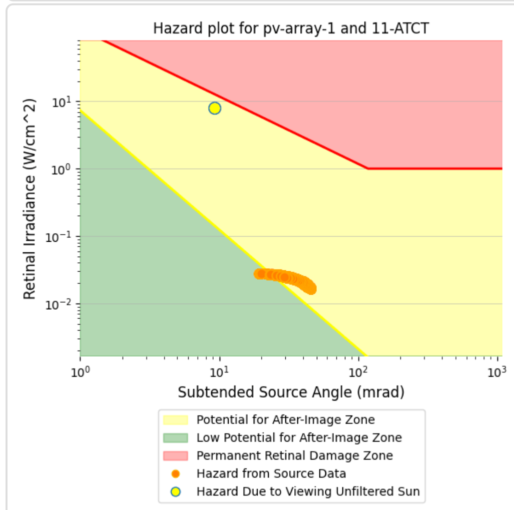
PV array is expected to produce the following glare for receptors at this location:

- 37 minutes of "green" glare with low potential to cause temporary after-image.
- 1,598 minutes of "yellow" glare with potential to cause temporary after-image.





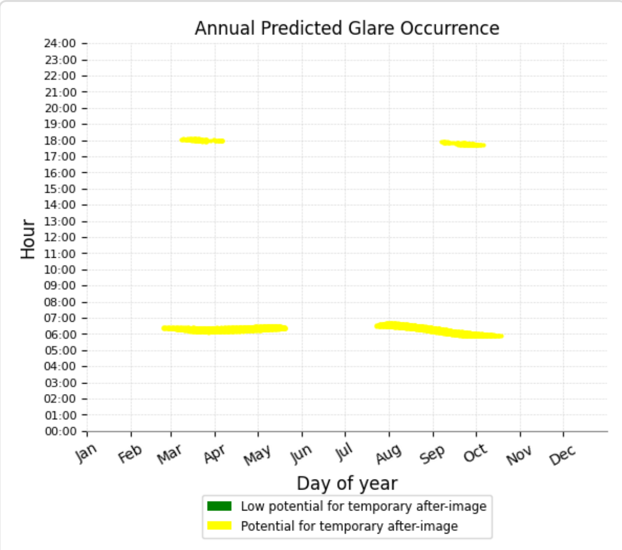


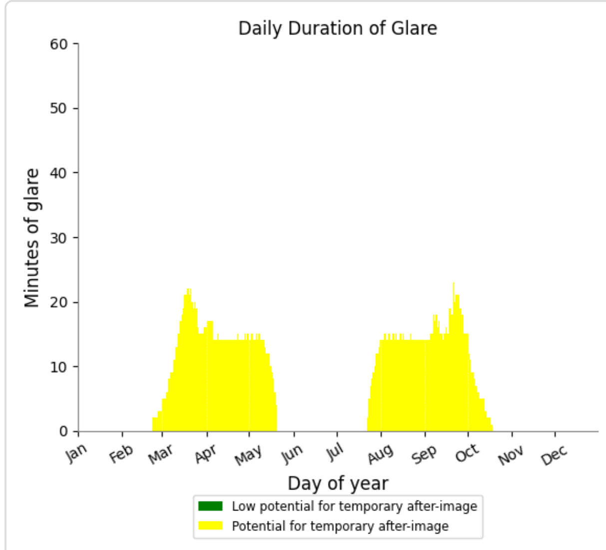


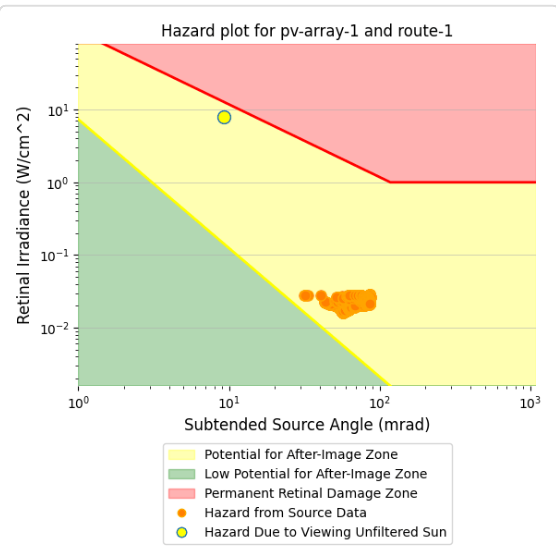
PV array 1 - Route Receptor (Route 1)

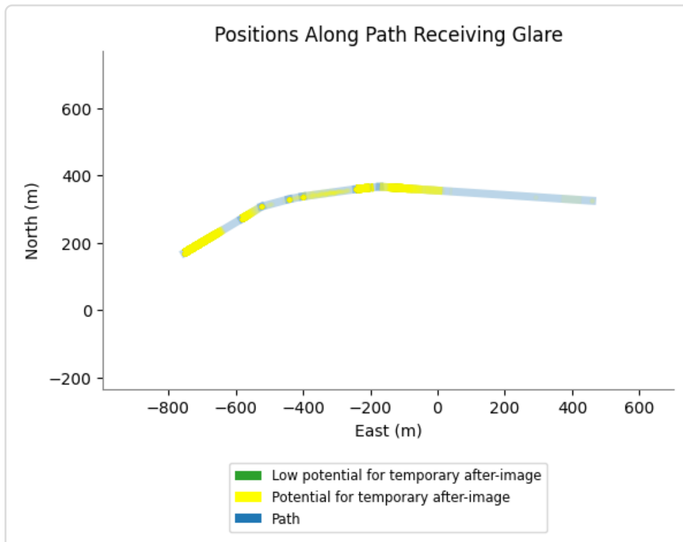
PV array is expected to produce the following glare for receptors at this location:

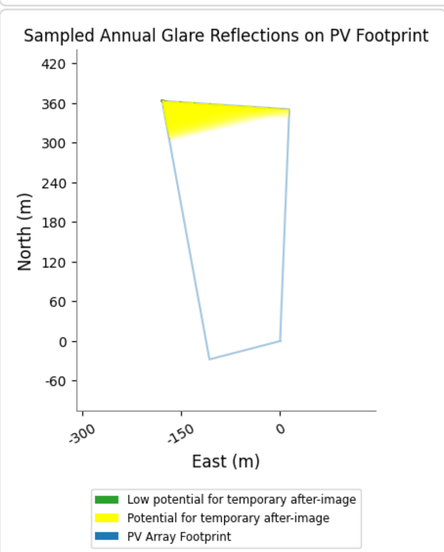
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,284 minutes of "yellow" glare with potential to cause temporary after-image.











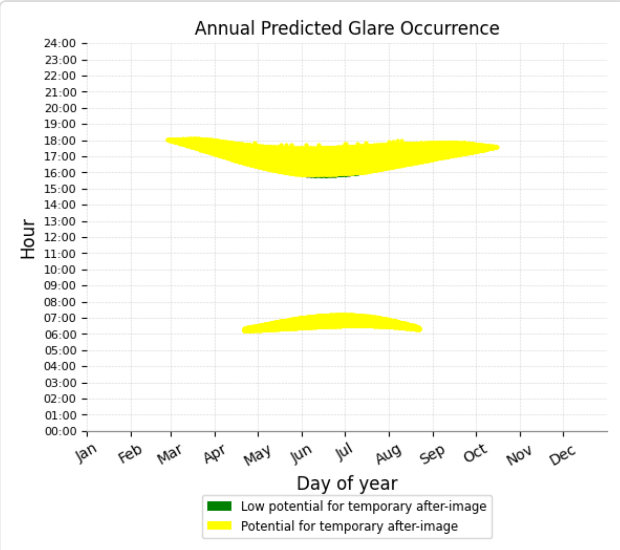
PV array 1 - Route Receptor (Route 2)

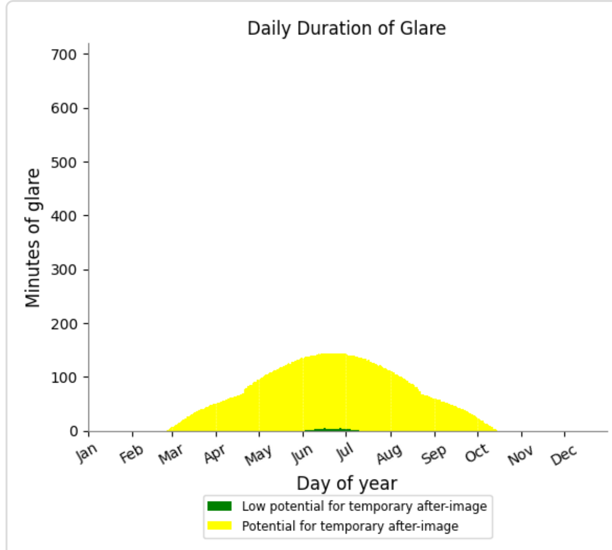
No glare found

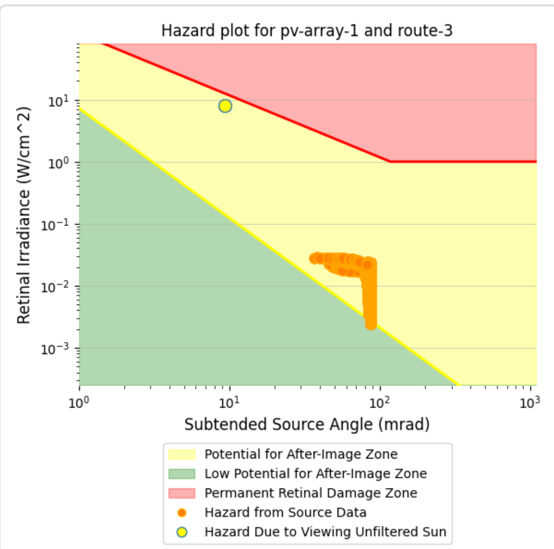
PV array 1 - Route Receptor (Route 3)

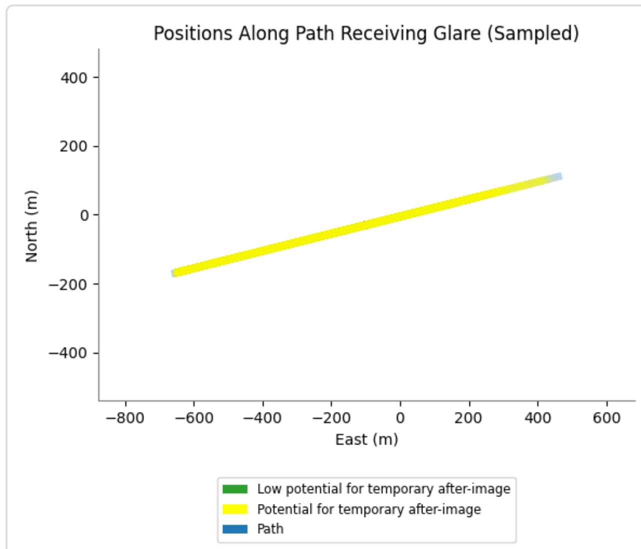
PV array is expected to produce the following glare for receptors at this location:

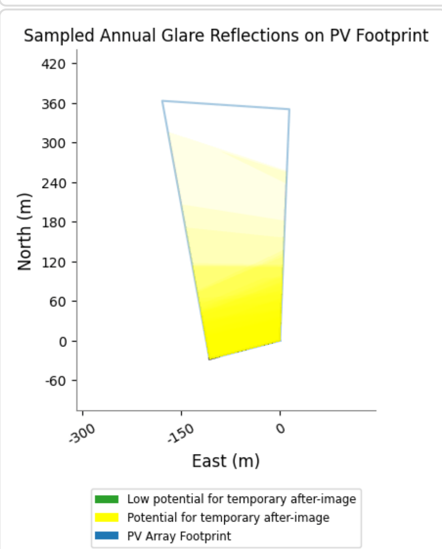
- 121 minutes of "green" glare with low potential to cause temporary after-image.
- 19,013 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

BNTCL 5MW PV Farm

BNTCL_LightlyTextured_ARC_2FP

Client: BNOCL

Created May 12, 2022
Updated May 12, 2022
Time-step 1 minute
Timezone offset UTC-4
Site ID 69001.9238

Project type Advanced
Project status: active
Category 500 kW to 1 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

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

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	15.0	180.0	5,186	39,633	-

Component Data

PV Array(s)

Total PV footprint area: 55,735 m^2

Name: PV array 1
Footprint area: 55,735 m^2
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Light textured glass with AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.16 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.077475	-59.499126	58.00	1.46	59.46
2	13.080642	-59.498997	63.41	1.46	64.87
3	13.080757	-59.500772	66.29	1.46	67.75
4	13.077224	-59.500113	56.11	1.46	57.57

2-Mile Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height : 15 m
Direction: 76.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.071136	-59.506635	55.44	15.24	70.68
2-mile point	13.064416	-59.535538	24.28	215.08	239.36

Name: FP 2
Description:
Threshold height : 15 m
Direction: 255.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.078052	-59.478343	50.40	15.24	65.64
2-mile point	13.085227	-59.449555	0.00	234.33	234.33

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.079016	-59.506061	72.47	1.20	73.67
2	13.079935	-59.504484	71.15	1.20	72.35
3	13.080259	-59.503947	70.90	1.20	72.10
4	13.080458	-59.503196	70.27	1.20	71.47
5	13.080531	-59.502821	68.56	1.20	69.76
6	13.080730	-59.501351	67.09	1.20	68.29
7	13.080792	-59.500707	66.37	1.20	67.57
8	13.080416	-59.494892	61.43	1.20	62.63

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.080677	-59.498926	63.60	1.20	64.80
2	13.077438	-59.499033	58.00	1.20	59.20

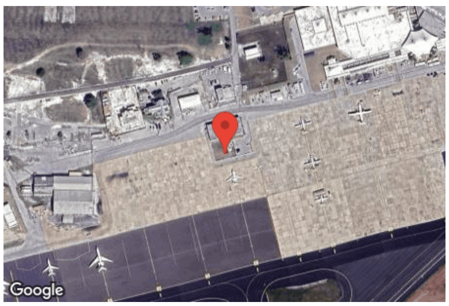
Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.075943	-59.505159	59.58	1.20	60.78
2	13.078472	-59.494881	59.60	1.20	60.80

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.077496	-59.501009	57.30	1.80	59.10
OP 2	13.077512	-59.501075	57.37	4.80	62.17
OP 3	13.077115	-59.501228	56.95	1.80	58.75
OP 4	13.078485	-59.505356	66.60	1.80	68.40
OP 5	13.080724	-59.502755	69.48	4.80	74.28
OP 6	13.080834	-59.502181	69.03	1.80	70.83
OP 7	13.080938	-59.499847	65.40	1.80	67.20
OP 8	13.079259	-59.495156	62.01	1.80	63.81
OP 9	13.077482	-59.497366	57.46	4.80	62.26
OP 10	13.076482	-59.499246	57.87	1.80	59.67
11-ATCT	13.078125	-59.490296	56.37	22.00	78.37

11-ATCT map image



Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array 1	15.0	180.0	5,186	39,633	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	0	0	117	453	271	0	0	0	0	0
pv-array-1 (yellow)	0	95	1598	2897	4295	4613	4583	3458	2135	452	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

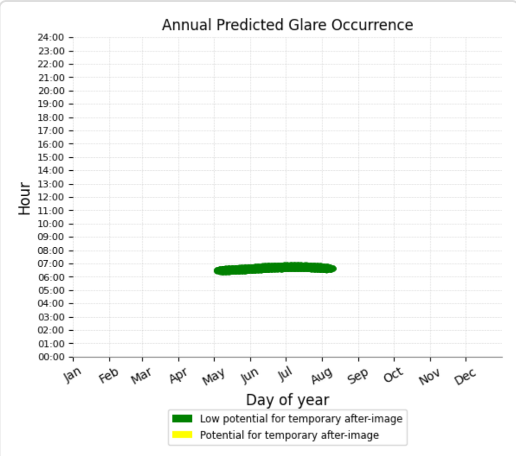
PV array 1 potential temporary after-image

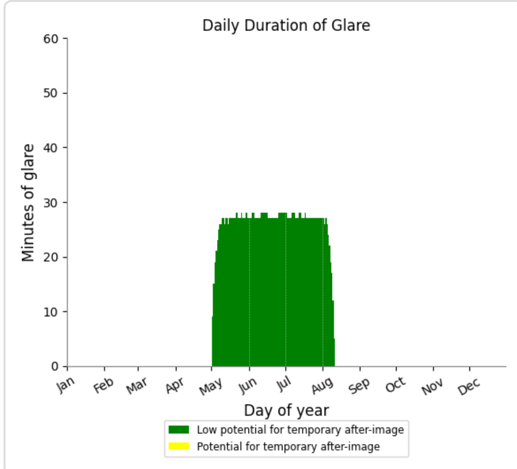
Component	Green glare (min)	Yellow glare (min)
FP: FP 1	2659	0
FP: FP 2	1096	0
OP: OP 1	0	1969
OP: OP 2	0	4228
OP: OP 3	0	9
OP: OP 4	23	3429
OP: OP 5	0	896
OP: OP 6	0	368
OP: OP 7	0	0
OP: OP 8	0	52
OP: OP 9	0	3597
OP: OP 10	0	0
OP: 11-ATCT	567	1646
Route: Route 1	0	3209
Route: Route 2	0	0
Route: Route 3	841	20230

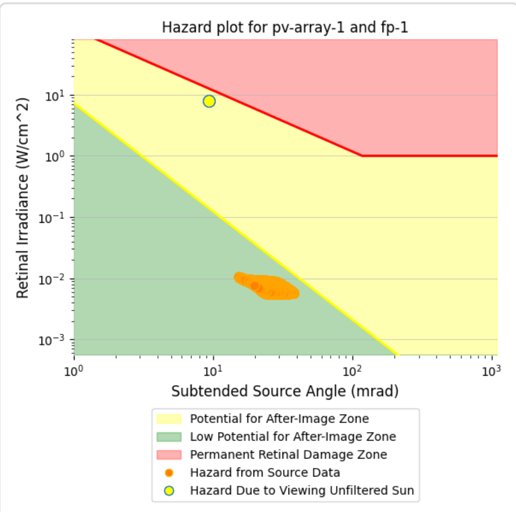
PV array 1 - Receptor (FP 1)

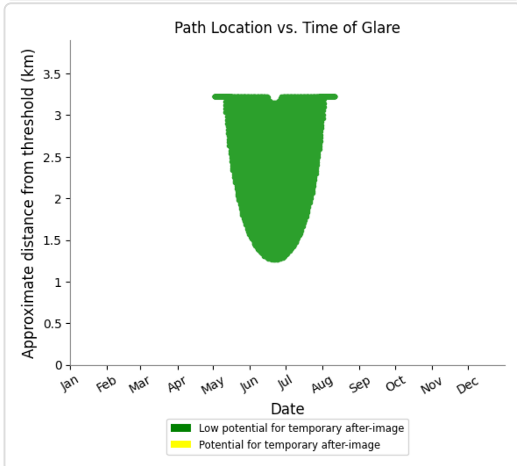
PV array is expected to produce the following glare for observers on this flight path:

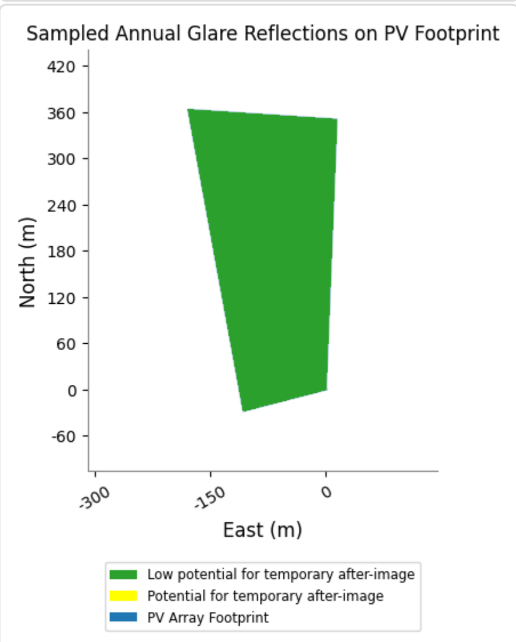
- 2,659 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

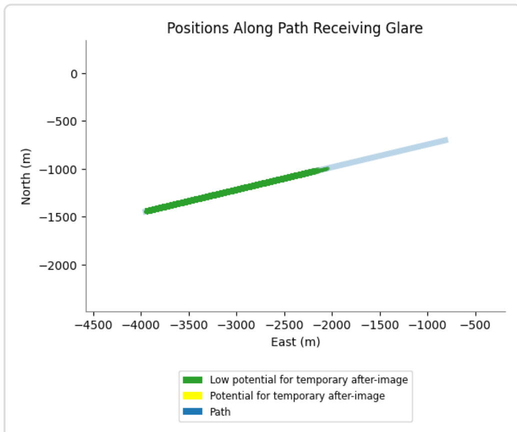








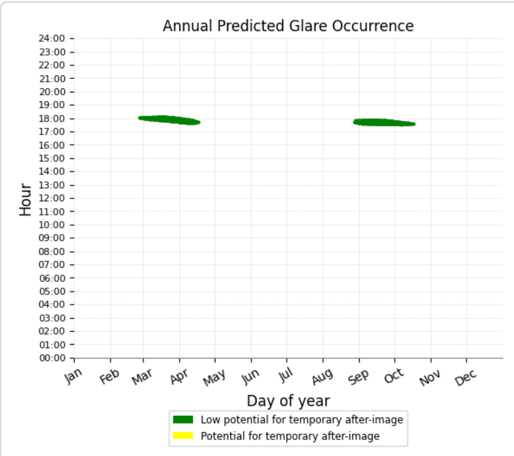


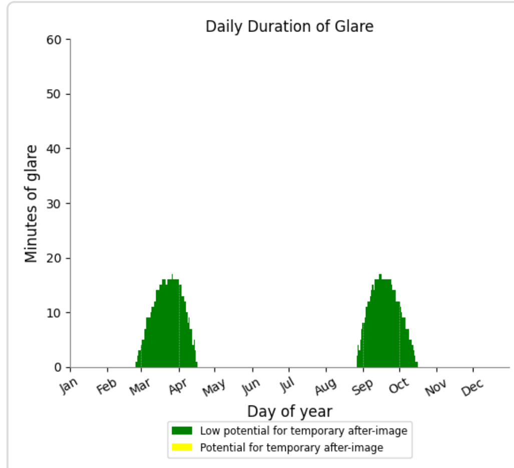


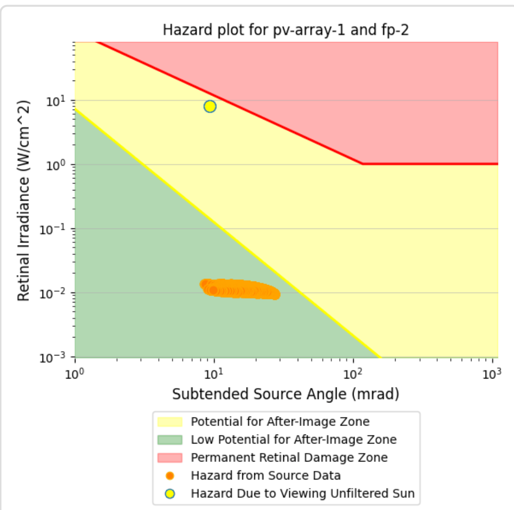
PV array 1 - Receptor (FP 2)

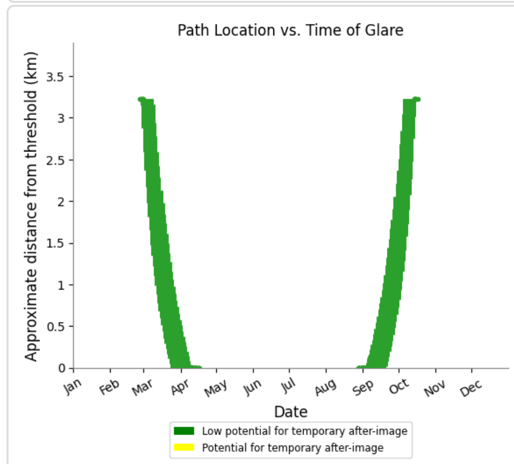
PV array is expected to produce the following glare for observers on this flight path:

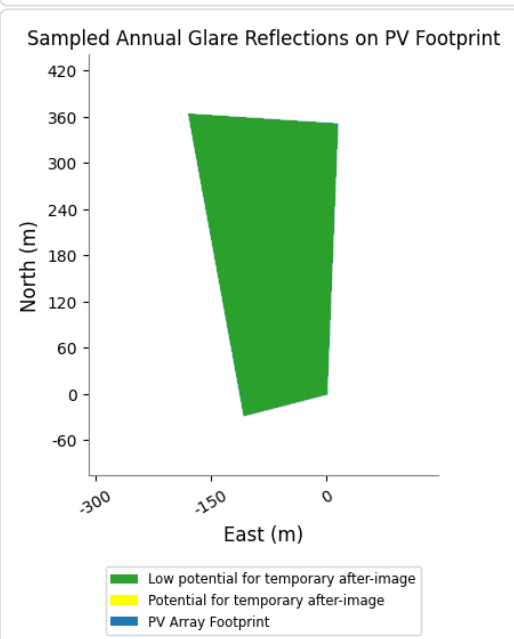
- 1,096 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

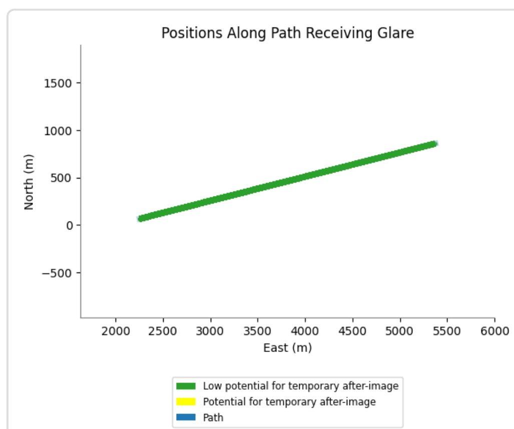








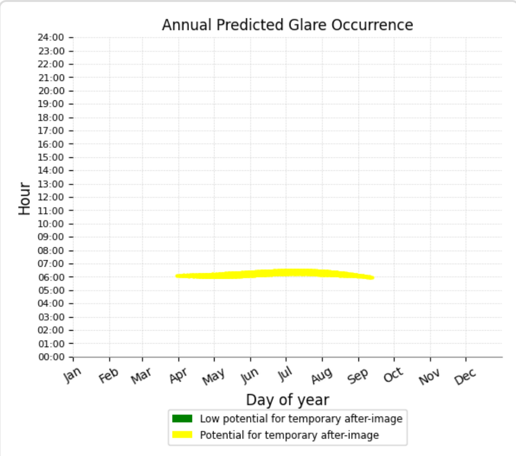


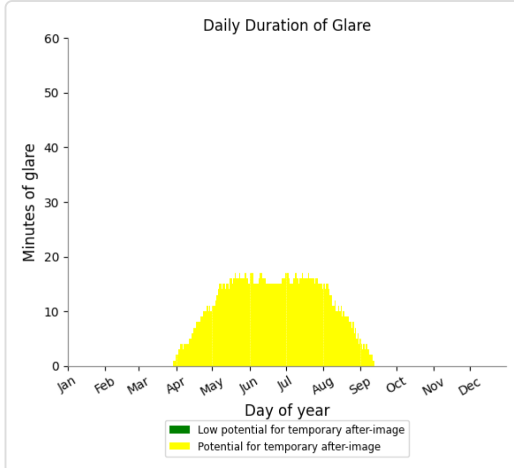


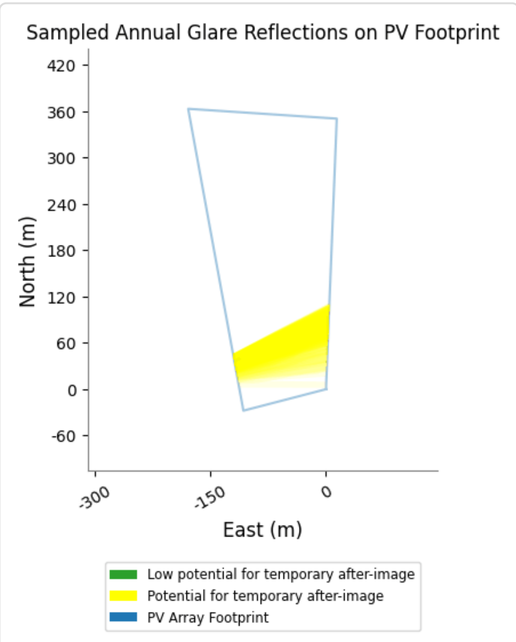
PV array 1 - OP Receptor (OP 1)

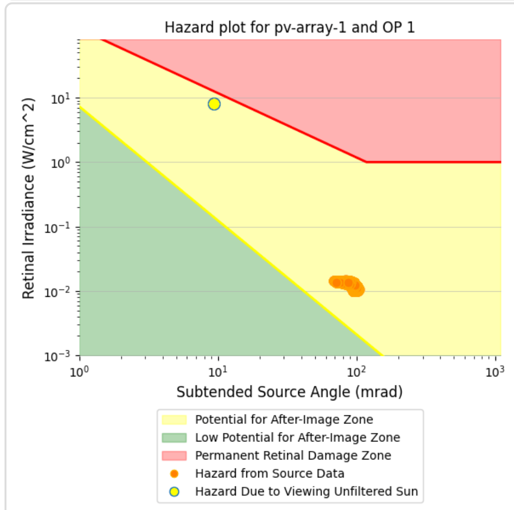
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 1,969 minutes of "yellow" glare with potential to cause temporary after-image.





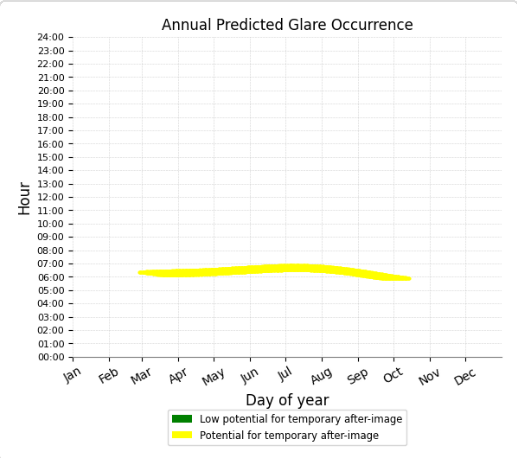


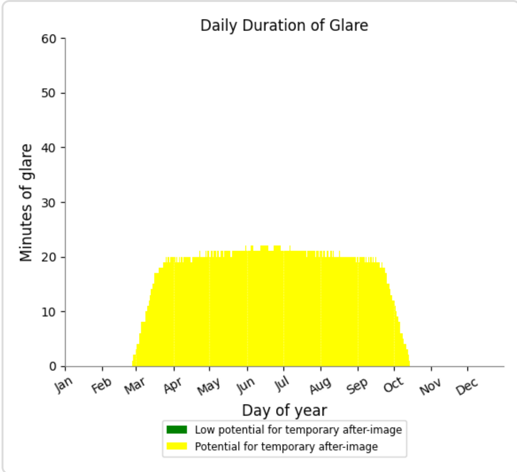


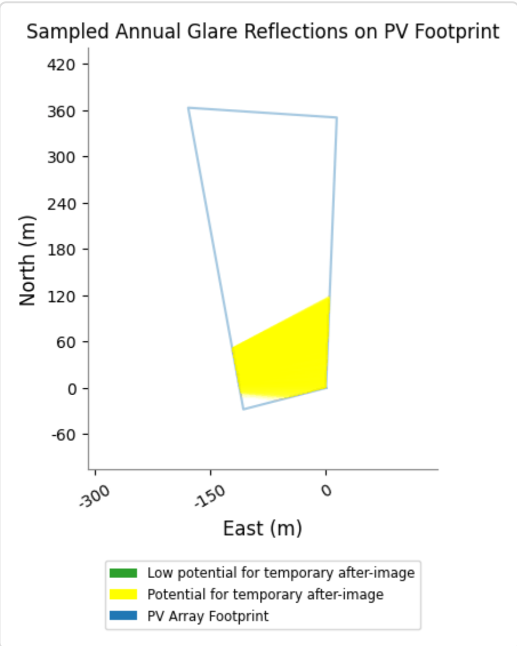
PV array 1 - OP Receptor (OP 2)

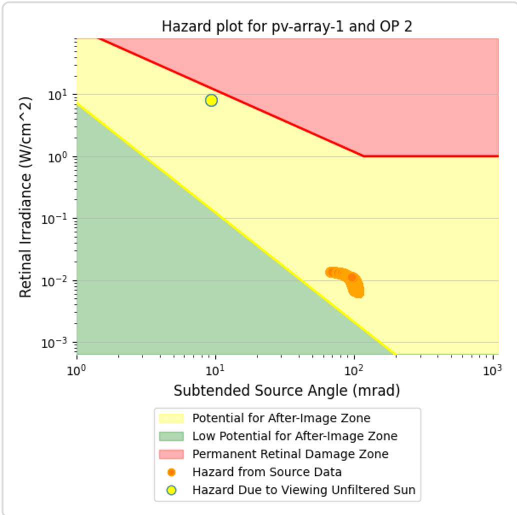
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,228 minutes of "yellow" glare with potential to cause temporary after-image.





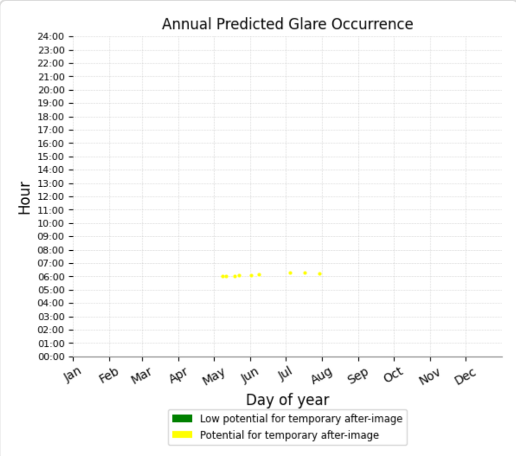


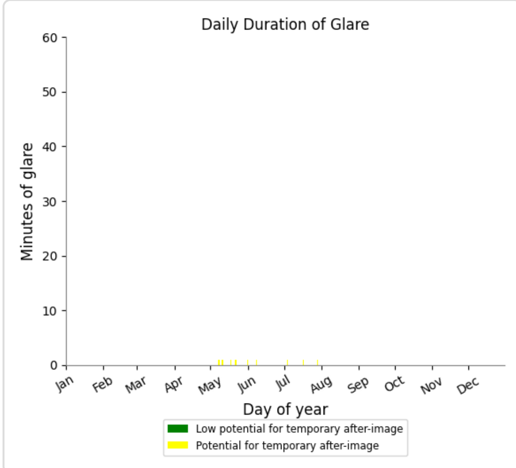


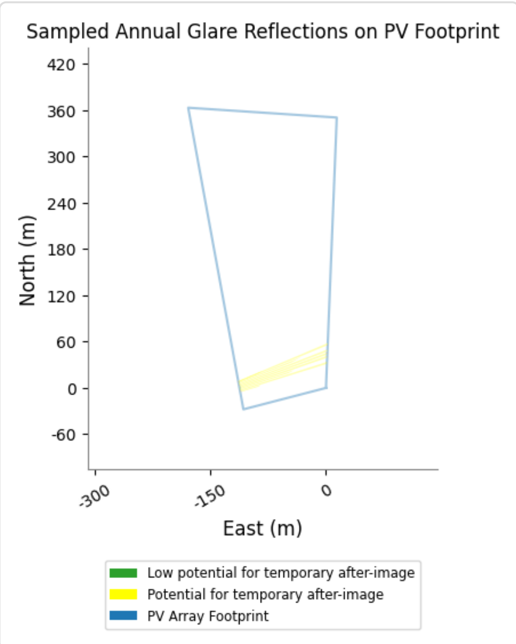
PV array 1 - OP Receptor (OP 3)

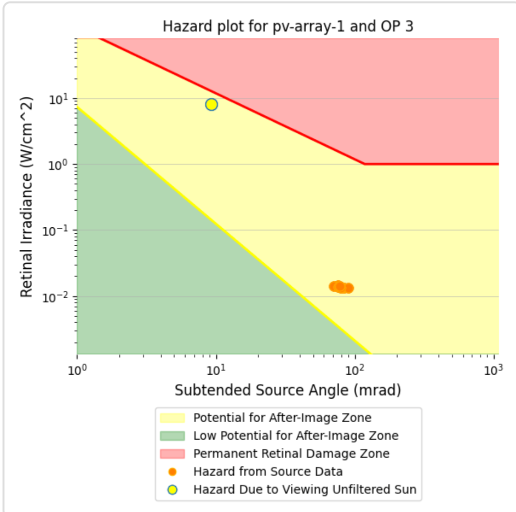
PV array is expected to produce the following glare for receptors at this location:

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





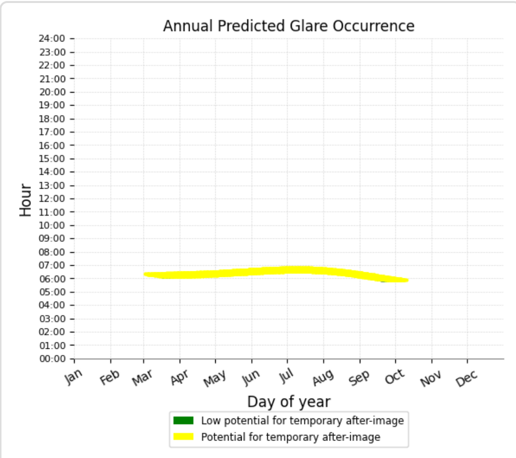


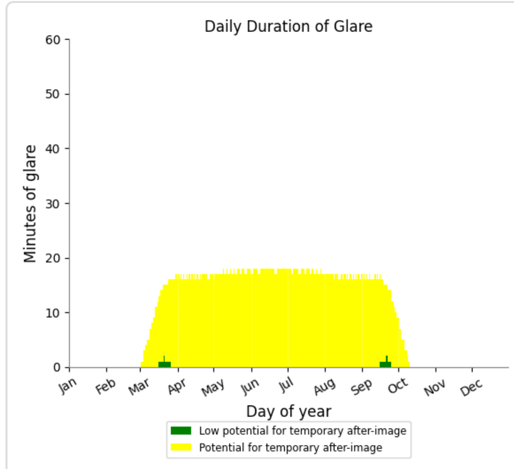


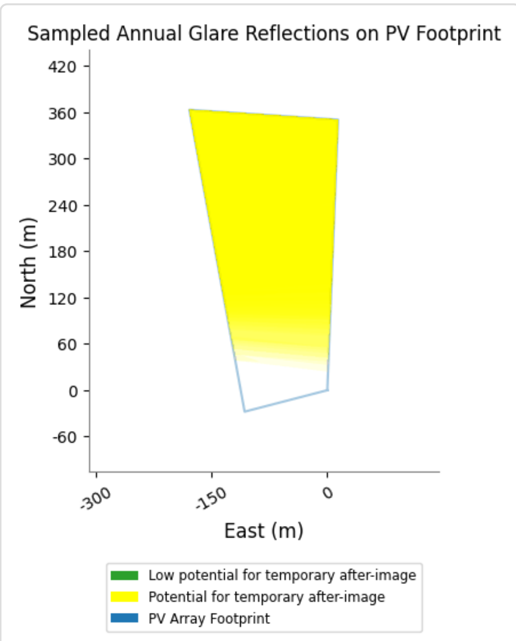
PV array 1 - OP Receptor (OP 4)

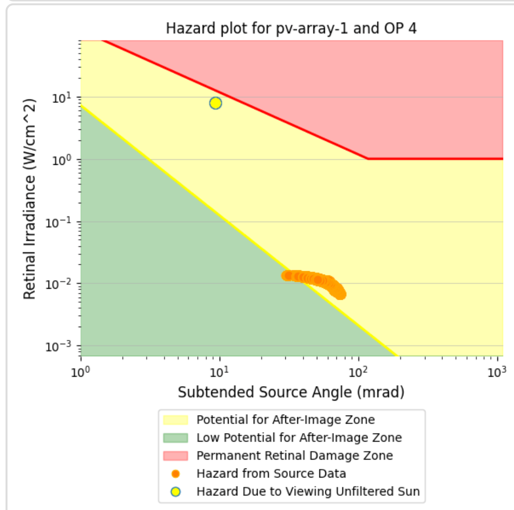
PV array is expected to produce the following glare for receptors at this location:

- 23 minutes of "green" glare with low potential to cause temporary after-image.
- 3,429 minutes of "yellow" glare with potential to cause temporary after-image.





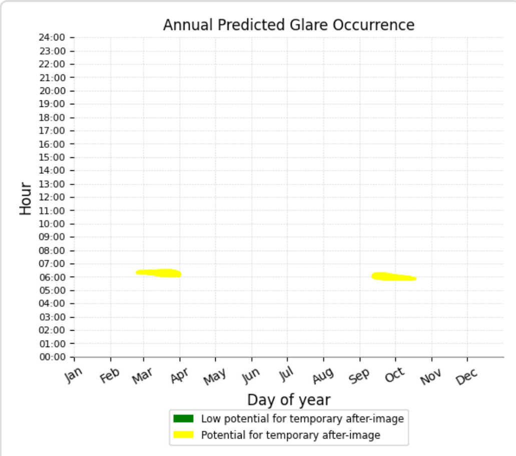


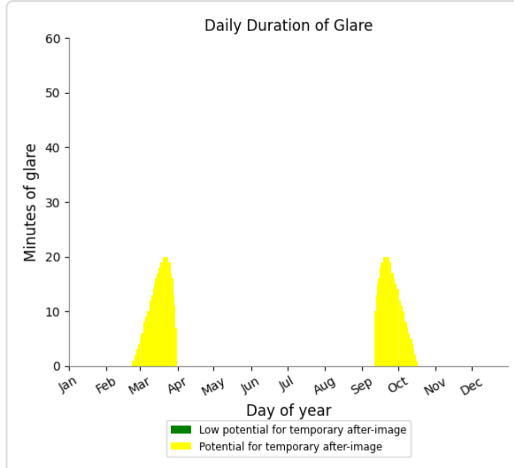


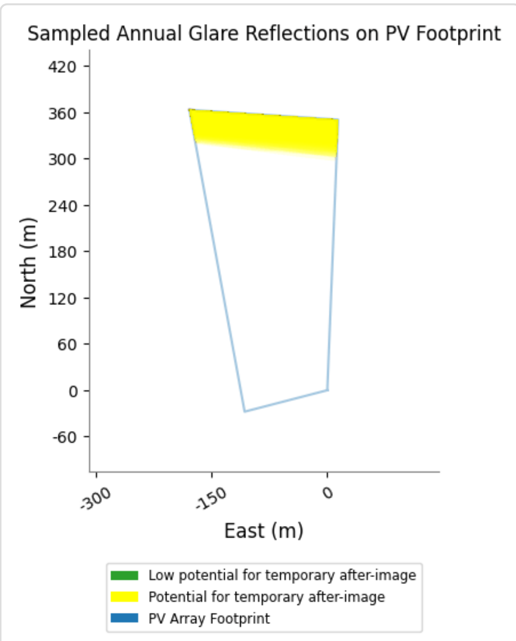
PV array 1 - OP Receptor (OP 5)

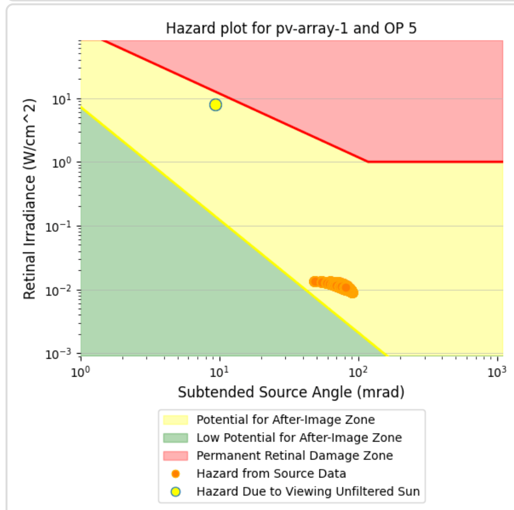
PV array is expected to produce the following glare for receptors at this location:

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





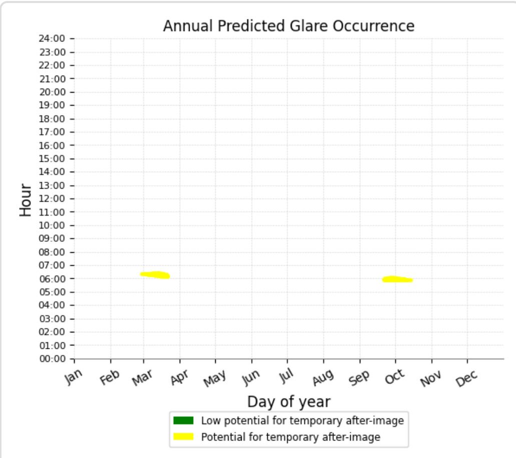


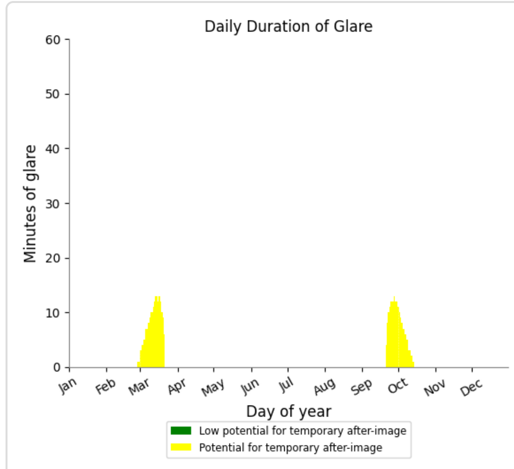


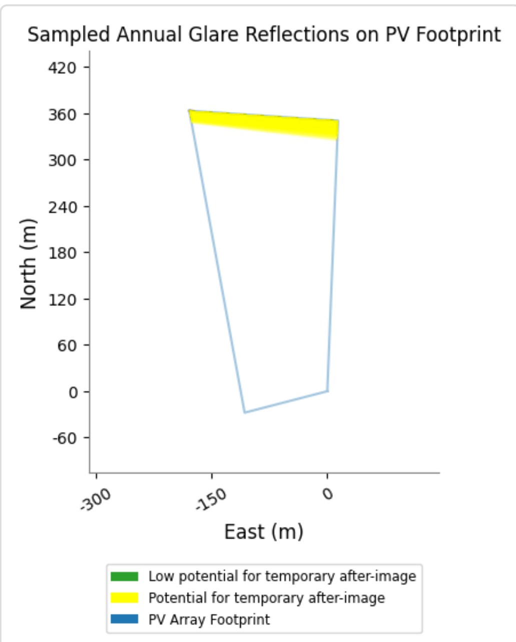
PV array 1 - OP Receptor (OP 6)

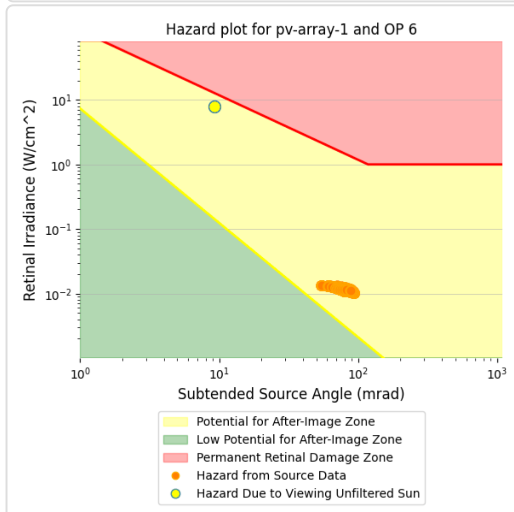
PV array is expected to produce the following glare for receptors at this location:

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









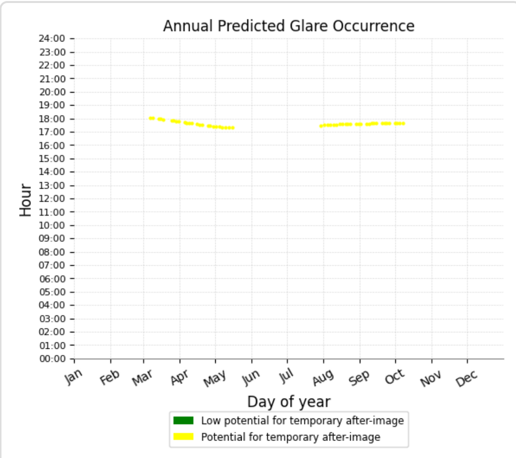
PV array 1 - OP Receptor (OP 7)

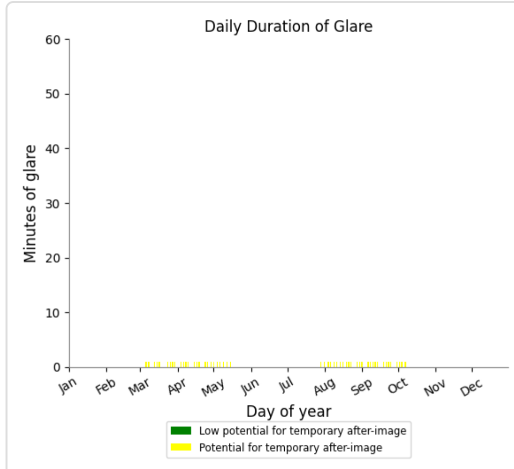
No glare found

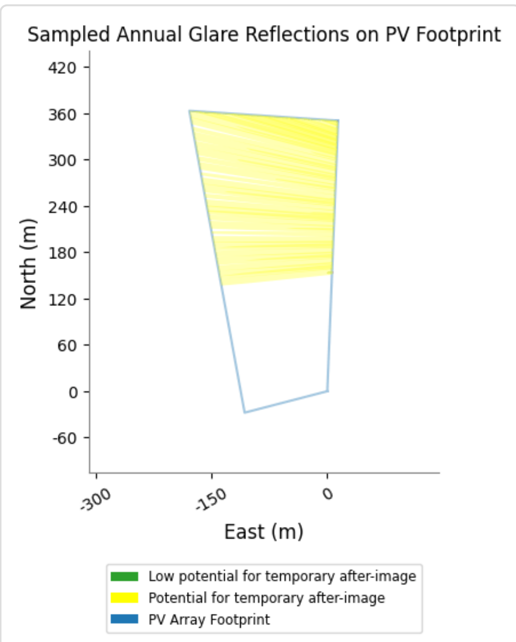
PV array 1 - OP Receptor (OP 8)

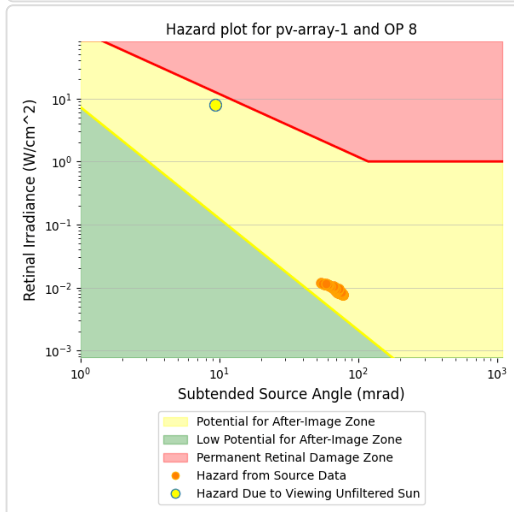
PV array is expected to produce the following glare for receptors at this location:

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





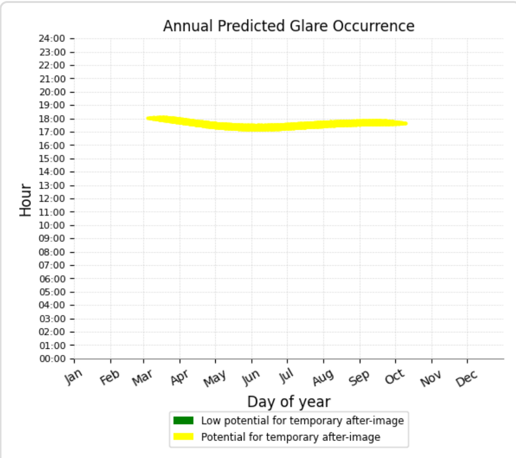


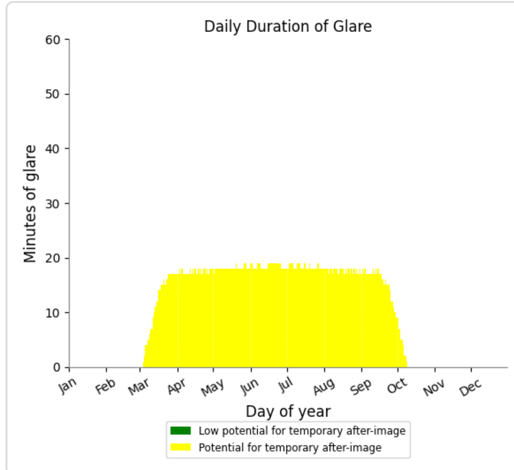


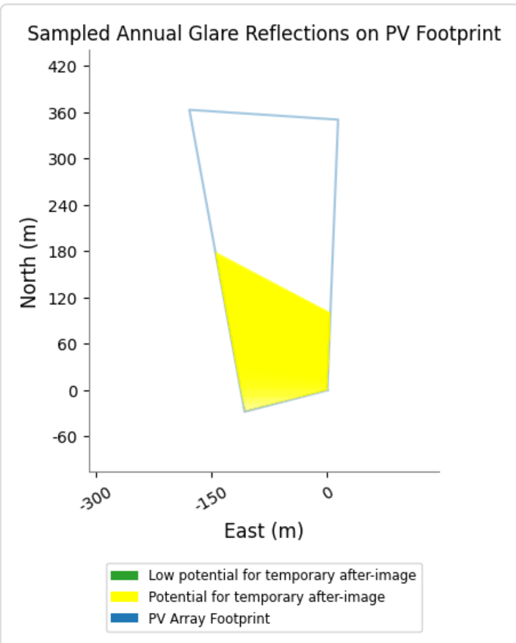
PV array 1 - OP Receptor (OP 9)

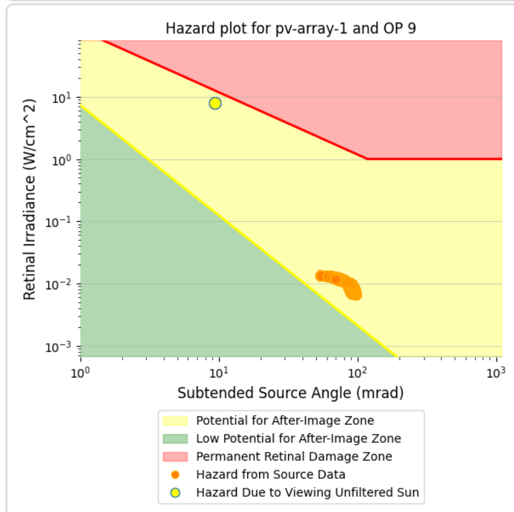
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,597 minutes of "yellow" glare with potential to cause temporary after-image.









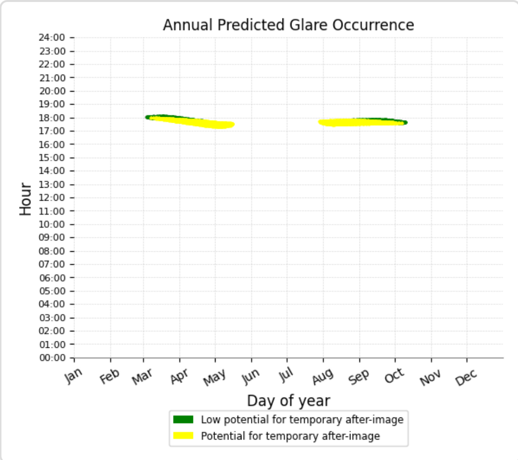
PV array 1 - OP Receptor (OP 10)

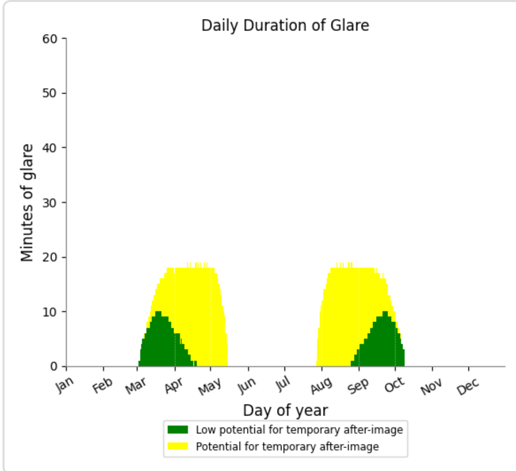
No glare found

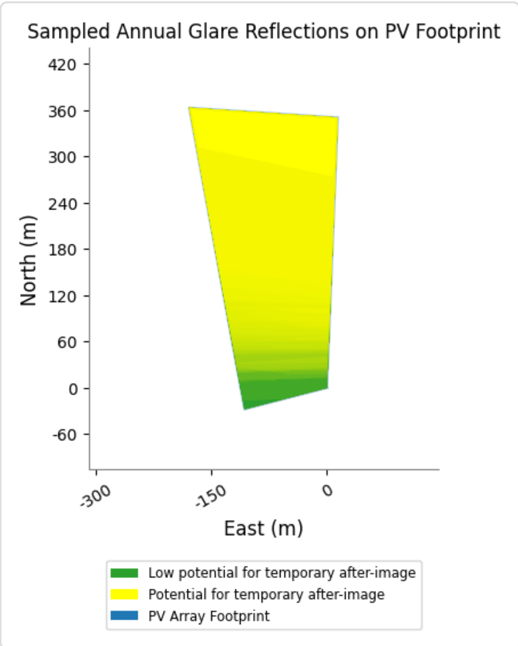
PV array 1 - OP Receptor (11-ATCT)

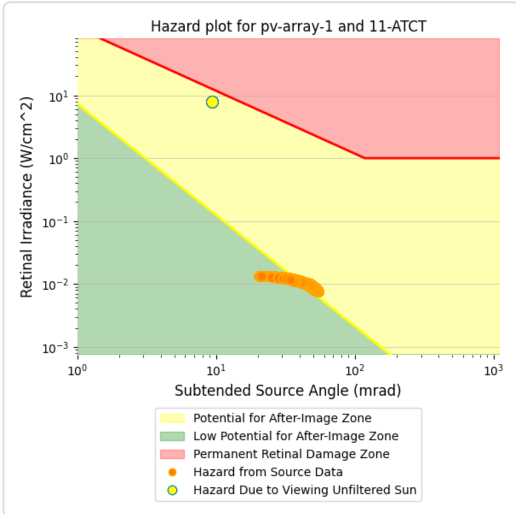
PV array is expected to produce the following glare for receptors at this location:

- 567 minutes of "green" glare with low potential to cause temporary after-image.
- 1,646 minutes of "yellow" glare with potential to cause temporary after-image.





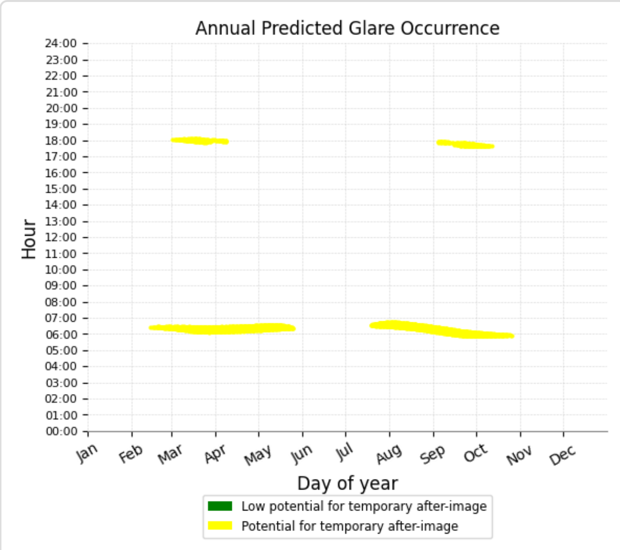


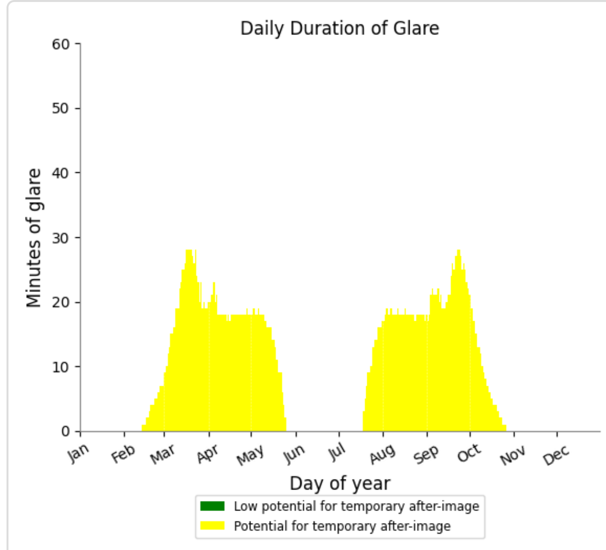


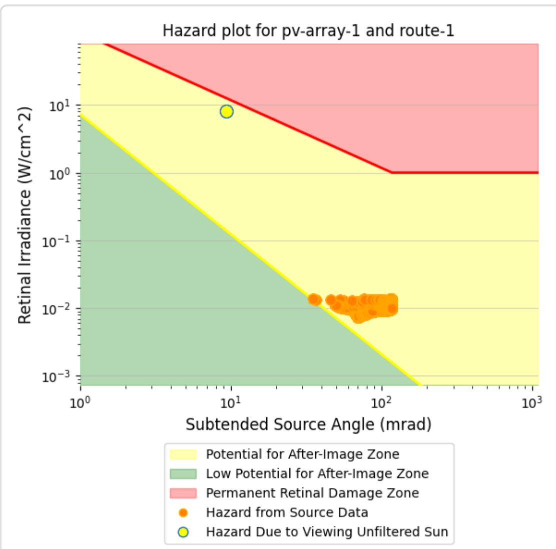
PV array 1 - Route Receptor (Route 1)

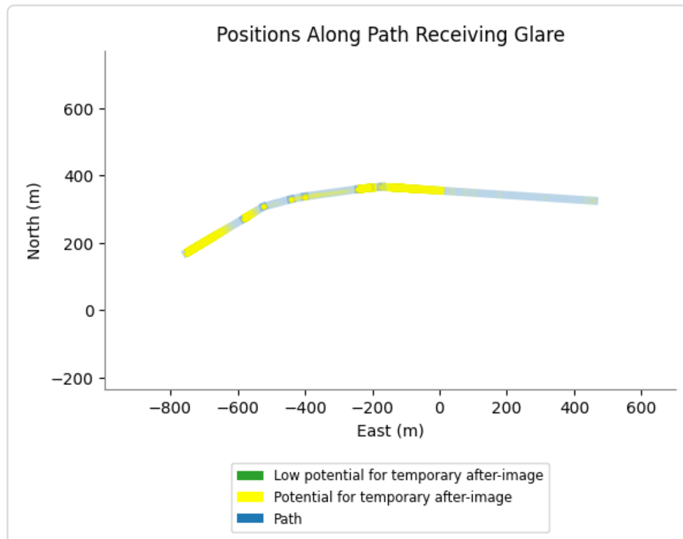
PV array is expected to produce the following glare for receptors at this location:

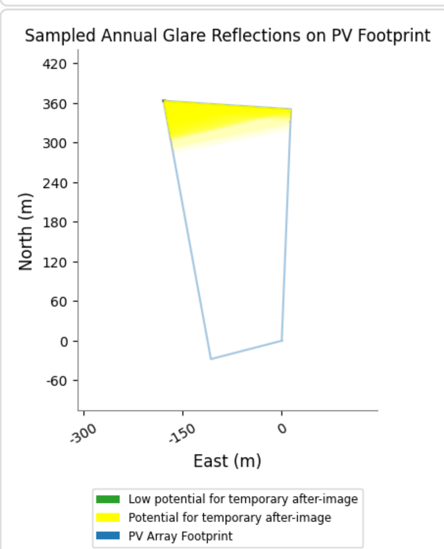
- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,209 minutes of "yellow" glare with potential to cause temporary after-image.











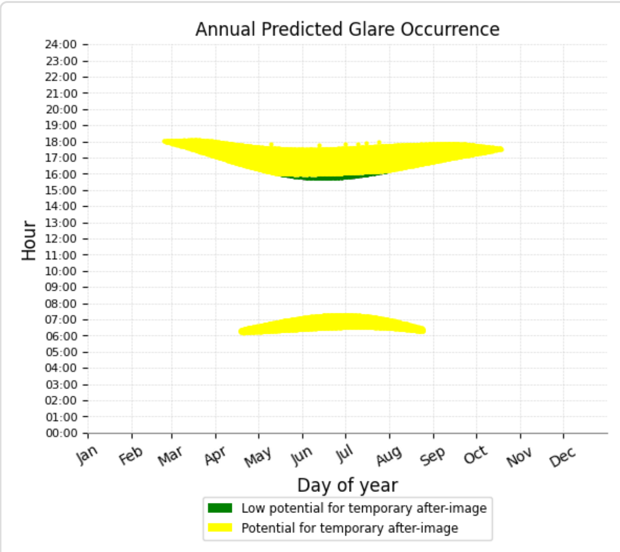
PV array 1 - Route Receptor (Route 2)

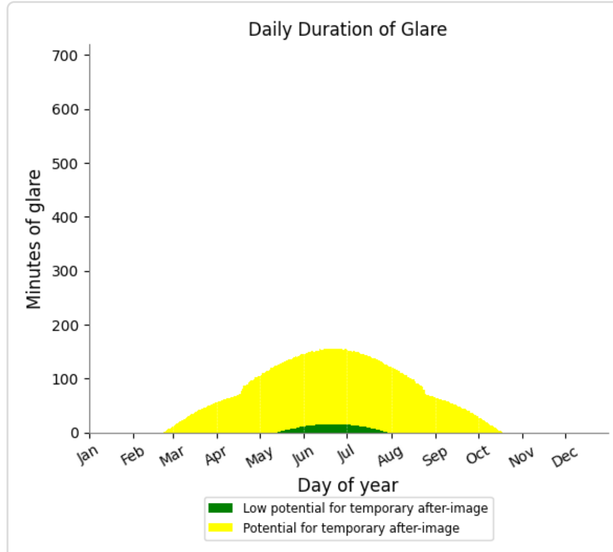
No glare found

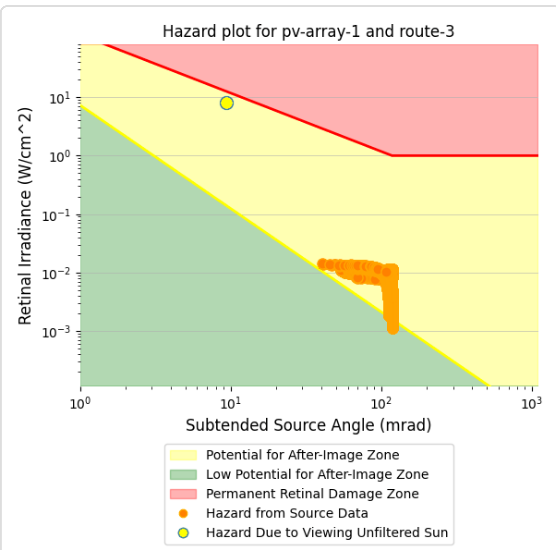
PV array 1 - Route Receptor (Route 3)

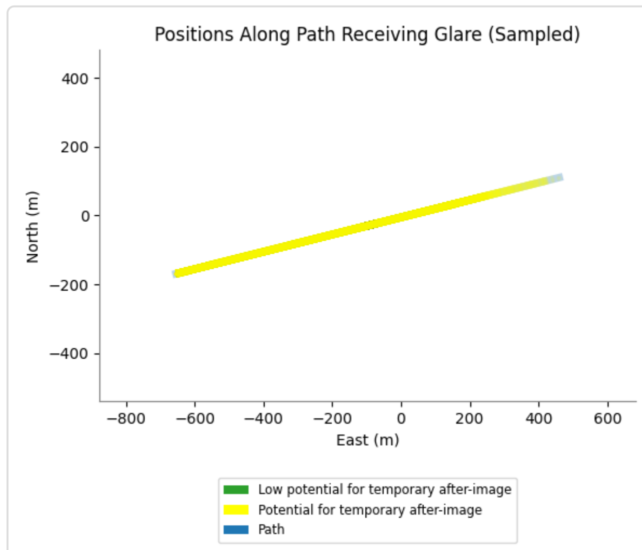
PV array is expected to produce the following glare for receptors at this location:

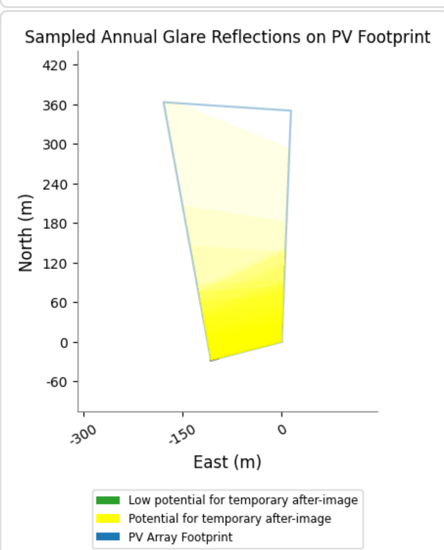
- 841 minutes of "green" glare with low potential to cause temporary after-image.
- 20,230 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

BNTCL 5MW PV Farm

BNTCL_LightlyTextured_no ARC_2FP

Client: BNOCL

Created May 12, 2022
Updated May 12, 2022
Time-step 1 minute
Timezone offset UTC-4
Site ID 69000.9238

Project type Advanced
Project status: active
Category 500 kW to 1 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:

- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

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

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	15.0	180.0	5,415	41,035	-

Component Data

PV Array(s)

Total PV footprint area: 55,735 m^2

Name: PV array 1
Footprint area: 55,735 m^2
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Light textured glass without AR coating
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 9.7 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.077475	-59.499126	58.00	1.46	59.46
2	13.080642	-59.498997	63.41	1.46	64.87
3	13.080757	-59.500772	66.29	1.46	67.75
4	13.077224	-59.500113	56.11	1.46	57.57

2-Mile Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height : 15 m
Direction: 76.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.071136	-59.506635	55.44	15.24	70.68
2-mile point	13.064416	-59.535538	24.28	215.08	239.36

Name: FP 2
Description:
Threshold height : 15 m
Direction: 255.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.078052	-59.478343	50.40	15.24	65.64
2-mile point	13.085227	-59.449555	0.00	234.33	234.33

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.079016	-59.506061	72.47	1.20	73.67
2	13.079935	-59.504484	71.15	1.20	72.35
3	13.080259	-59.503947	70.90	1.20	72.10
4	13.080458	-59.503196	70.27	1.20	71.47
5	13.080531	-59.502821	68.56	1.20	69.76
6	13.080730	-59.501351	67.09	1.20	68.29
7	13.080792	-59.500707	66.37	1.20	67.57
8	13.080416	-59.494892	61.43	1.20	62.63

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.080677	-59.498926	63.60	1.20	64.80
2	13.077438	-59.499033	58.00	1.20	59.20

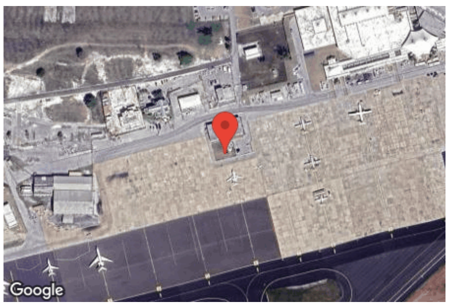
Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.075943	-59.505159	59.58	1.20	60.78
2	13.078472	-59.494881	59.60	1.20	60.80

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.077496	-59.501009	57.30	1.80	59.10
OP 2	13.077512	-59.501075	57.37	4.80	62.17
OP 3	13.077115	-59.501228	56.95	1.80	58.75
OP 4	13.078485	-59.505356	66.60	1.80	68.40
OP 5	13.080724	-59.502755	69.48	4.80	74.28
OP 6	13.080834	-59.502181	69.03	1.80	70.83
OP 7	13.080938	-59.499847	65.40	1.80	67.20
OP 8	13.079259	-59.495156	62.01	1.80	63.81
OP 9	13.077482	-59.497366	57.46	4.80	62.26
OP 10	13.076482	-59.499246	57.87	1.80	59.67
11-ATCT	13.078125	-59.490296	56.37	22.00	78.37

11-ATCT map image



Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced	Data File
	deg	deg	min	min	kWh	
PV array 1	15.0	180.0	5,415	41,035	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	0	0	1	0	106	434	251	0	1	0	0	0
pv-array-1 (yellow)	0	113	1649	2950	4389	4723	4694	3514	2188	492	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

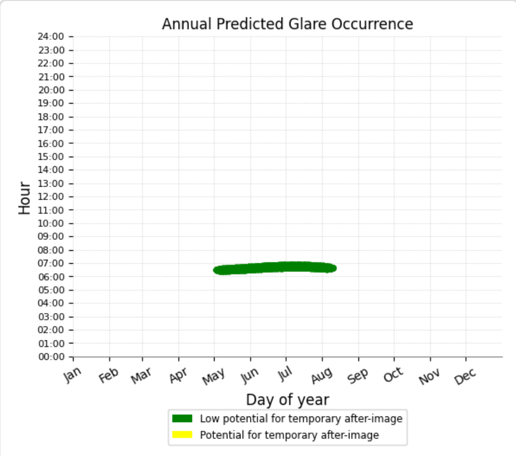
PV array 1 potential temporary after-image

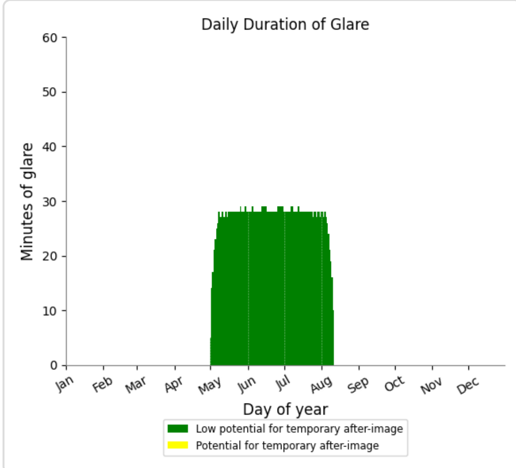
Component	Green glare (min)	Yellow glare (min)
FP: FP 1	2772	0
FP: FP 2	1166	0
OP: OP 1	0	2012
OP: OP 2	0	4416
OP: OP 3	0	7
OP: OP 4	31	3600
OP: OP 5	0	962
OP: OP 6	0	410
OP: OP 7	0	0
OP: OP 8	0	52
OP: OP 9	0	3777
OP: OP 10	0	0
OP: 11-ATCT	653	1686
Route: Route 1	2	3422
Route: Route 2	0	0
Route: Route 3	791	20691

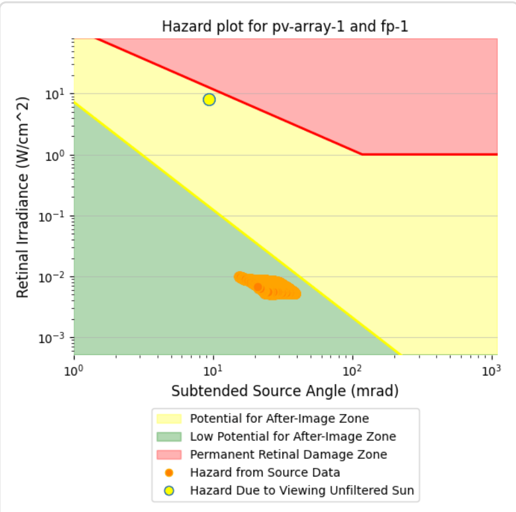
PV array 1 - Receptor (FP 1)

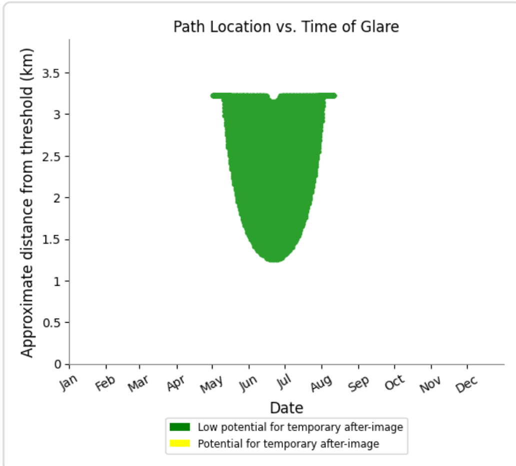
PV array is expected to produce the following glare for observers on this flight path:

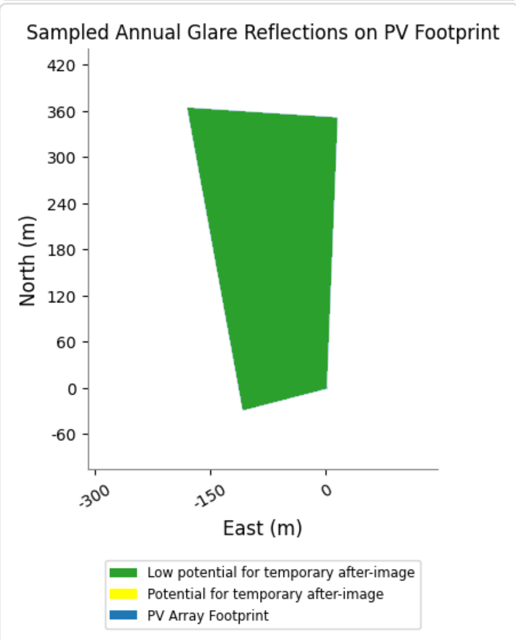
- 2,772 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

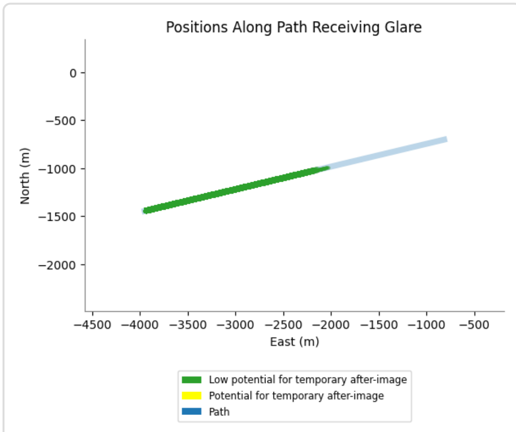








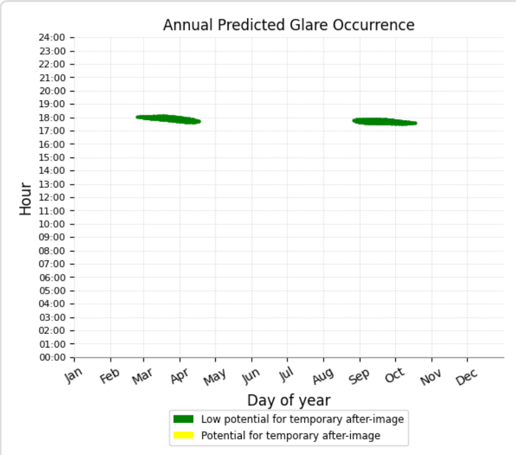


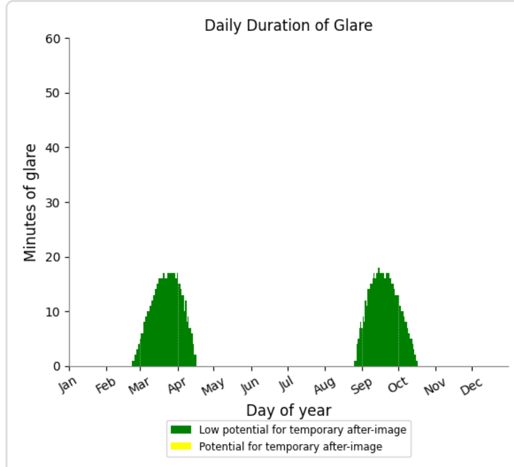


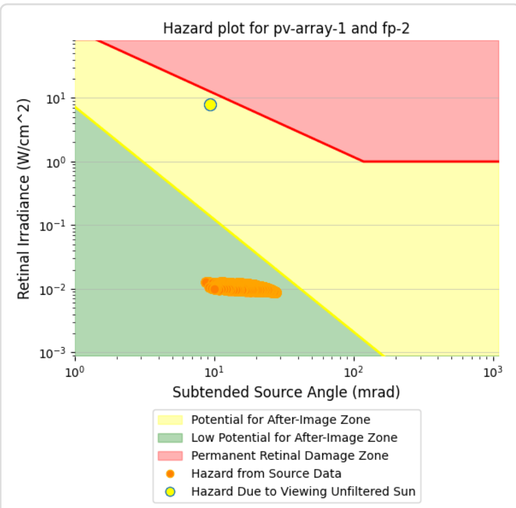
PV array 1 - Receptor (FP 2)

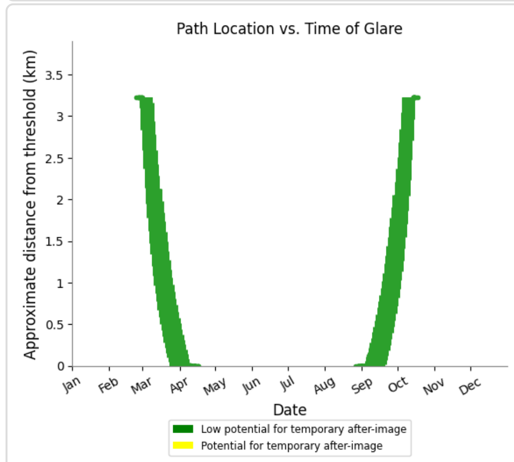
PV array is expected to produce the following glare for observers on this flight path:

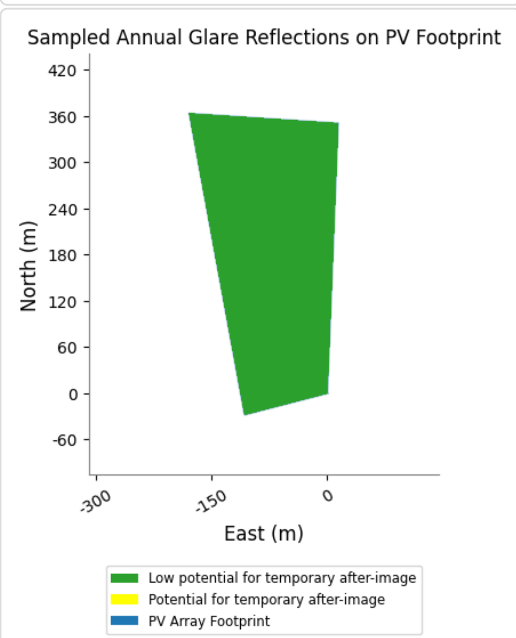
- 1,166 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

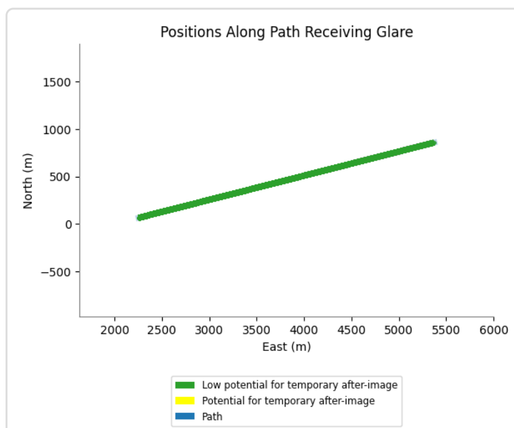








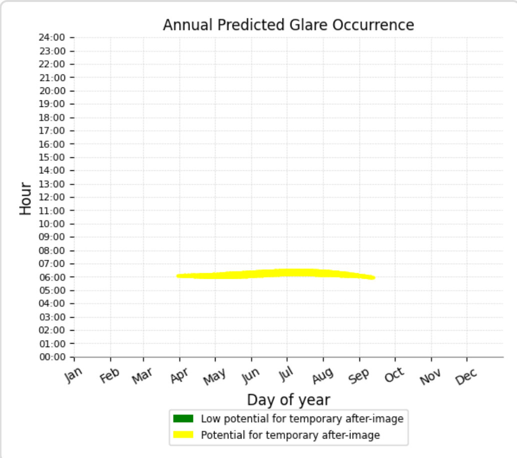


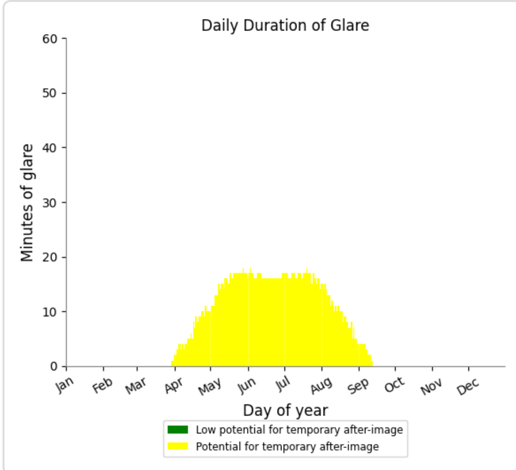


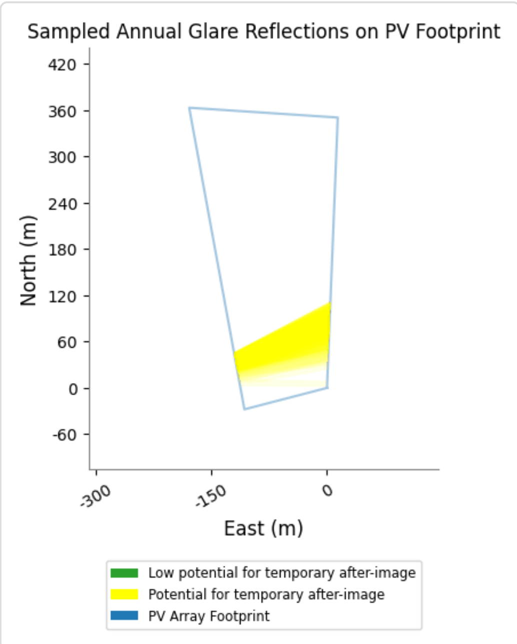
PV array 1 - OP Receptor (OP 1)

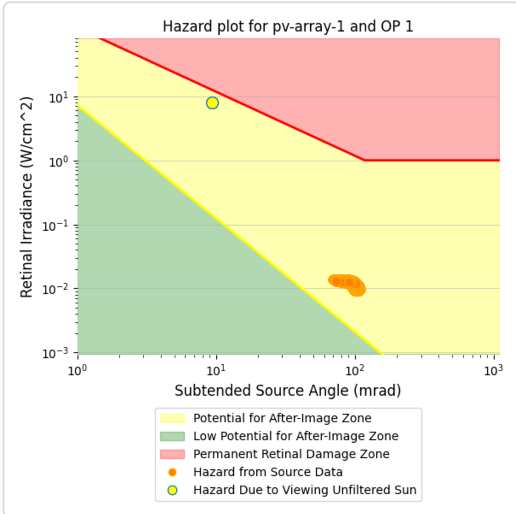
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 2,012 minutes of "yellow" glare with potential to cause temporary after-image.





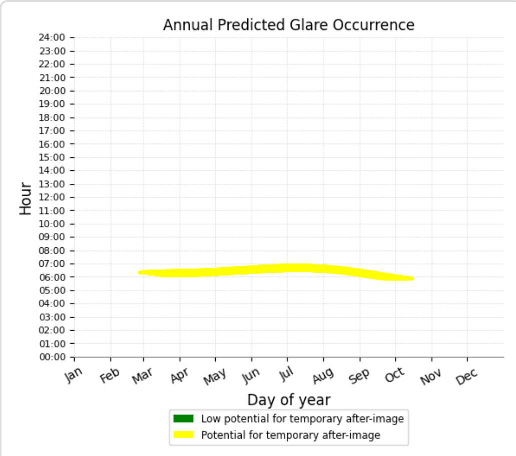


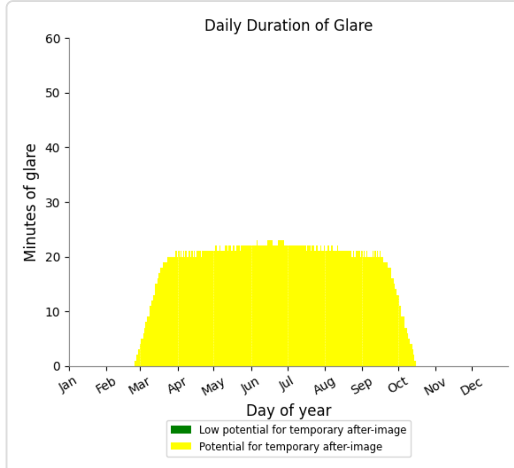


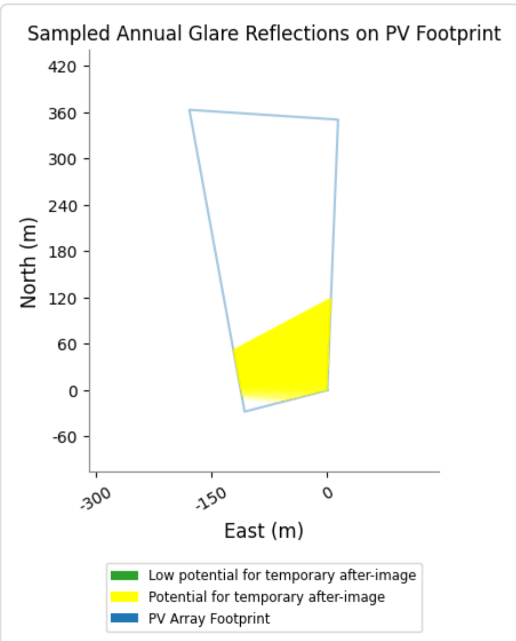
PV array 1 - OP Receptor (OP 2)

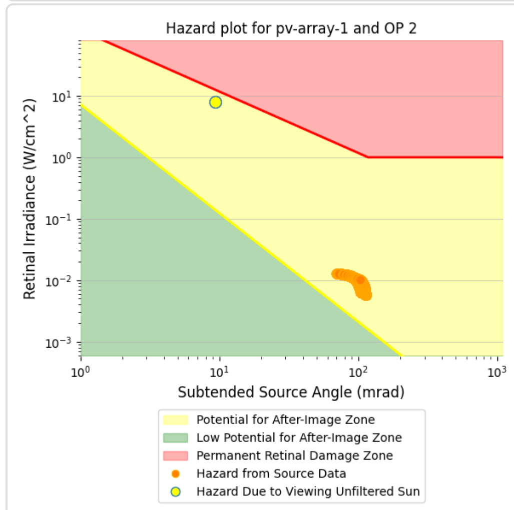
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 4,416 minutes of "yellow" glare with potential to cause temporary after-image.





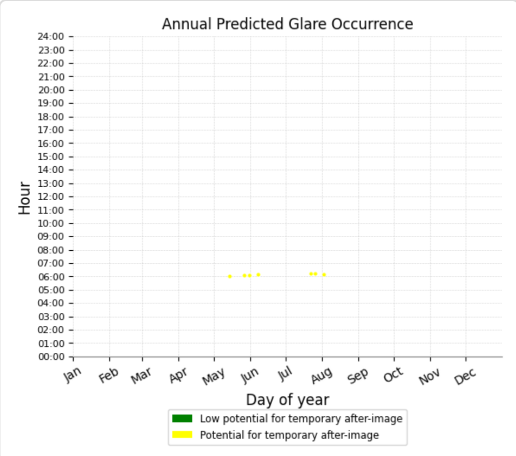


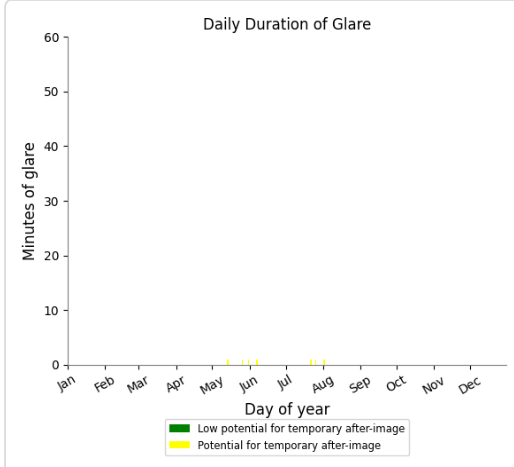


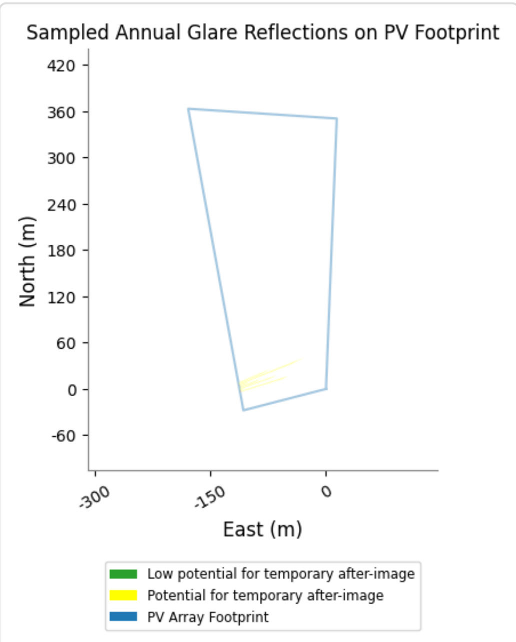
PV array 1 - OP Receptor (OP 3)

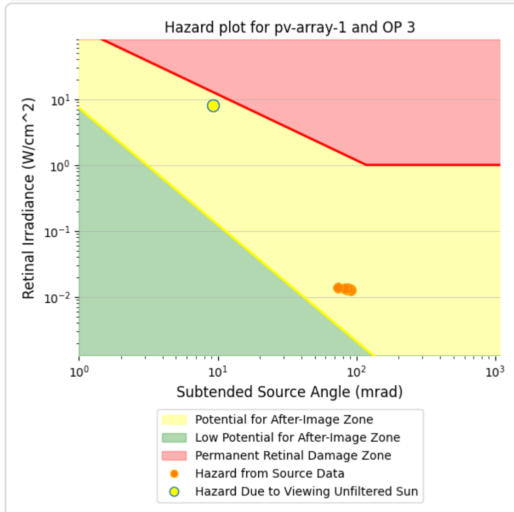
PV array is expected to produce the following glare for receptors at this location:

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





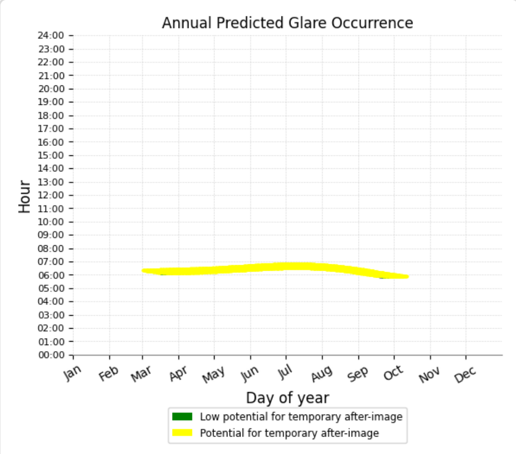


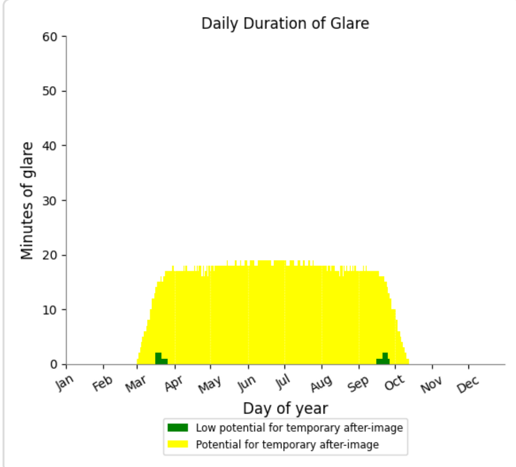


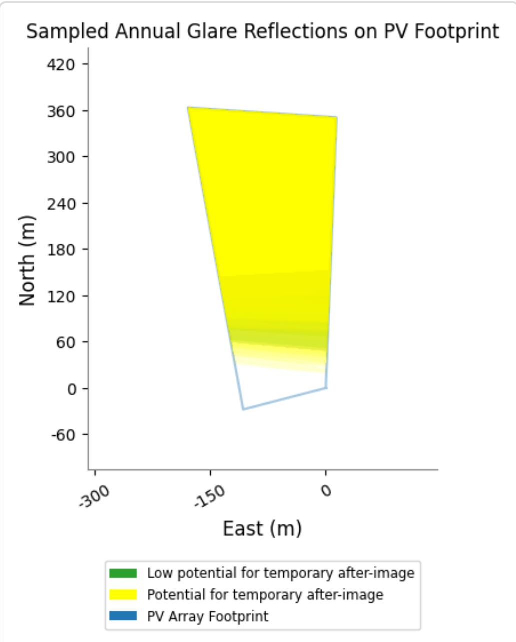
PV array 1 - OP Receptor (OP 4)

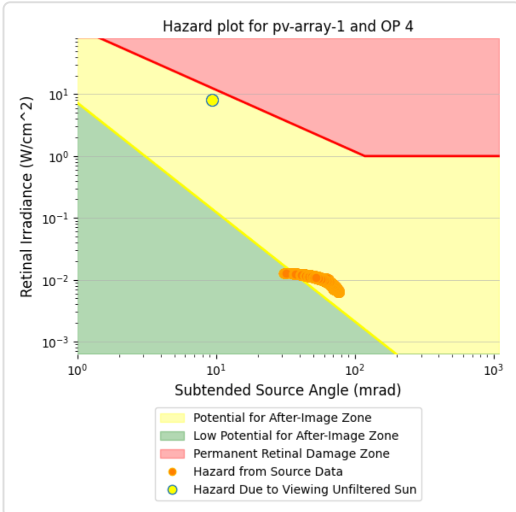
PV array is expected to produce the following glare for receptors at this location:

- 31 minutes of "green" glare with low potential to cause temporary after-image.
- 3,600 minutes of "yellow" glare with potential to cause temporary after-image.





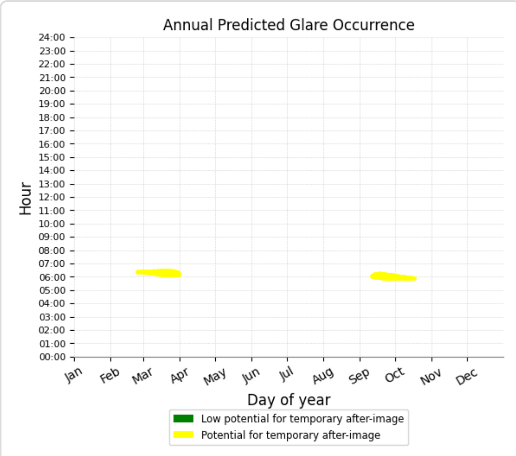


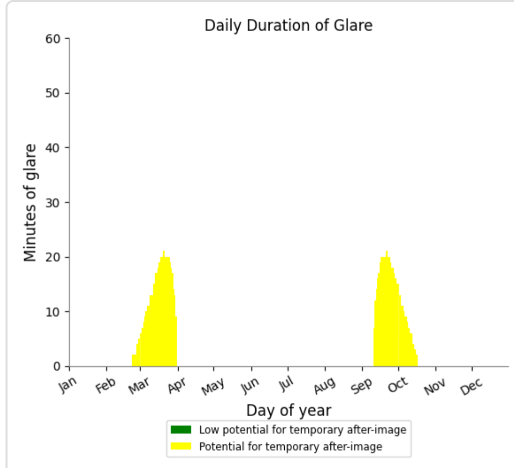


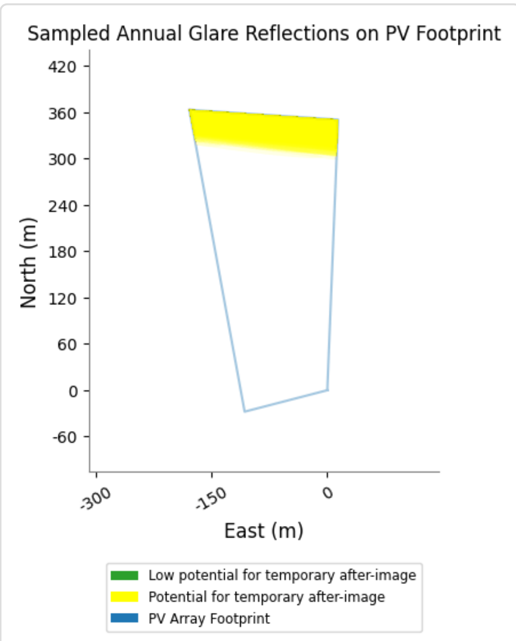
PV array 1 - OP Receptor (OP 5)

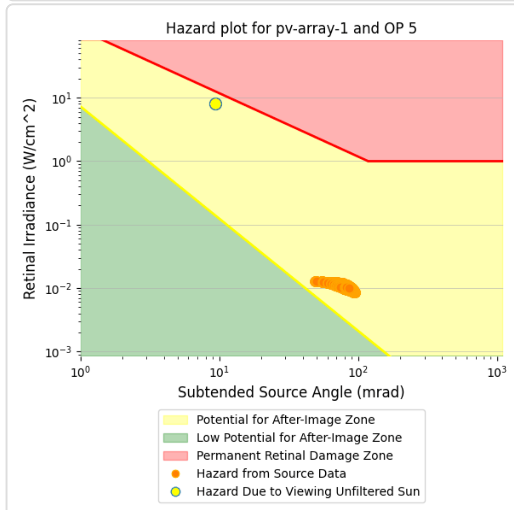
PV array is expected to produce the following glare for receptors at this location:

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





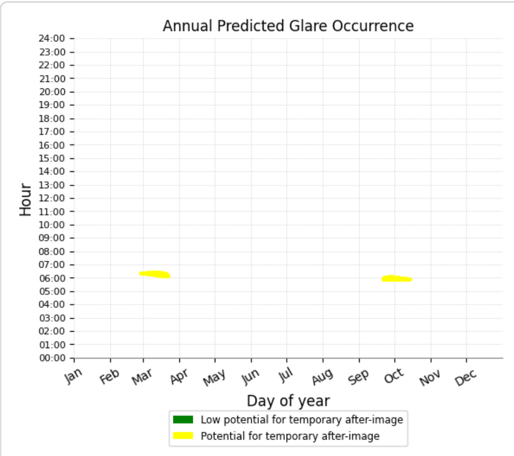


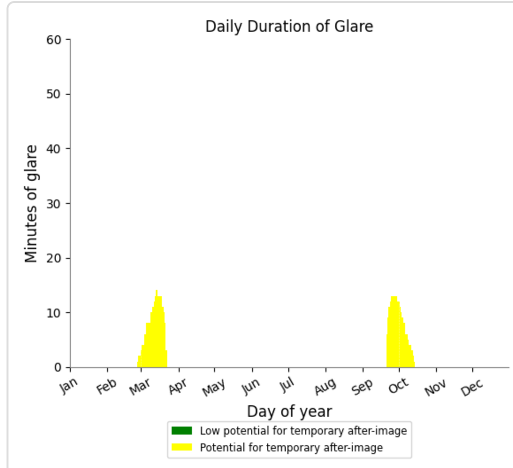


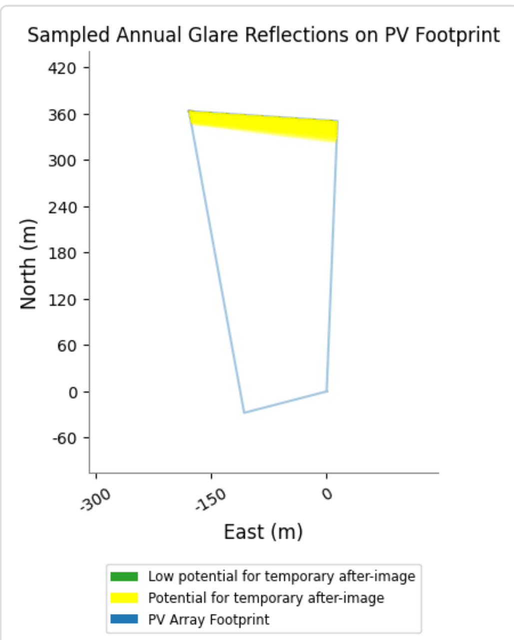
PV array 1 - OP Receptor (OP 6)

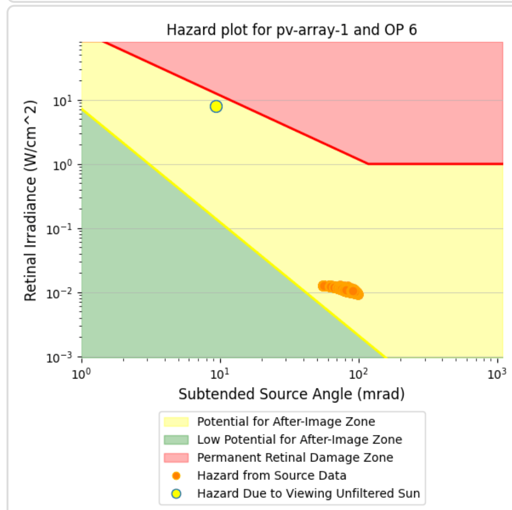
PV array is expected to produce the following glare for receptors at this location:

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









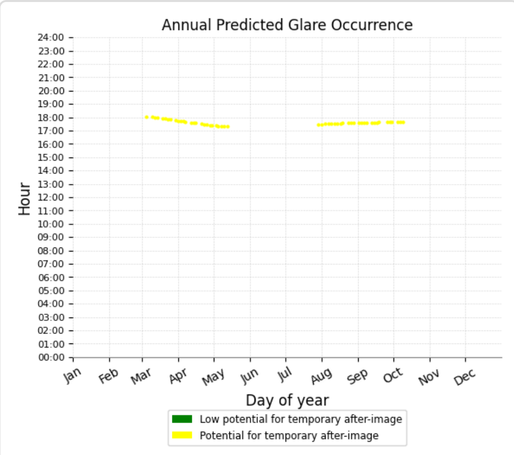
PV array 1 - OP Receptor (OP 7)

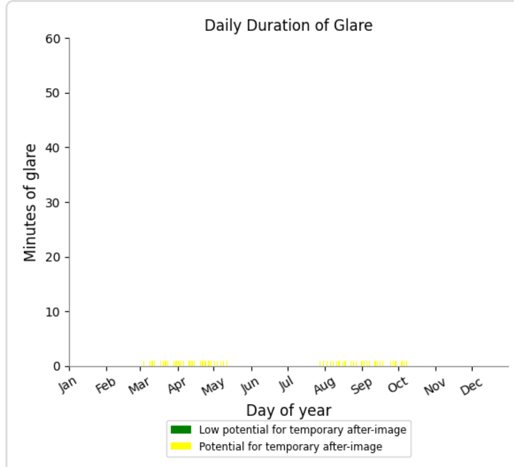
No glare found

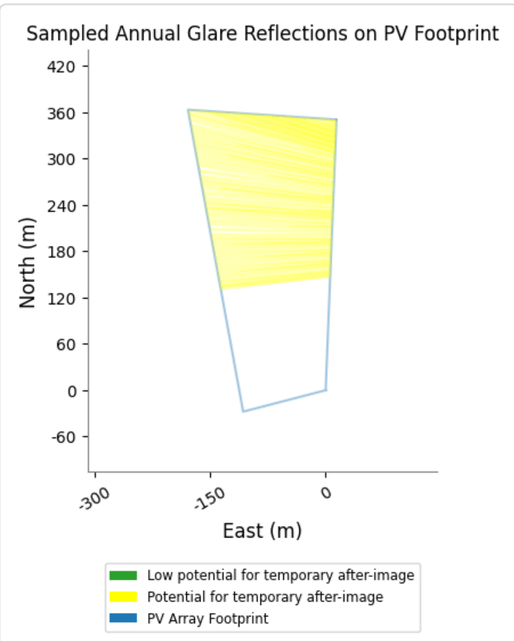
PV array 1 - OP Receptor (OP 8)

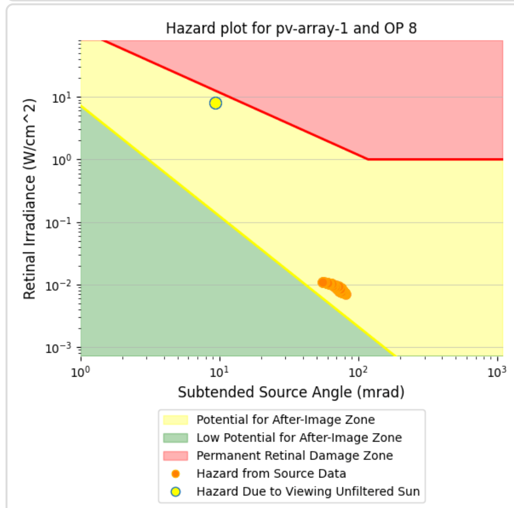
PV array is expected to produce the following glare for receptors at this location:

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





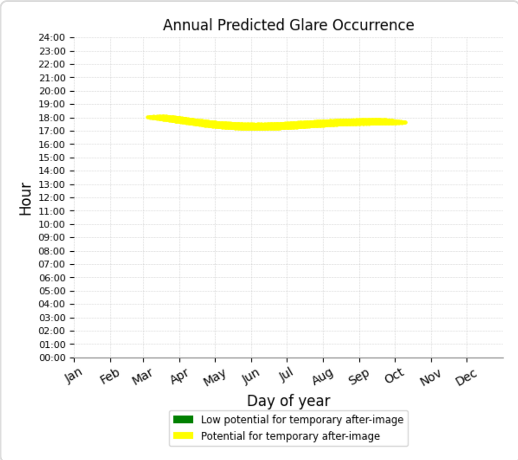


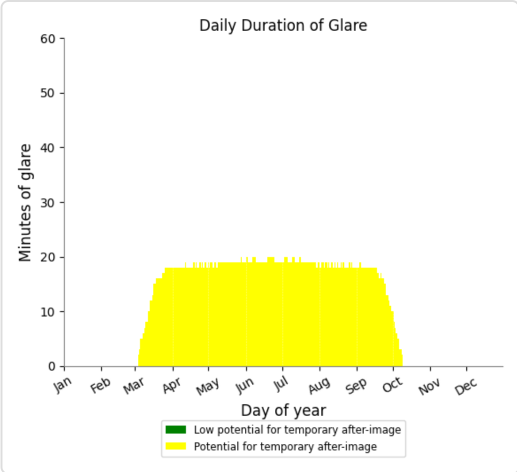


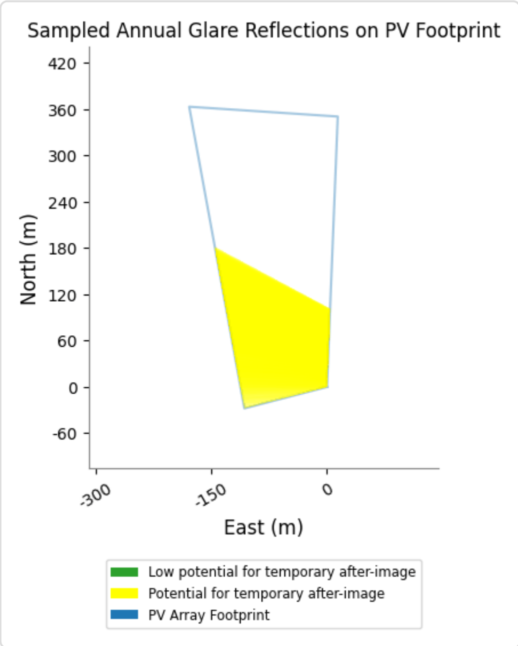
PV array 1 - OP Receptor (OP 9)

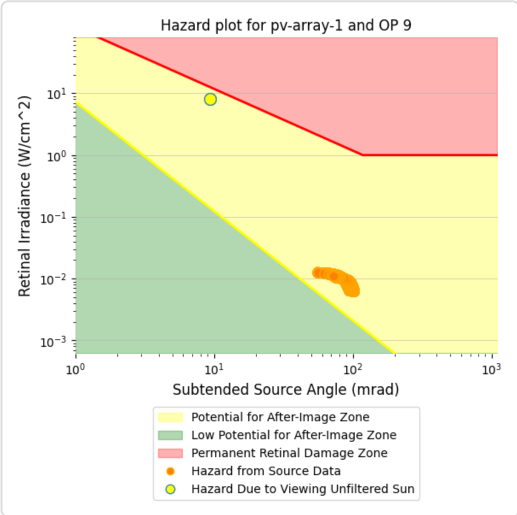
PV array is expected to produce the following glare for receptors at this location:

- 0 minutes of "green" glare with low potential to cause temporary after-image.
- 3,777 minutes of "yellow" glare with potential to cause temporary after-image.









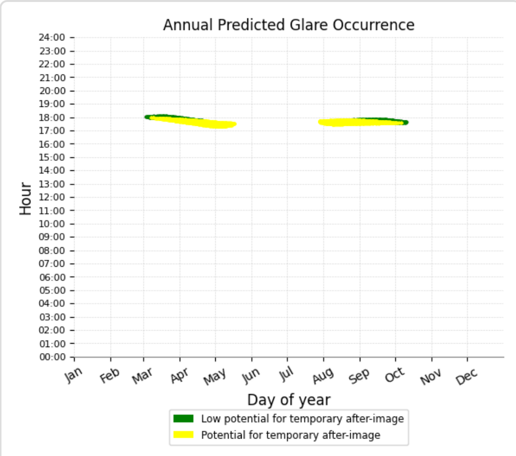
PV array 1 - OP Receptor (OP 10)

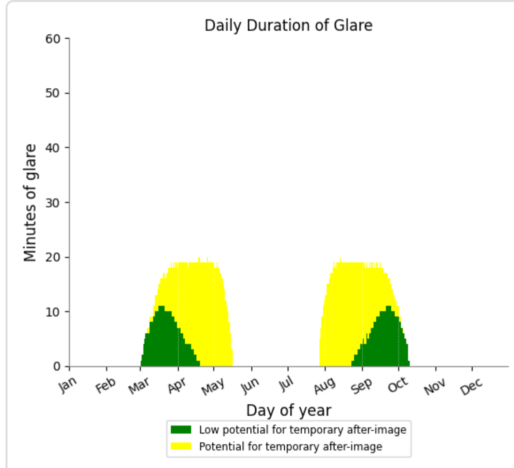
No glare found

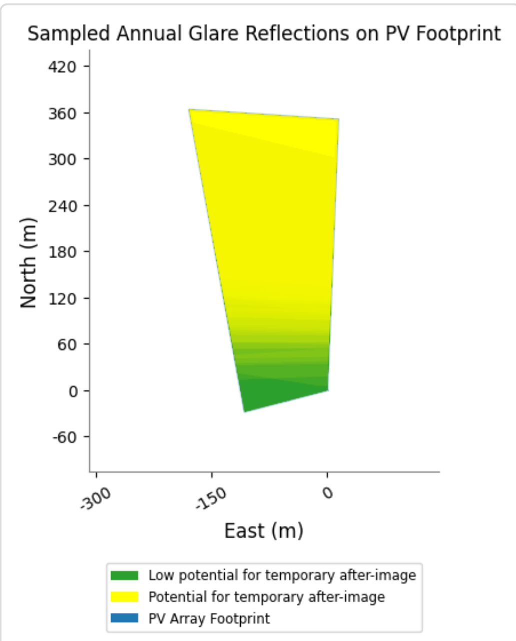
PV array 1 - OP Receptor (11-ATCT)

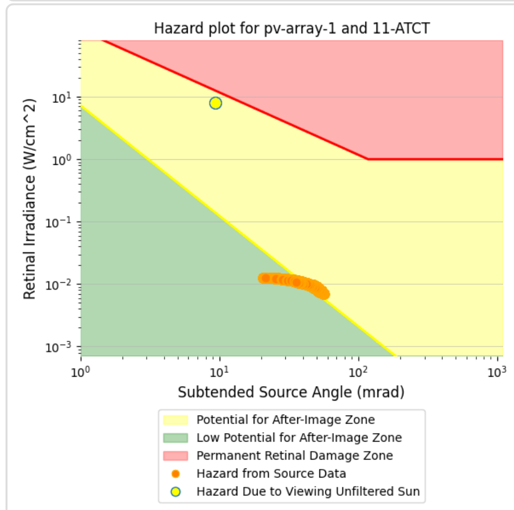
PV array is expected to produce the following glare for receptors at this location:

- 653 minutes of "green" glare with low potential to cause temporary after-image.
- 1,686 minutes of "yellow" glare with potential to cause temporary after-image.





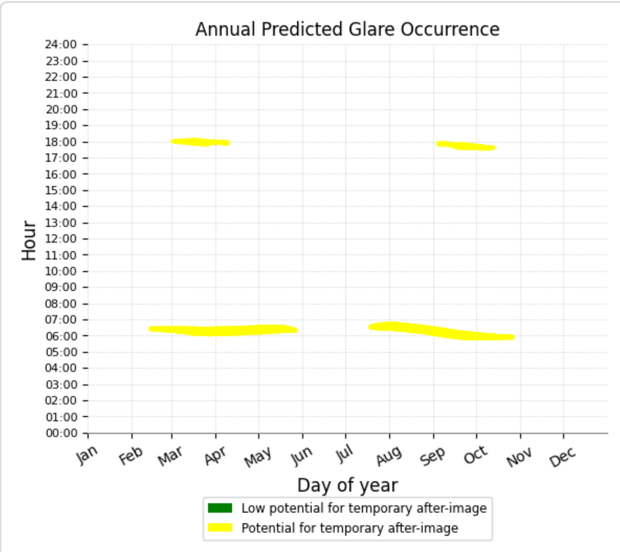


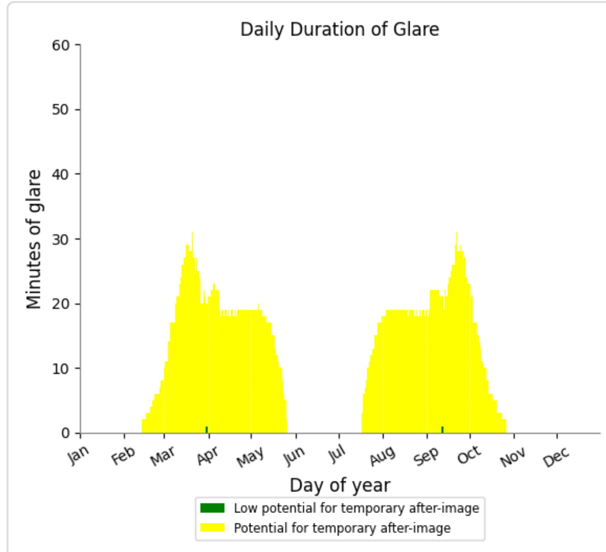


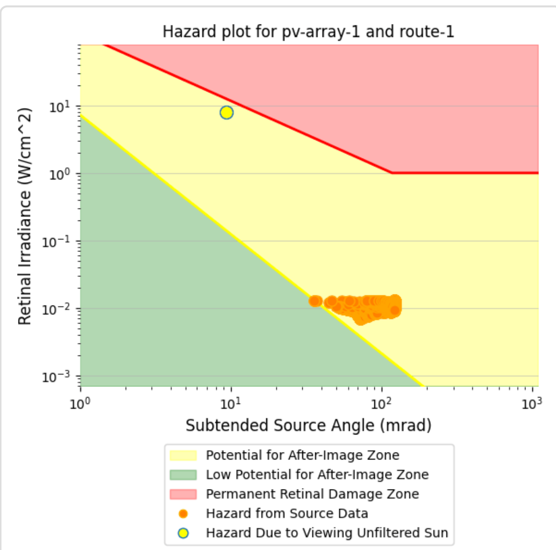
PV array 1 - Route Receptor (Route 1)

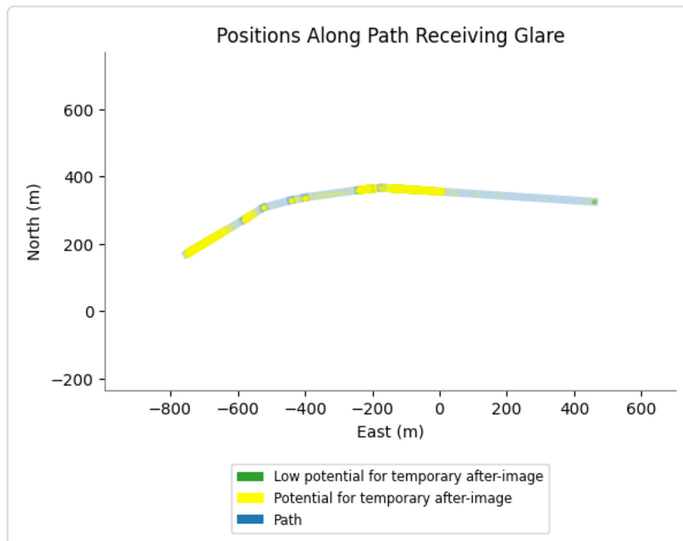
PV array is expected to produce the following glare for receptors at this location:

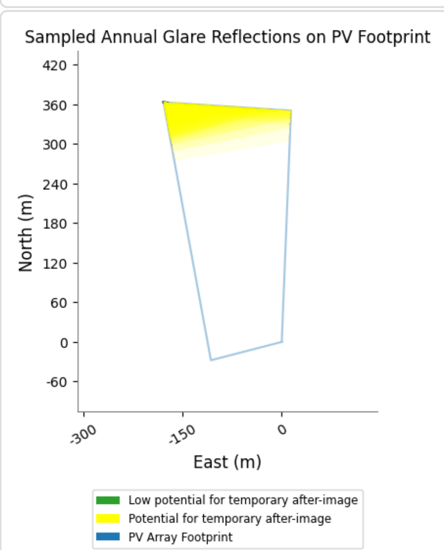
- 2 minutes of "green" glare with low potential to cause temporary after-image.
- 3,422 minutes of "yellow" glare with potential to cause temporary after-image.











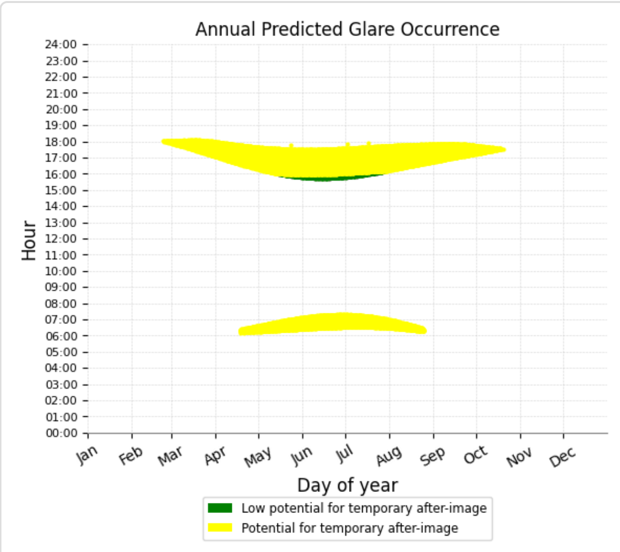
PV array 1 - Route Receptor (Route 2)

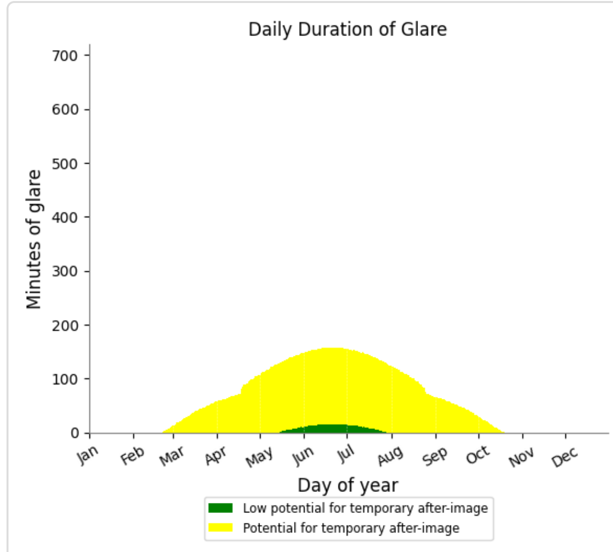
No glare found

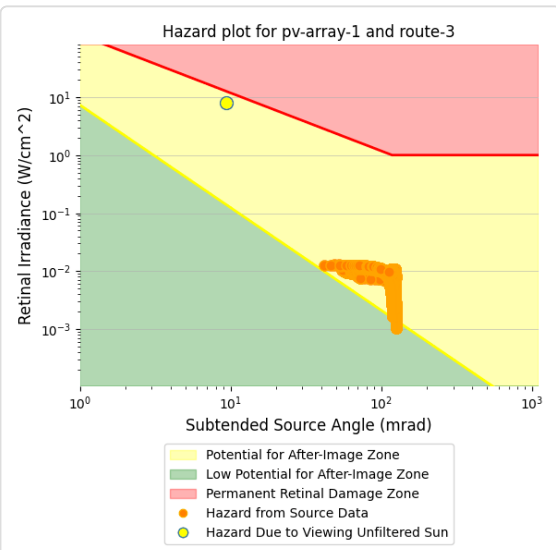
PV array 1 - Route Receptor (Route 3)

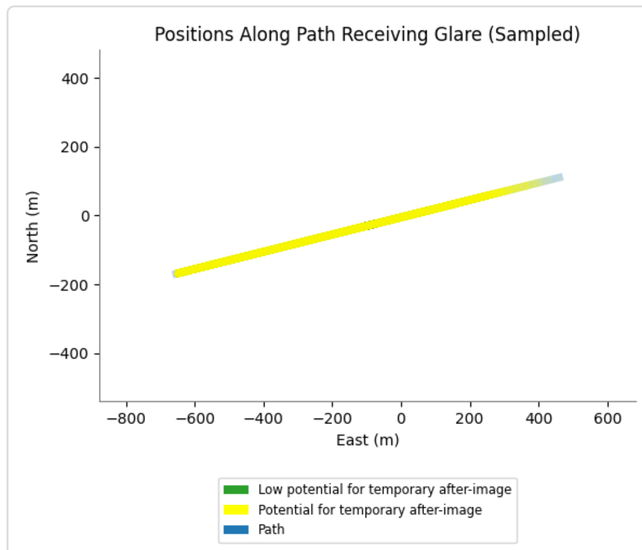
PV array is expected to produce the following glare for receptors at this location:

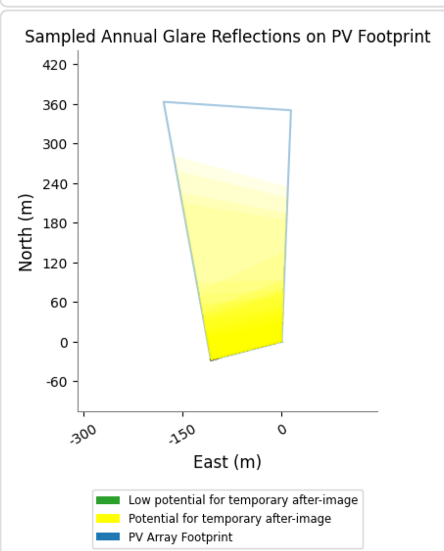
- 791 minutes of "green" glare with low potential to cause temporary after-image.
- 20,691 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, no 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

ForgeSolar

BNTCL 5MW PV Farm

BNTCL_DeeplyTextured_2FP

Client: BNOCL

Created May 12, 2022
Updated May 12, 2022
Time-step 1 minute
Timezone offset UTC-4
Site ID 69002.9238

Project type Advanced
Project status: active
Category 500 kW to 1 MW

Misc. Analysis Settings

DNI: **varies (1,000.0 W/m^2 peak)**
Ocular transmission coefficient: **0.5**
Pupil diameter: **0.002 m**
Eye focal length: **0.017 m**
Sun subtended angle: **9.3 mrad**

Analysis Methodologies:
- Observation point: **Version 2**
- 2-Mile Flight Path: **Version 2**
- Route: **Version 2**

Summary of Results

Glare with low potential for temporary after-image predicted

PV Name	Tilt	Orientation	"Green" Glare	"Yellow" Glare	Energy Produced
	deg	deg	min	min	kWh
PV array 1	15.0	180.0	348,811	0	-

Component Data

PV Array(s)

Total PV footprint area: 55,735 m^2

Name: PV array 1
Footprint area: 55,735 m^2
Axis tracking: Fixed (no rotation)
Tilt: 15.0 deg
Orientation: 180.0 deg

Rated power: -
Panel material: Deeply textured glass
Vary reflectivity with sun position? Yes
Correlate slope error with surface type? Yes
Slope error: 82.6 mrad

Vertex	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
1	13.077475	-59.499126	58.00	1.46	59.46
2	13.080642	-59.498997	63.41	1.46	64.87
3	13.080757	-59.500772	66.29	1.46	67.75
4	13.077224	-59.500113	56.11	1.46	57.57

2-Mile Flight Path Receptor(s)

Name: FP 1
Description:
Threshold height : 15 m
Direction: 76.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.071136	-59.506635	55.44	15.24	70.68
2-mile point	13.064416	-59.535538	24.28	215.08	239.36

Name: FP 2
Description:
Threshold height : 15 m
Direction: 255.6 deg
Glide slope: 3.0 deg
Pilot view restricted? Yes
Vertical view restriction: 30.0 deg
Azimuthal view restriction: 50.0 deg

Point	Latitude	Longitude	Ground elevation	Height above ground	Total elevation
	deg	deg	m	m	m
Threshold	13.078052	-59.478343	50.40	15.24	65.64
2-mile point	13.085227	-59.449555	0.00	234.33	234.33

Route Receptor(s)

Name: Route 1
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.079016	-59.506061	72.47	1.20	73.67
2	13.079935	-59.504484	71.15	1.20	72.35
3	13.080259	-59.503947	70.90	1.20	72.10
4	13.080458	-59.503196	70.27	1.20	71.47
5	13.080531	-59.502821	68.56	1.20	69.76
6	13.080730	-59.501351	67.09	1.20	68.29
7	13.080792	-59.500707	66.37	1.20	67.57
8	13.080416	-59.494892	61.43	1.20	62.63

Name: Route 2
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.080677	-59.498926	63.60	1.20	64.80
2	13.077438	-59.499033	58.00	1.20	59.20

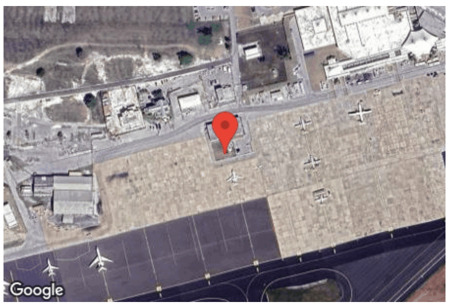
Name: Route 3
Route type Two-way
View angle: 50.0 deg

Vertex	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total elevation m
1	13.075943	-59.505159	59.58	1.20	60.78
2	13.078472	-59.494881	59.60	1.20	60.80

Discrete Observation Receptors

Number	Latitude deg	Longitude deg	Ground elevation m	Height above ground m	Total Elevation m
OP 1	13.077496	-59.501009	57.30	1.80	59.10
OP 2	13.077512	-59.501075	57.37	4.80	62.17
OP 3	13.077115	-59.501228	56.95	1.80	58.75
OP 4	13.078485	-59.505356	66.60	1.80	68.40
OP 5	13.080724	-59.502755	69.48	4.80	74.28
OP 6	13.080834	-59.502181	69.03	1.80	70.83
OP 7	13.080938	-59.499847	65.40	1.80	67.20
OP 8	13.079259	-59.495156	62.01	1.80	63.81
OP 9	13.077482	-59.497366	57.46	4.80	62.26
OP 10	13.076482	-59.499246	57.87	1.80	59.67
11-ATCT	13.078125	-59.490296	56.37	22.00	78.37

11-ATCT map image



Summary of PV Glare Analysis

PV configuration and total predicted glare

PV Name	Tilt deg	Orientation deg	"Green" Glare min	"Yellow" Glare min	Energy Produced kWh	Data File
PV array 1	15.0	180.0	348,811	0	-	-

Distinct glare per month

Excludes overlapping glare from PV array for multiple receptors at matching time(s)

PV	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
pv-array-1 (green)	5929	6460	9265	12243	17539	18672	18842	14269	9975	7770	6011	5626
pv-array-1 (yellow)	0	0	0	0	0	0	0	0	0	0	0	0

PV & Receptor Analysis Results

Results for each PV array and receptor

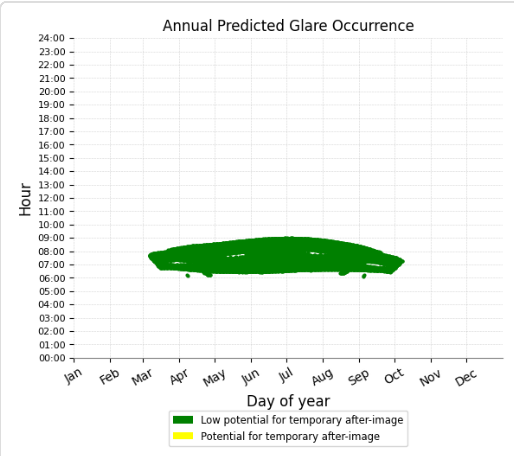
PV array 1 low potential for temporary after-image

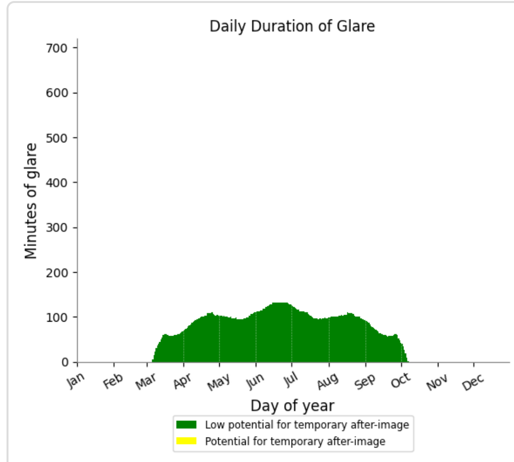
Component	Green glare (min)	Yellow glare (min)
FP: FP 1	19680	0
FP: FP 2	14095	0
OP: OP 1	734	0
OP: OP 2	33152	0
OP: OP 3	0	0
OP: OP 4	14757	0
OP: OP 5	27191	0
OP: OP 6	13537	0
OP: OP 7	3	0
OP: OP 8	44	0
OP: OP 9	23250	0
OP: OP 10	8540	0
OP: 11-ATCT	20310	0
Route: Route 1	56165	0
Route: Route 2	2048	0
Route: Route 3	115305	0

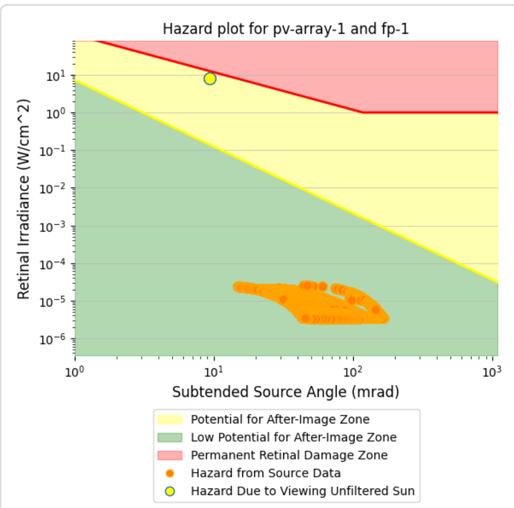
PV array 1 - Receptor (FP 1)

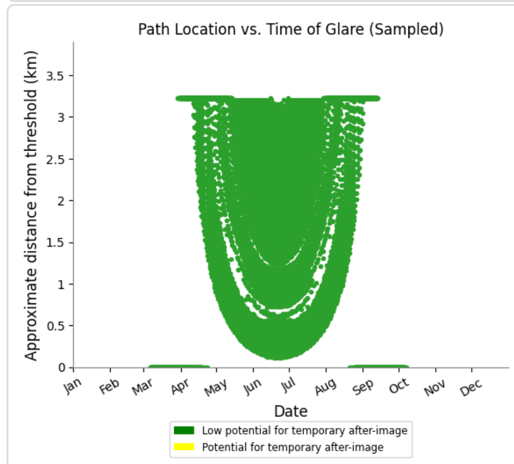
PV array is expected to produce the following glare for observers on this flight path:

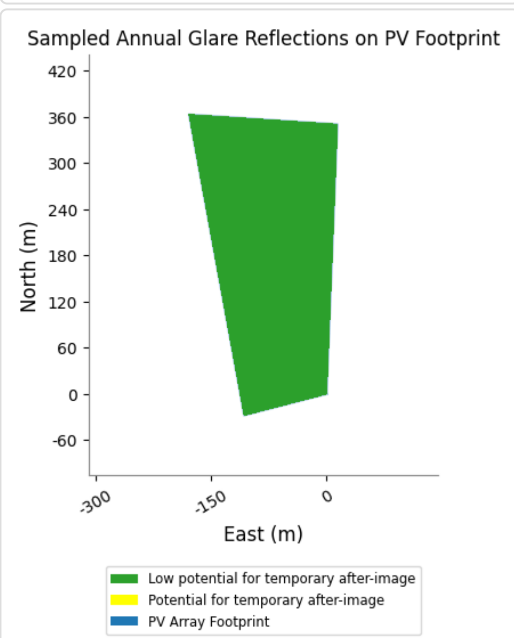
- 19,680 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

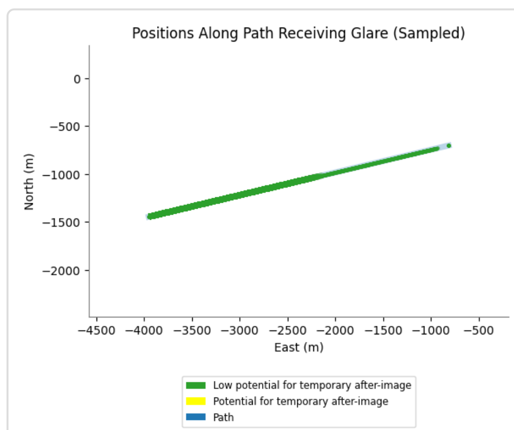








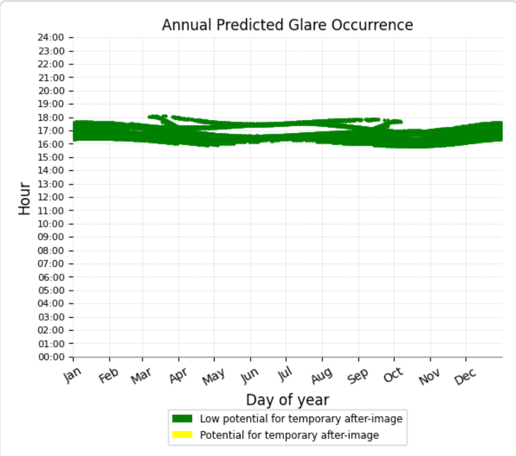


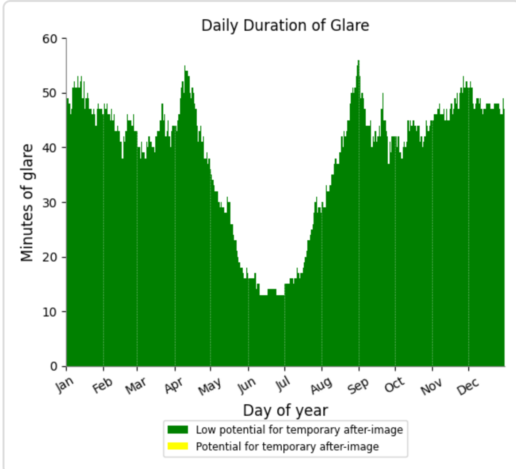


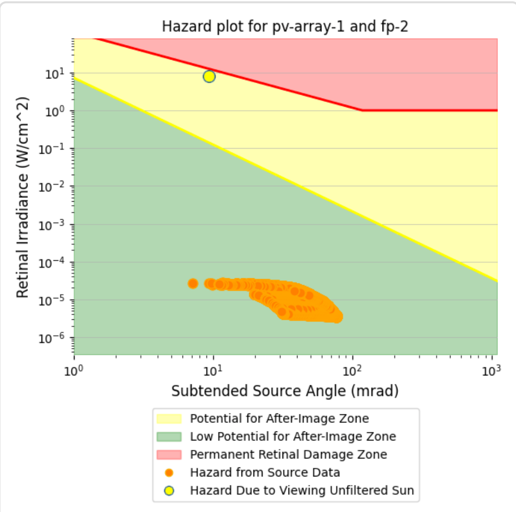
PV array 1 - Receptor (FP 2)

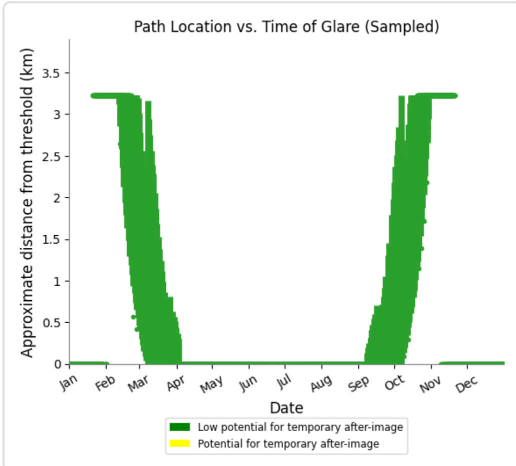
PV array is expected to produce the following glare for observers on this flight path:

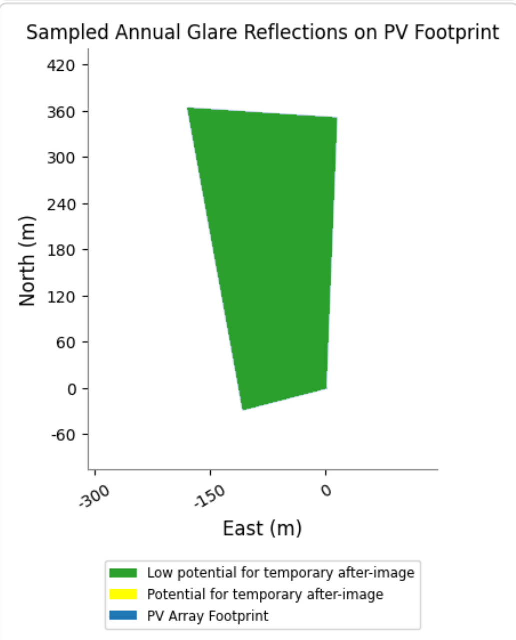
- 14,095 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.

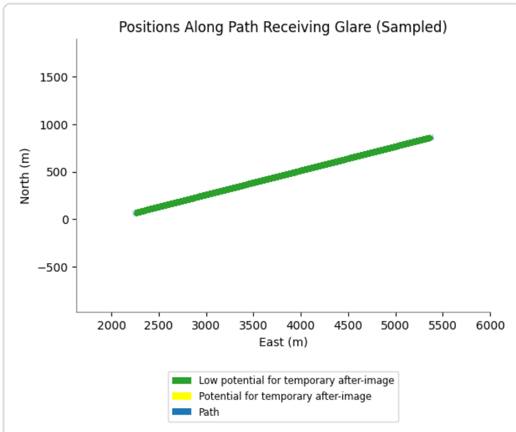








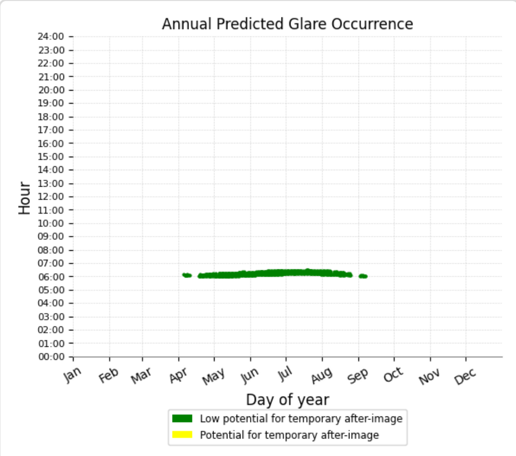


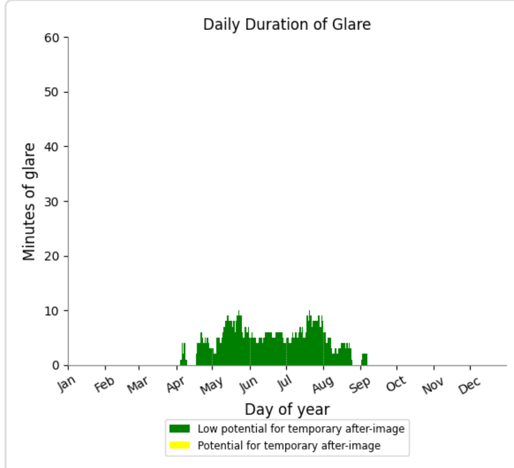


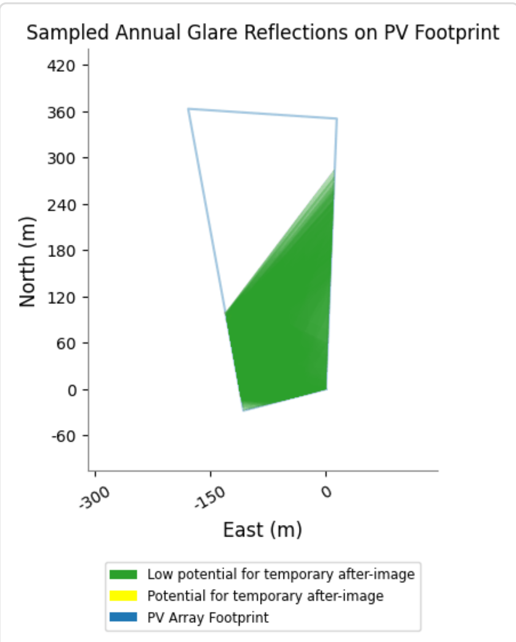
PV array 1 - OP Receptor (OP 1)

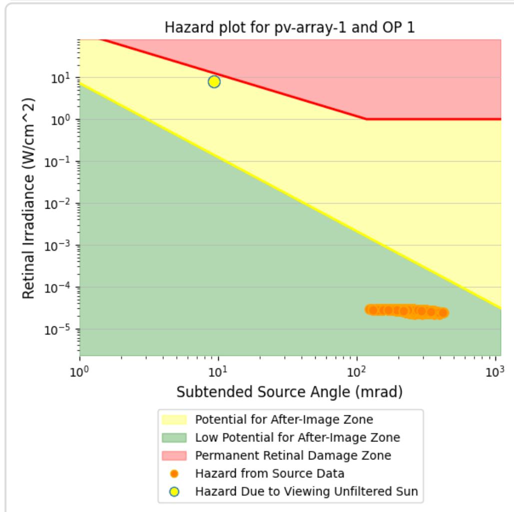
PV array is expected to produce the following glare for receptors at this location:

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





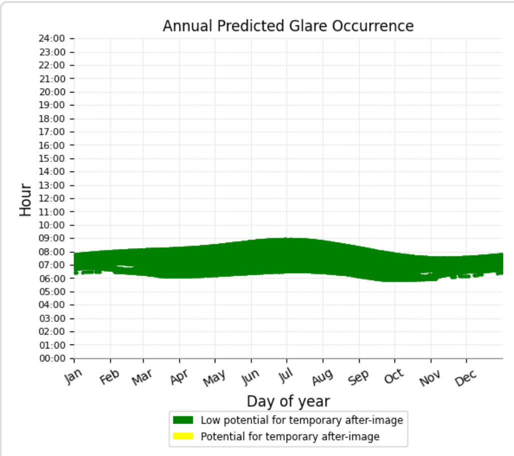


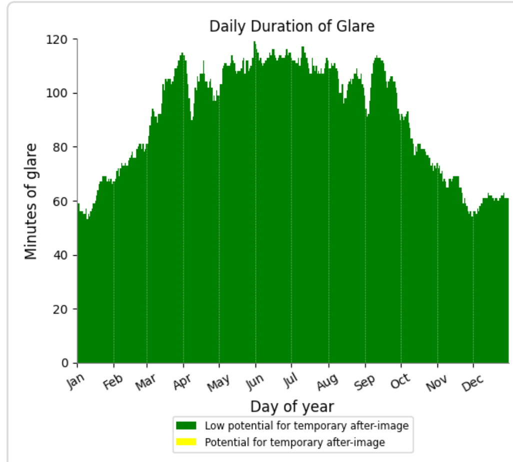


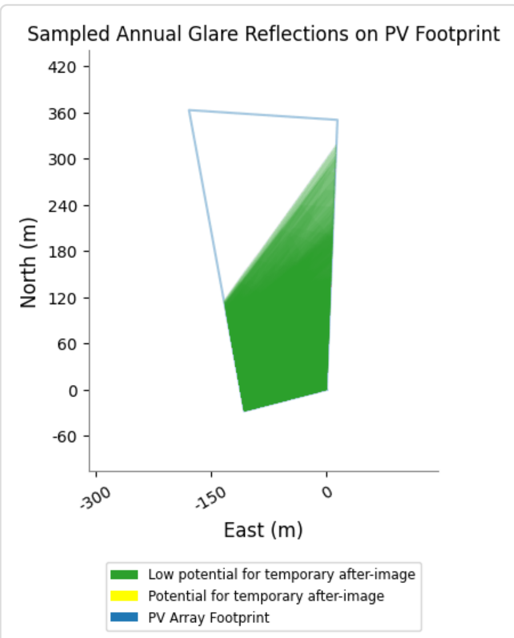
PV array 1 - OP Receptor (OP 2)

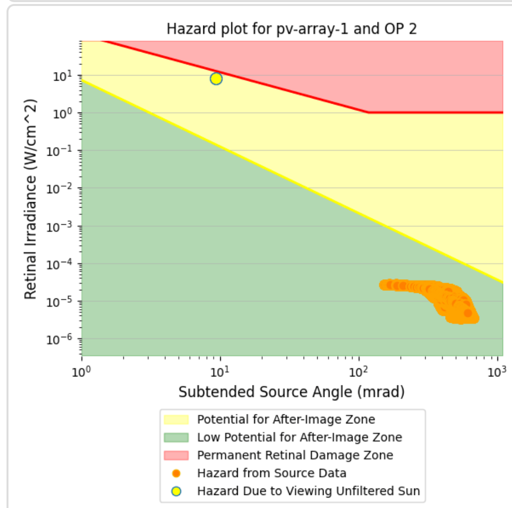
PV array is expected to produce the following glare for receptors at this location:

- 33,152 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.









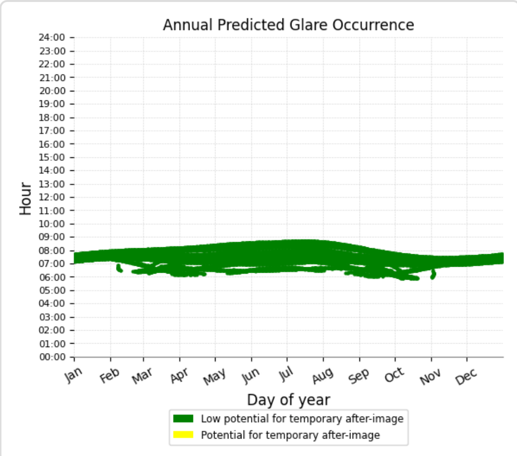
PV array 1 - OP Receptor (OP 3)

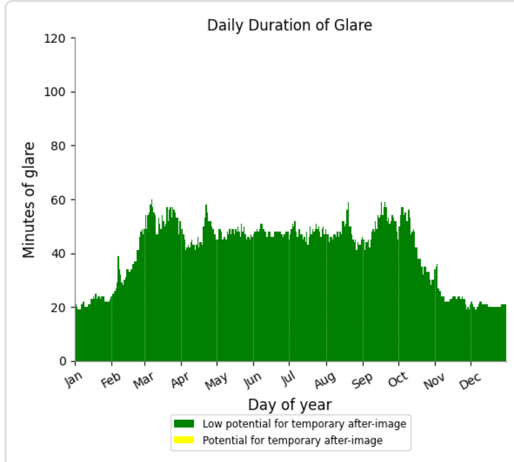
No glare found

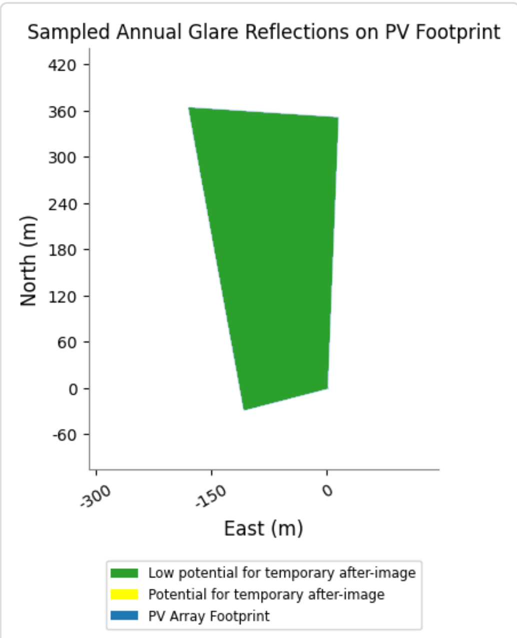
PV array 1 - OP Receptor (OP 4)

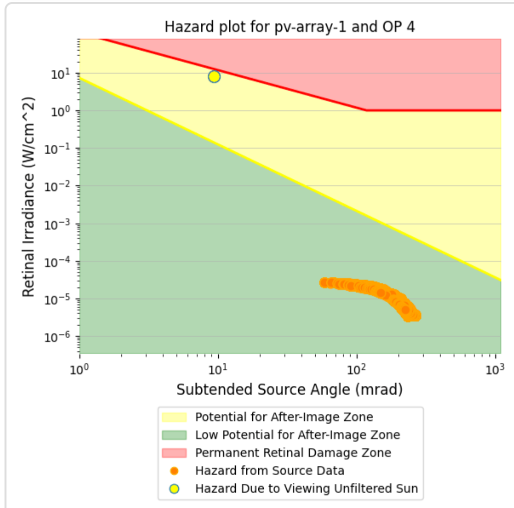
PV array is expected to produce the following glare for receptors at this location:

- 14,757 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





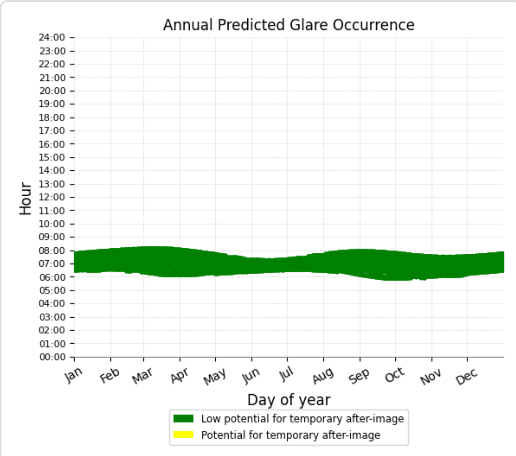


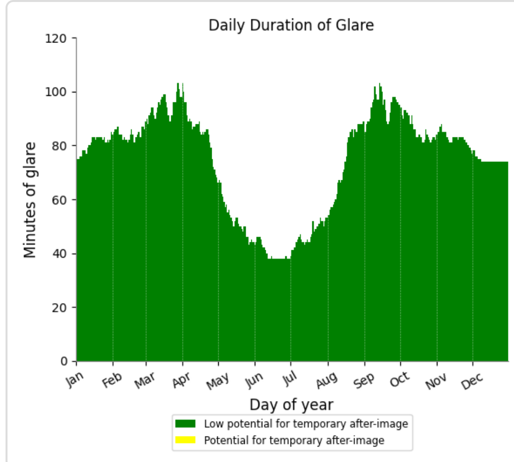


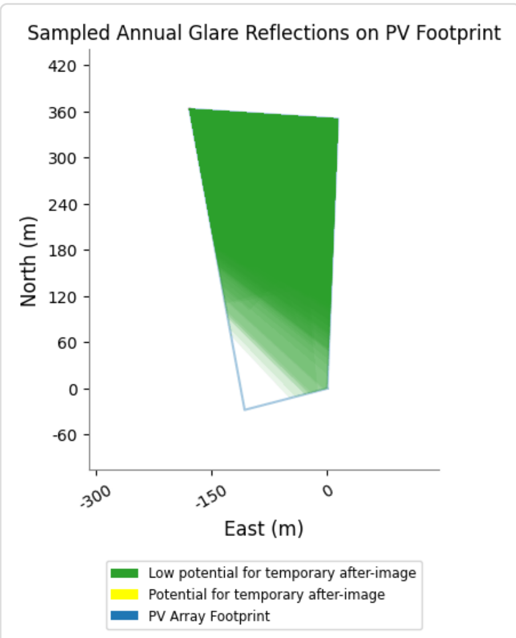
PV array 1 - OP Receptor (OP 5)

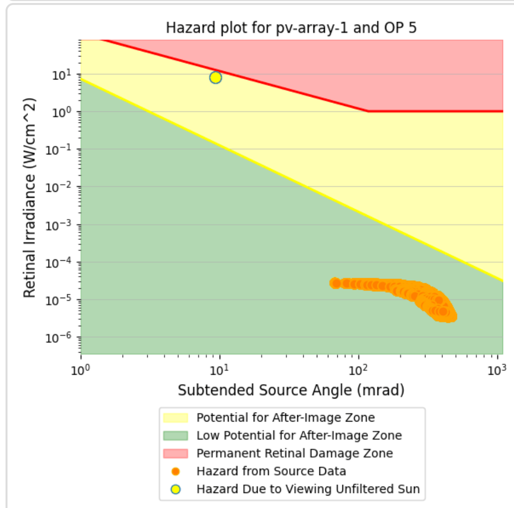
PV array is expected to produce the following glare for receptors at this location:

- 27,191 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





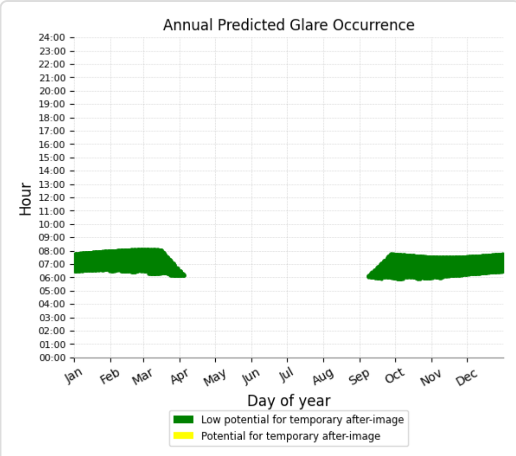


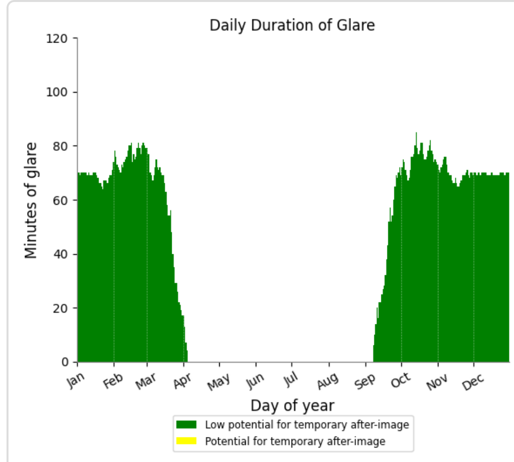


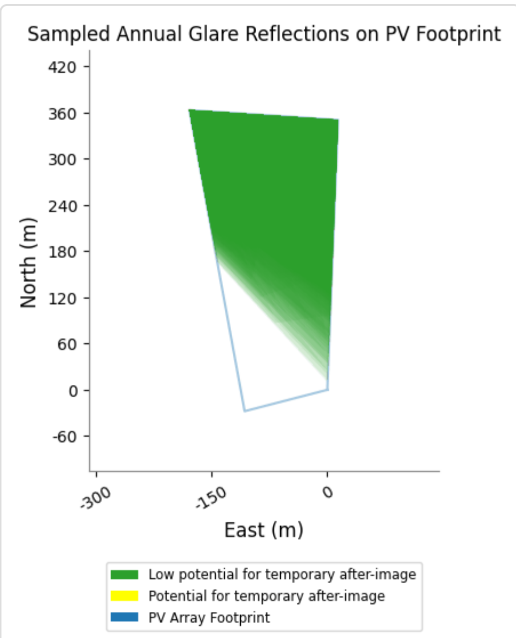
PV array 1 - OP Receptor (OP 6)

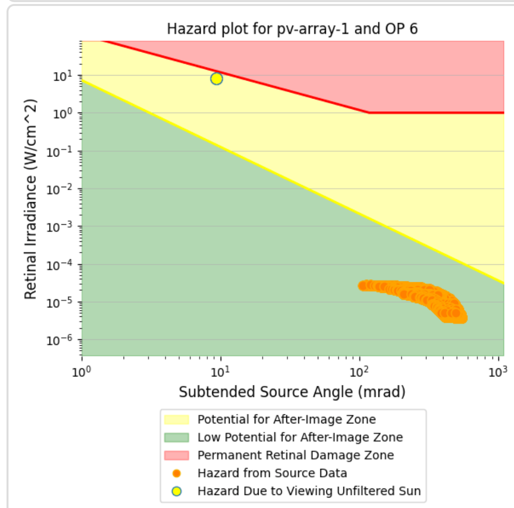
PV array is expected to produce the following glare for receptors at this location:

- 13,537 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





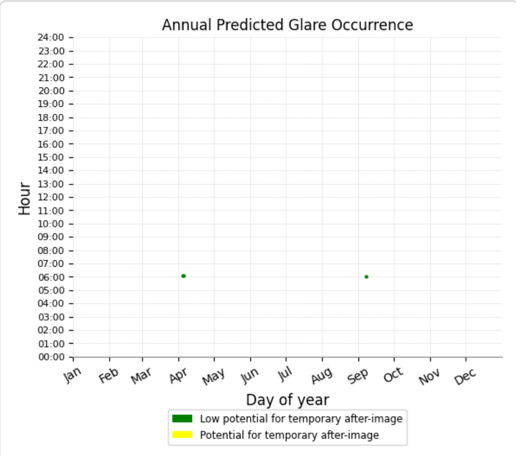


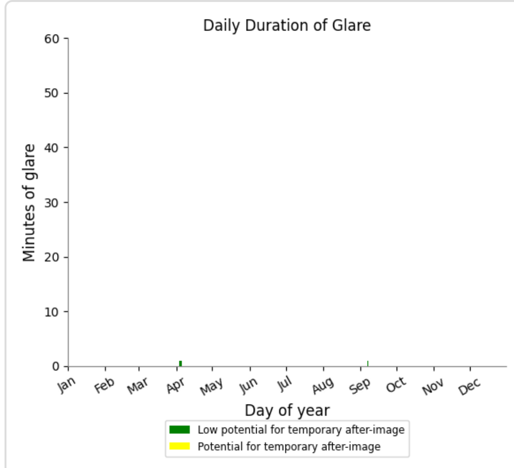


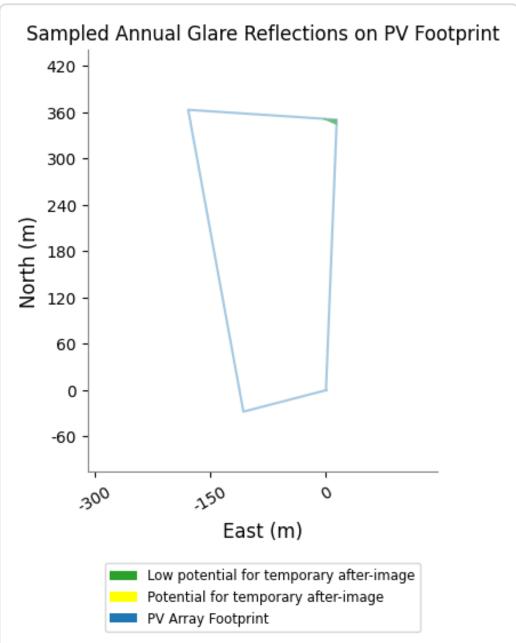
PV array 1 - OP Receptor (OP 7)

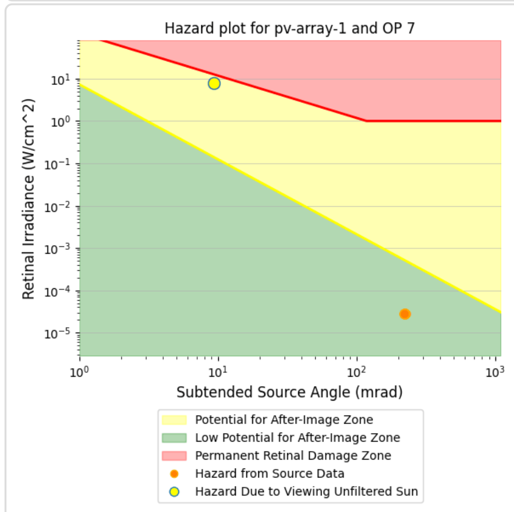
PV array is expected to produce the following glare for receptors at this location:

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





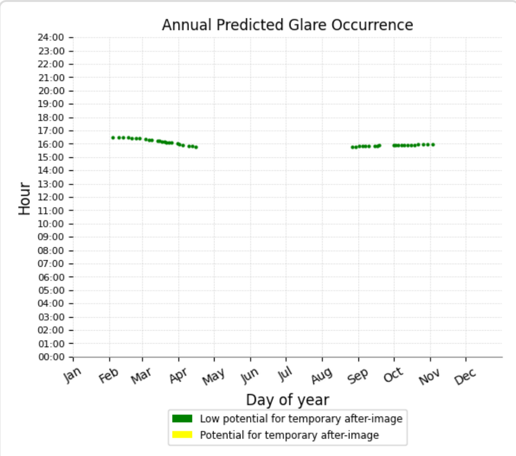


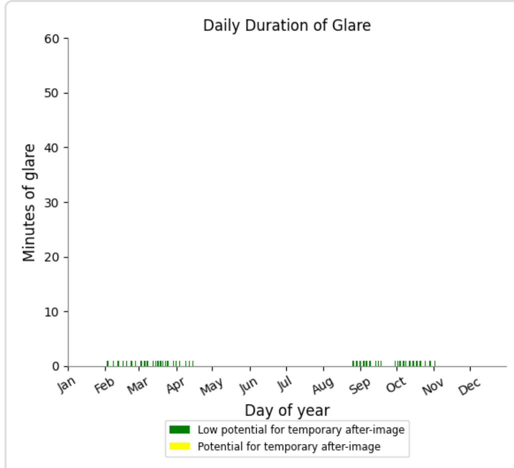


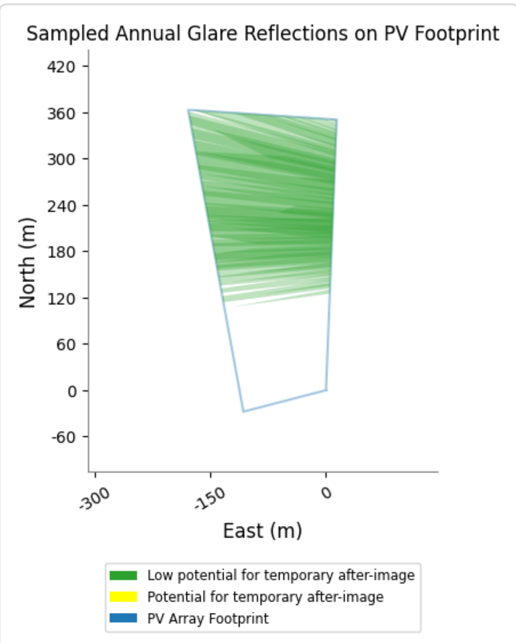
PV array 1 - OP Receptor (OP 8)

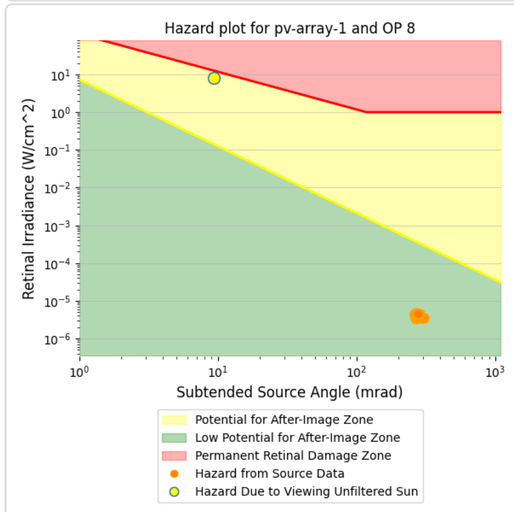
PV array is expected to produce the following glare for receptors at this location:

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





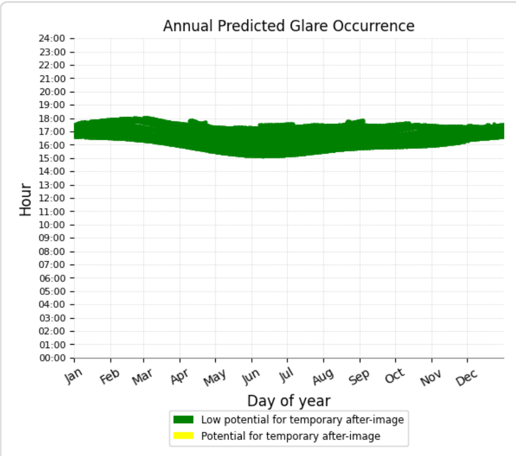


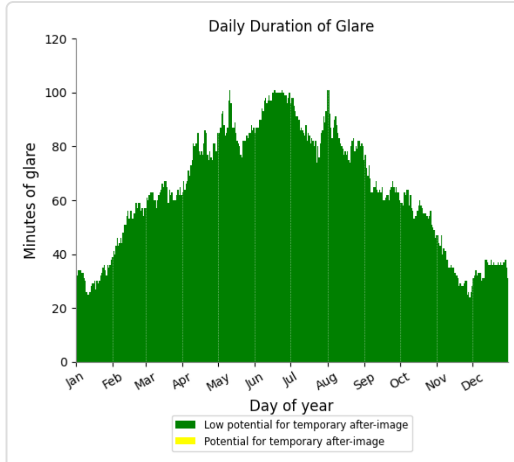


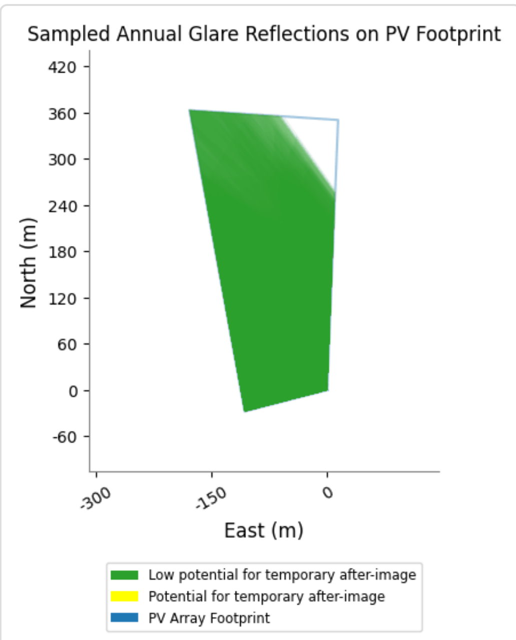
PV array 1 - OP Receptor (OP 9)

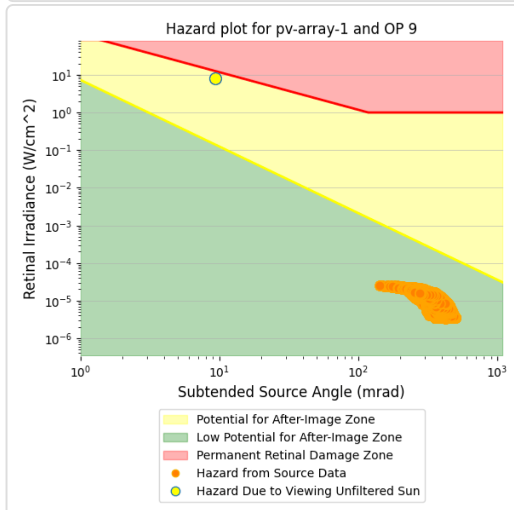
PV array is expected to produce the following glare for receptors at this location:

- 23,250 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





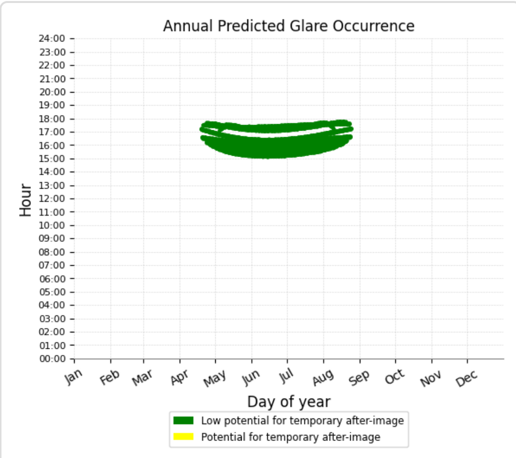


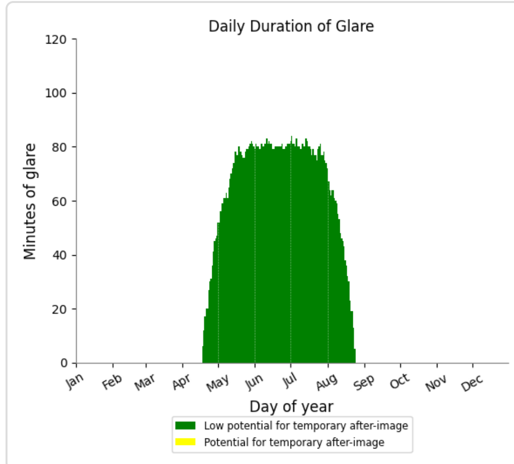


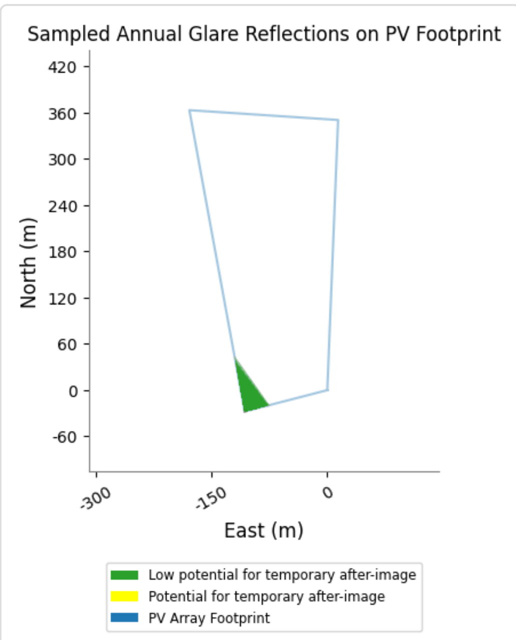
PV array 1 - OP Receptor (OP 10)

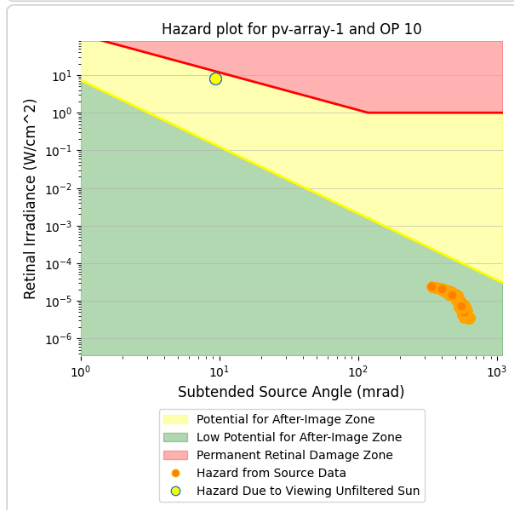
PV array is expected to produce the following glare for receptors at this location:

- 8,540 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





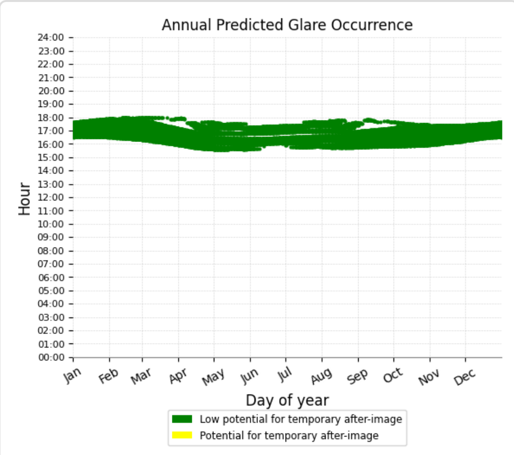


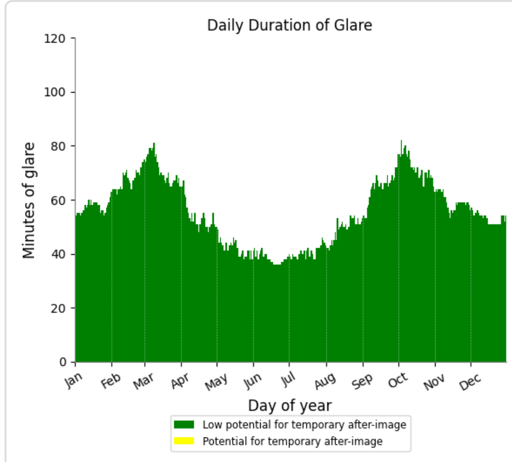


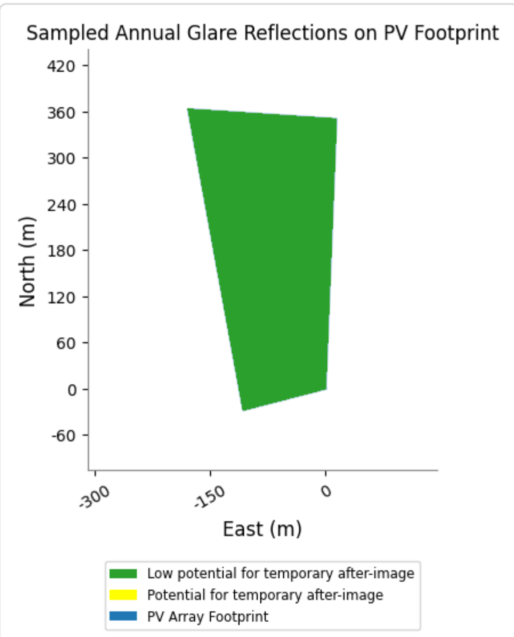
PV array 1 - OP Receptor (11-ATCT)

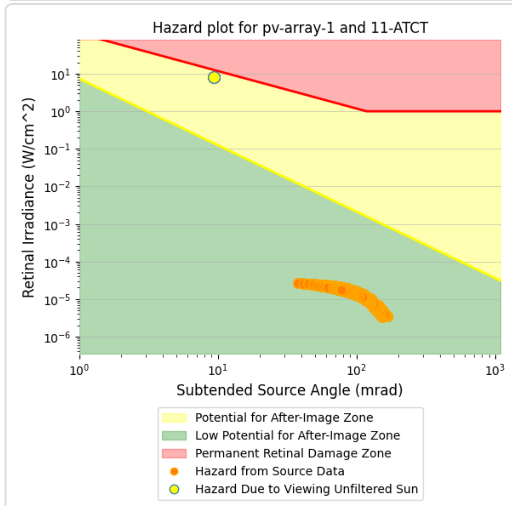
PV array is expected to produce the following glare for receptors at this location:

- 20,310 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.





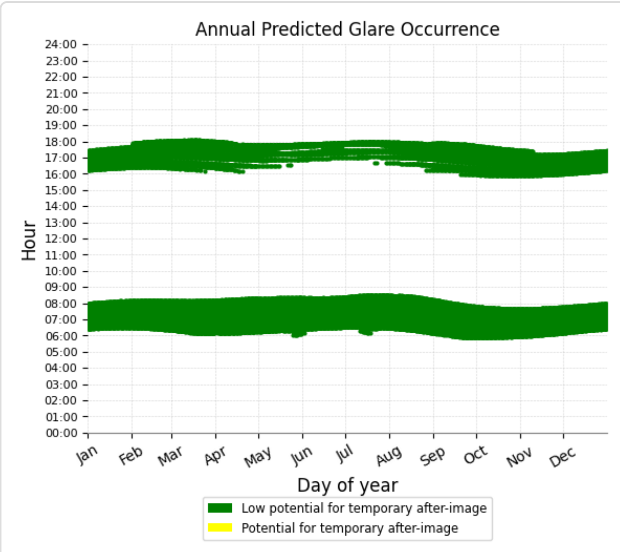


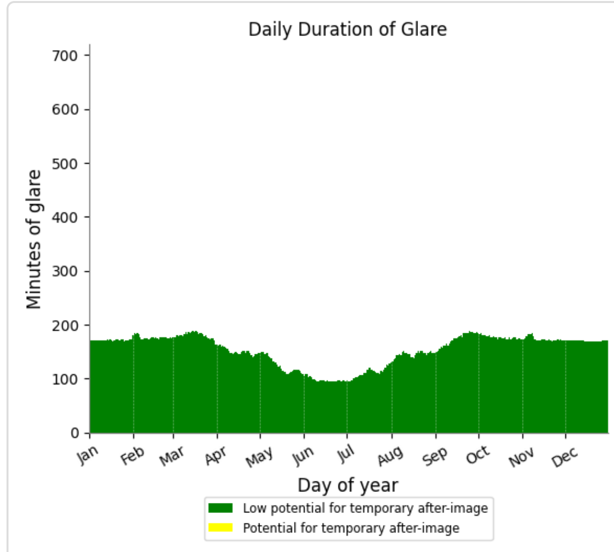


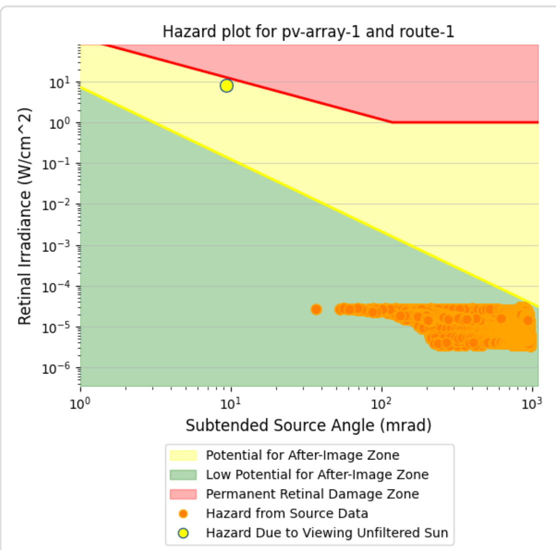
PV array 1 - Route Receptor (Route 1)

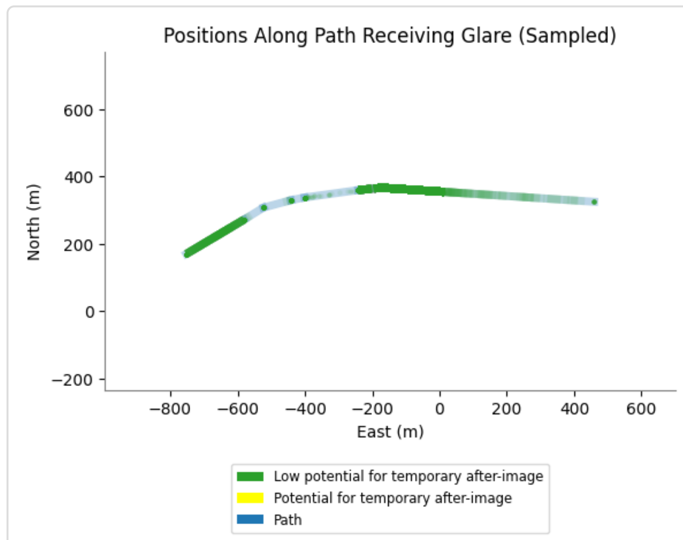
PV array is expected to produce the following glare for receptors at this location:

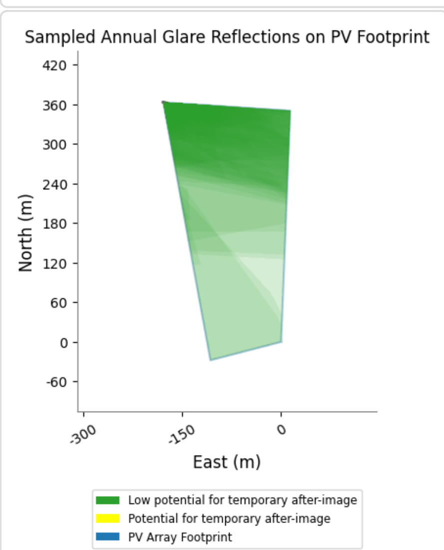
- 56,165 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







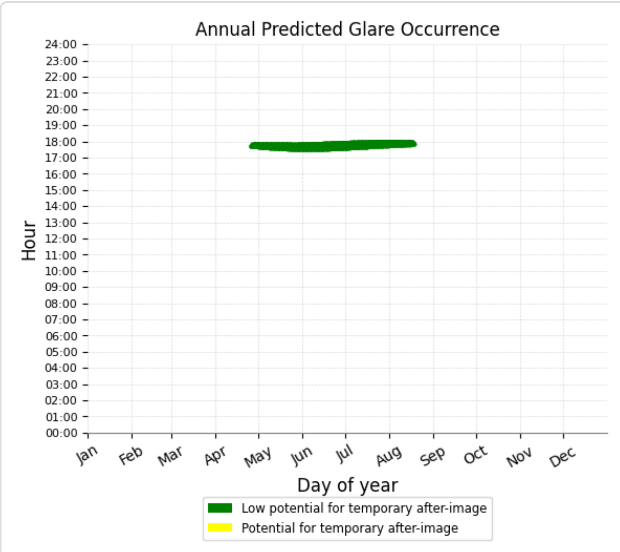


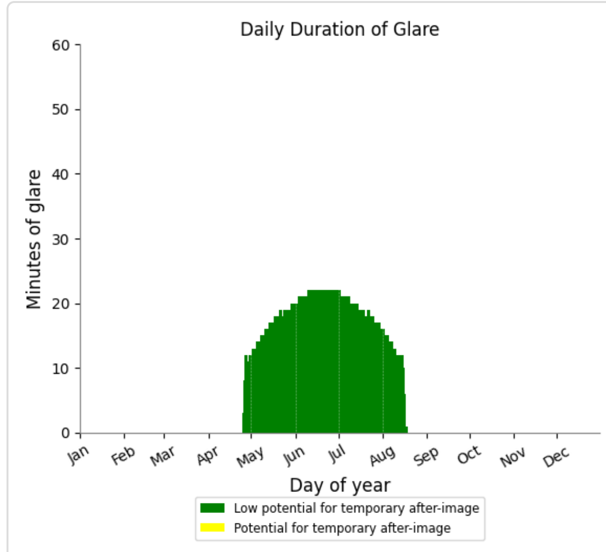


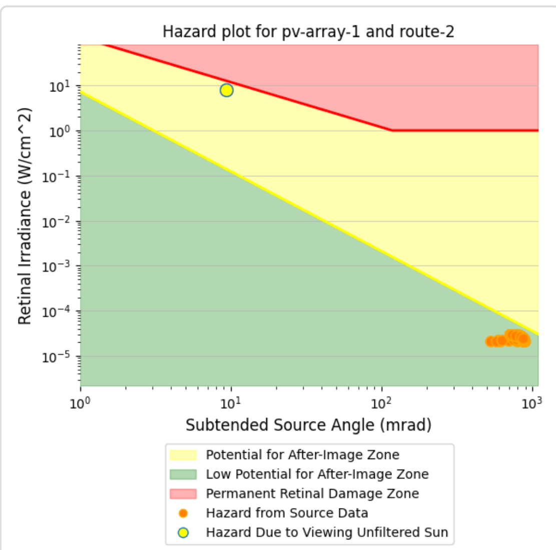
PV array 1 - Route Receptor (Route 2)

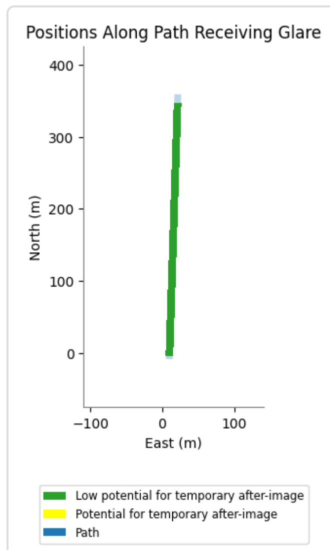
PV array is expected to produce the following glare for receptors at this location:

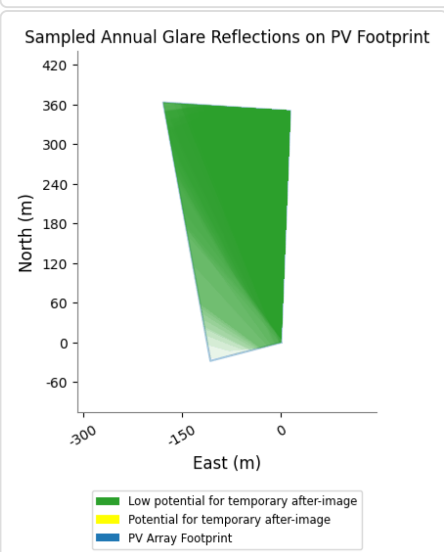
- 2,048 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.







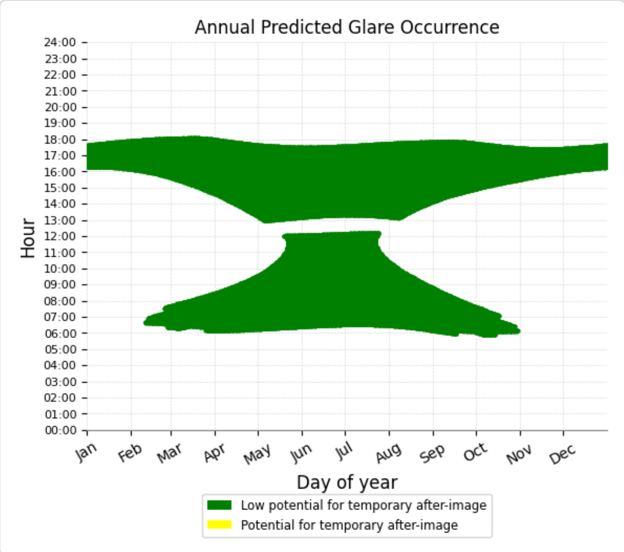


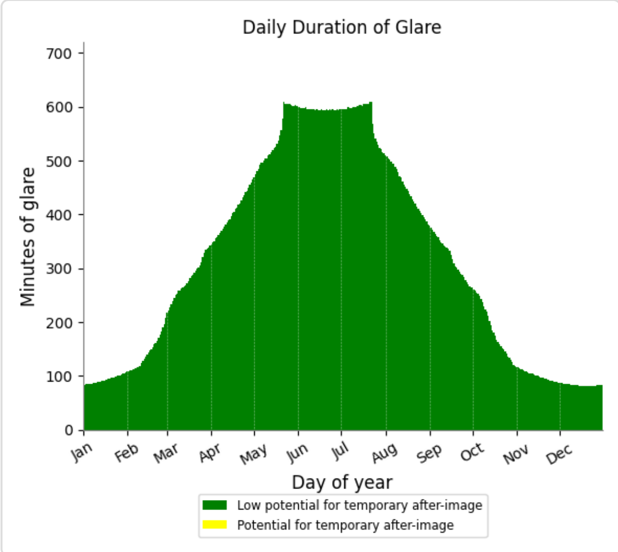


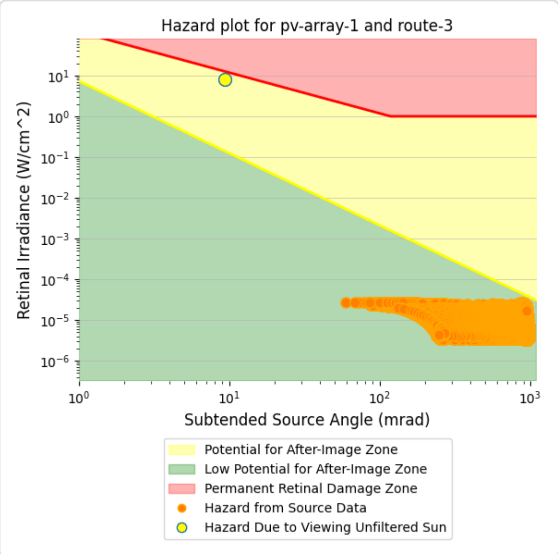
PV array 1 - Route Receptor (Route 3)

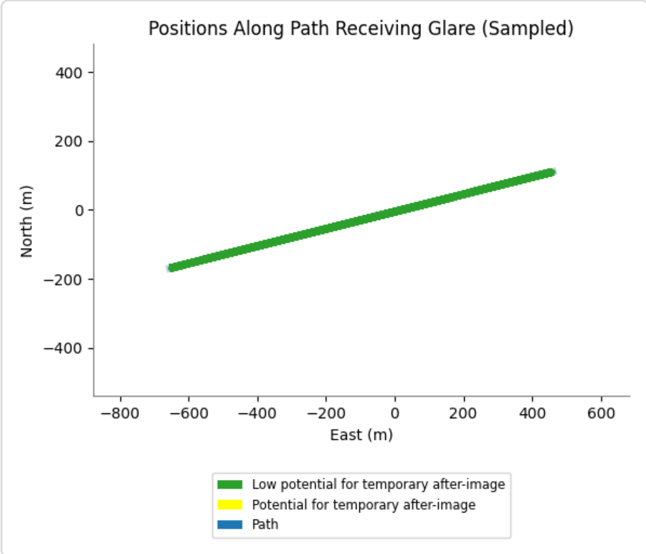
PV array is expected to produce the following glare for receptors at this location:

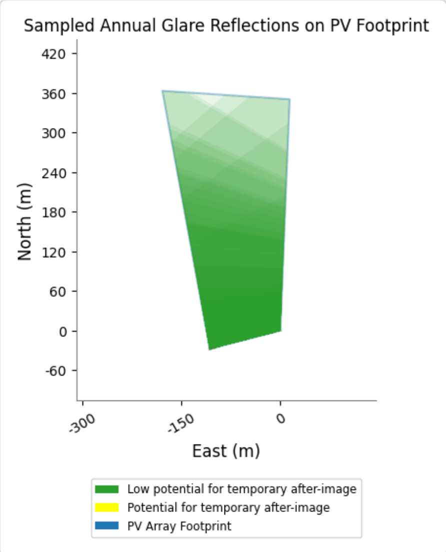
- 115,305 minutes of "green" glare with low potential to cause temporary after-image.
- 0 minutes of "yellow" glare with potential to cause temporary after-image.











Assumptions

- Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
- Glare analyses do not account for physical obstructions between reflectors and receptors. This includes buildings, tree cover and geographic obstructions
- Detailed system geometry is not rigorously simulated.
- The glare hazard determination relies on several approximations including observer eye characteristics, angle of view, and typical blink response time. Actual values and results may vary.
- The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
- Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for larg PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare.
- The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
- Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, nc 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.
- Refer to the **Help page** for detailed assumptions and limitations not listed here.

Appendix C

RAPID SOCIAL IMPACT ASSESSMENT STUDY

5MW PV Power Plant, Barbados National Oil Terminal

Rapid Social Assessment

Social Engagement Plan

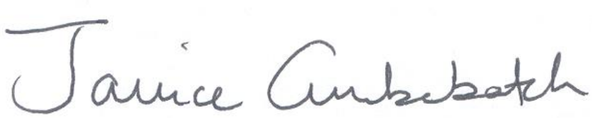
Grievance Redress Mechanism

Social Monitoring Plan

May 2022

Submitted: 27 May 2022

Submitted by: Janice Cumberbatch Ph. D (Consultant)

Signature: 

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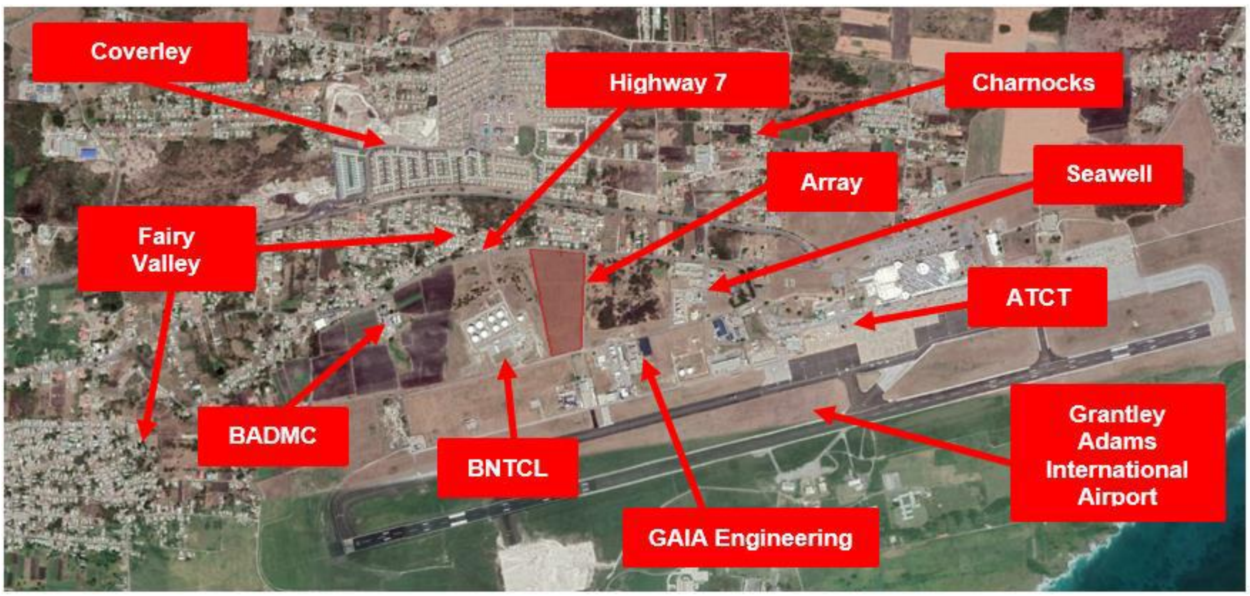
Rapid Social Assessment

1 Rapid Social Assessment - Introduction

The Developer proposes the construction of a Photo Voltaic “solar farm” on the lands of the Barbados National Terminal Corporation Ltd. (BNTCL), Fairy Valley, Christ Church, Barbados. The farm will occupy an approximate area of 56,000m^2 (13.84 acres). The solar farm will consist of 14,520 ground mounted panels facing in a Southward direction at a tilt angle of 15 degrees to the horizontal. This system is proposed to produce 5MW AC of renewable energy for integration in the Barbados Light & Power Co. Ltd’s (BL&P) electricity grid. The farm is near to the Grantley Adams International Airport (GAIA).

Figure 1: Map of communities adjacent to the project area



The following rapid social assessment provides a summary of the main potential social impacts based on secondary sources of data.

2 Regulatory considerations

Table 1 provides a listing and description of the several policies, laws and regulations that govern the energy sector in Barbados.

Table 1: Description of the policies, laws and regulations associated with renewable energy in Barbados

Legislation	Description
National Strategic Plan of Barbados for 2005–2025	The National Strategic Plan of Barbados 2005 – 2025, was developed to enhance Barbadian society to become prosperous and globally competitive by 2025. One objective within the Plan was to ensure an efficient and reliable energy sector. This included programmes to expand renewable energy; 40% of the energy supply was to be derived

	from renewable energy and increased renewable energy production and usage.[12]
The National Sustainable Development Policy	The National Sustainable Development (NSD) Policy attempted to encourage an integrated and holistic approach to sustainable development. The NSD Policy sought to ensure Barbados met the obligations as a party of UNFCCC through alternative energy, energy efficiency and conservation.[3]
Sustainable Energy Framework for Barbados	The objective of the Sustainable Energy Framework for Barbados was to promote renewable energy and energy efficiency to reduce the fossil fuel dependency while enhancing energy security and environmental sustainability[4].
Draft National Sustainable Energy Policy	Developed as a complementary policy to the Sustainable Energy Framework, the Draft National Sustainable Energy Policy addressed the high importation of fossil fuels and sought to increase efficiency and sustainability in the energy supply and demand. The policy aimed to encourage energy cost reduction technologies, reduce fossil fuel dependency, and decrease the impacts of global warming[5].
Barbados National Energy Policy 2017 – 2037	The Barbados National Energy Policy 2017 – 2037 aimed to provide a direction for Barbados to transition from a fossil fuel-based economy to mainly renewable energy. The BNEP 2017 – 2037 sought to ensure energy security that was affordable with a sustainable energy sector with increased renewable energy and energy efficiency[6].
Barbados National Energy Policy 2019 – 2030	The Barbados National Energy Policy 2019 – 2030 outlines the transition to a 100% renewable energy and carbon-neutral island by 2030. The policy attempts to ensure the provision of reliable, sustainable climate-friendly energy with zero domestic fossil fuel consumption and expansion of research and development in renewable energy[7].
The Electric Light and Power Act (2013)	The Electric Light and Power Act (ELPA) allows independent power producers (IPPs) (residential and commercial) with a license to generate electricity from renewable energy sources and supply the excess to the BL&P. The ELPA initially allowed 20MW of solar PV and 15 MW of wind energy to be supplied to the grid[8].

[1] Government of Barbados. 2005. "National Strategic Plan of Barbados 2005-2025." Government of Barbados, Bridgetown, Barbados. http://www.sice.oas.org/ctyindex/BRB/Plan2005-2025.pdf

[2] Green Growth Knowledge Platform. 2019. "Barbados Draft National Sustainable Energy Policy." Accessed 13th August 2019. https://www.greengrowthknowledge.org/national-documents/barbados-draft-national-sustainable-energy-policy.

[3] Government of Barbados. 2004. "National Sustainable Development Policy for Barbados." Government of Barbados, Bridgetown, Barbados

[4] Division of Energy 2019. "Sustainable Energy Framework for Barbados." Accessed 1st July 2019. https://www.energy.gov.bb/web/sustainable-energy-framework-for-barbados

[5] Division of Energy. 2019. "National Sustainable Energy Policy." Accessed 30th June 2019. https://www.energy.gov.bb/web/national-sustainable-energy-policy.

[6] Division of Energy. 2019. "National Energy Policy for Barbados 2017 - 2037." Accessed 30th June 2019. http://www.energy.gov.bb/web/barbados-national-energy-policy-2017-2037

[7] Division of Energy. 2019. "National Energy Policy for Barbados 2019 - 2030." Accessed 5th December 2019. https://www.energy.gov.bb/web/national-energy-policy-for-barbados-2019-2030.

[8] Brown, Desmond. 2017. "Barbados Steps Up Plans for Renewables, Energy Efficiency | Inter Press Service." 2017. http://www.ipsnews.net/2017/07/barbados-steps-plans-renewables-energy-efficiency/.

The Fair Trading Commission Act (2001)	The Fair Trading Commission Act allows the Fair Trading Commission (FTC) and regulation of the Renewable Energy Rider[9].
The Utilities Regulation Act	The Utilities Regulation Act enforced by the FTC, monitors and establishes the rates to be passed to consumers while determining a maximum rate charge[10].
Renewable Energy Rider	The Renewable Energy Rider was an agreement allowing domestic customers to sell energy back to the electrical grid at 1.6 times the level of the Fuel Clause Adjustment[11].
Feed-in-tariff	The feed-in-tariff is a pricing framework that provides fixed electricity rates paid to renewable energy producers for each unit of energy produced and sent to the electrical grid. This action offers stability and confidence for investors into renewable energy. The feed-in-tariff replaces the renewable energy rider, established in 2010[12] (Government Information Service 2019b).

Source: Ayanna Evelyn. 2020. The knowledge, attitude, and practices toward renewable energy among Barbadian university students and their households. A Research Paper Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science in Natural Resource and Environmental Management of The University of the West Indies.

More broadly, beyond the energy sector, Barbados has utilised a Physical Development Plan (PDP) since the 1970s to provide a national settlement development strategy and policies. Although a Physical Development Plan (PDP) 2017[13] has been prepared, it is still in draft pending amendments to align it to recently approved planning legislation. As such, the proposed development must be compliant with the requirements of the existing Physical Development Plan (PDP) 2003[14]. Notably, the policies detailed in the 2003 document to address the issues of noise, safety, and the potential effects of long-term exposure to radar emissions associated with development in proximity to the Grantley Adams International Airport, remain the same in the 2017 document as follows:

i. There shall be no subdivision of land where vacant lots will be created within the Approach and Take-off Zones (NEF 25 to 28 and NEF 28 to 30), NEF 30 to 35 and NEF 35 to NEF 40.
ii. One single family house only per lot or parcel of land will be permitted in the Approach and Take-off Zones (NEF 25 to 28 and NEF 28 to 30), NEF 30 to NEF 35, and NEF 35 to NEF 40.
iii. There shall be no new development within the NEF 40 or greater except that which is associated with the GAIA.
iv. There shall be no development (building) within a 300 metre radius of the Radar Facility.

[9] International Business Publications. 2017. Barbados Energy Policy, Laws and Regulations Handbook Volume 1 . https://books.google.com/books?id=-AcABwAAQBAJ&pg=PA54&lpg=PA54&dq=the+fair+trading+commission+barbados+and+renewable+energy&source=bl&ots=eOnp0SgTxE&sig=ACfU3U3ouuVWaeGBhmvb2sUWc9K46B44dA&hl=en&sa=X&ved=2ahUKEwjqqpuq6q3lAhWlxFkKHb1hArMQ6AEwB3oECAkQAg#v=onepage&q=the fair trading commission barbados and renewable energy&f=false.
[10] REEEP. 2013. "Barbados (2014)." Accessed 15th August 2019. https://www.reeep.org/barbados-2014
[11] Government of Barbados. 2017. Barbados National Energy Policy (2017-2037). Government of Barbados, Bridgetown, Barbados.
[12] Government of Barbados. 2019. "The National Strategic Plan of Barbados 2006-2025: Global Excellence, Barbadian Traditions." Accessed 13th August 2019. https://www.greengrowthknowledge.org/national-documents/national-strategic-plan-barbados-2006-2025-global-excellence-barbadian-traditions.
[13] Government of Barbados. 2017. *Barbados Physical Development Plan, Amendment. Draft February 2017. Toward a Green, Prosperous and Resilient Nation.* s.l.: Government of Barbados Printing Department.
[14] Government of Barbados. 2003. *Barbados Physical Development Plan, Amended (2003).* Government of Barbados Printing Department.

v. The height of any structure which falls within the 300 metre and 1000 metre radius of the Radar Facility will be restricted. The maximum allowable elevation will be determined on an individual basis and based on Barbados Datum. Roof covering and any material used to erect means of enclosure shall be non-metallic.

vi. There shall be no development in the radar line of sight cones except that which is associated with the GAIA.

In addition, **the Civil Aviation Act Cap. 288A**[15] makes provision in Section 12 for the control over land in interest of civil aviation. Specifically, the Minister can declare any land, structure, works or apparatus specified in the order, subject to control, if satisfied that it is necessary to do so in the interest of civil aviation.

With specific reference to health and safety of persons living within proximity of the project there is the more general **Health Services Act, Cap. 44 (1999-18) Commencement 1 September 1969.** This Act relates to the promotion and preservation of the health of the inhabitants of Barbados and makes provision, *inter alia,* for Public Health Inspectors and their duties, and confers on the Minister the right to serve notice on premises in the interest of the public health. There are also provisions for regulations to ensure water quality, disposal of waste, control of vermin, maintaining sanitary conditions and preventing the incidence of disease, including food borne illness[16]. Two regulations relevant to this project are the Health Services (Building) Regulations, 1969 and the Health Services (Nuisance) Regulations, 1969.

Specific legislation addressing the health and safety of workers is found in the **Safety and Health at Work Act, Cap. 356 (2005-12) Commencement 1 January 2005** which makes provisions for (a) securing the health, safety and welfare of persons at work; (b) protecting other persons against risks to health and safety in connection with the activities of persons at work; and (c) controlling the release of certain emissions into the environment[17].

Barbados does not have any specific gender-focused legislation, but it has adopted relevant gender related international conventions, i.e. the Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) and The Inter-American Convention on the Prevention, Punishment, and Eradication of Violence against Women. There is a Bureau of Gender Affairs which has been working on the development of a national gender policy. However, the UN Women Caribbean Gender Portal confirms that the policy is not yet in place[18]. In the 2016 country assessment, Rawwida Baksh and Associates reported that with regard to the Conventions on Equal Remuneration and Discrimination, the International Trade Union Confederation (ITUC) has commented that Barbados' efforts to address gender discrimination in employment and remuneration need to be strengthened[19].

2.1 Regulatory agencies

Competent authorities with regulatory responsibilities for the social aspects of this project include:

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[15] Government of Barbados. 1983. *Civil Aviation, Cap 288 A.* Commencement 1983/156. Bridgetown, Barbados: Government of Barbados (GOB), Printing Department

[16] Government of Barbados. 1969. *Health Services Act, Cap. 44 (1999-18) Commencement 1 September 1969.* Bridgetown, Barbados: Government of Barbados (GOB), Printing Department, 1969.

[17] Government of Barbados. **2005.** *Safety and Health at Work Act, Cap. 356 (2005-12) Commencement 1 January 2005*. Bridgetown, Barbados : Government of Barbados (GOB), Printing Department, 2005.

[18] https://caribbean.unwomen.org/en/caribbean-gender-portal/barbados

[19] Rawwida Baksh and Associates. 2016. *Country Gender Assessment Barbados*. Caribbean Development Bank.

- The Town and Country Development Planning Office – responsible for policy and regulation of physical planning and development and ongoing monitoring of the implementation of construction activities.
- The Prime Minister's Office Planning Unit (PMOPU) – responsible for the regulation of EIA in Barbados and controlling the development of land having regard to proper planning standards and environmental management practices.
- The Division of Energy – responsibility for monitoring and regulating the energy sector, RE and energy conservation, and the development of policy by collaborating closely with institutions and stakeholders with an active role in the energy sector.
- The Ministry of Environment and National Beautification – specifically, (i) The Environmental Protection Department with primary responsibility for environmental regulations related to noise, water and air quality; and (ii) The Sanitation Services Authority with responsibility for solid waste collection and disposal.
- Ministry of Labour and Social Partnership Relations – The Labour Department with responsibility for ensuring decent work standards.

3 Rapid social assessment of the adjacent communities

Two methods were used to collect social information on the communities likely to be affected by the project. Google Earth was first used to identify and characterize communities and social amenities surrounding the project site. This was followed by a drive through of the areas immediately surrounding the project site to ground truth the information collected via Google Earth. The communities identified were Charnocks, Coverley, Fairy Valley, the airport and its immediate surroundings.

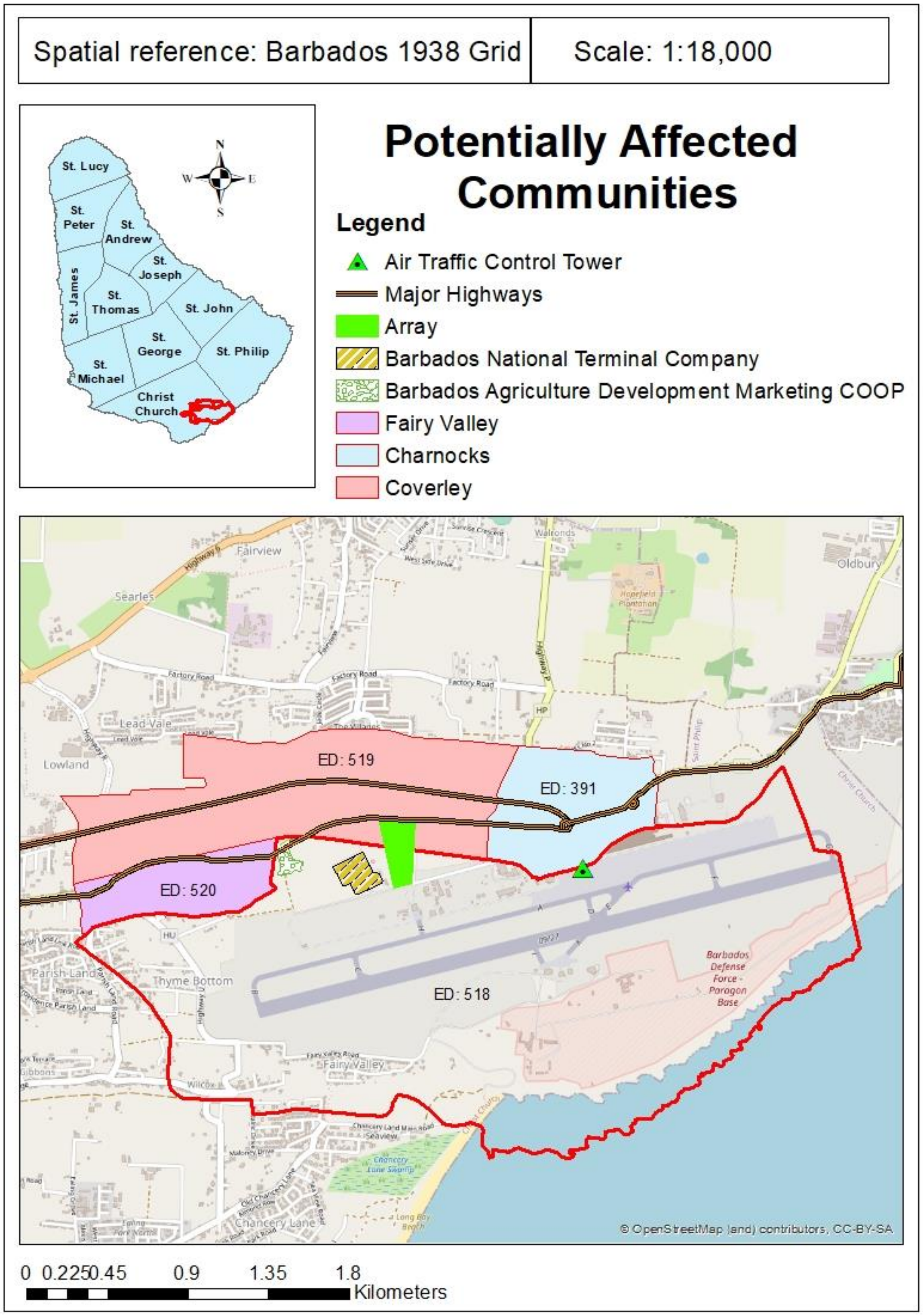
To better understand the social structure within the identified communities, social data were sourced from the Barbados 2010 census dataset. A shapefile (Census_ED_Boundary_2010) with enumeration districts (EDs) for the entire country was opened using ArcMap 10.5.1. This shapefile consisted of an attribute table which contained information on population size, gender, education, employment, the number and type of houses in a given area and the number of individuals within each household. Using 'Open Street Map' as a base layer in ArcMap, EDs for the potentially affected communities were identified using the identification tool. These EDs were manually selected and the social data for each community was extracted.

Within the dataset four main limitations were identified: (1) data were not disaggregated by gender; (2) the age profile of respondents was not included; (3) there were incomplete data fields for education and employment and; (4) the data are 10 years old and do not accurately reflect the present social structure.

Additionally, further limitations were encountered when trying to align the communities identified within Google Earth with the EDs in the census dataset. EDs within the census study did not line up precisely with the communities of interest as EDs often consist of two or more communities. For example, Seawell is captured within the Charnocks ED 391 and Coverley ED 519. ED 518 captures the Grantley Adams International Airport but also parts of Wilcox, Thyme Bottom and Fairy Valley. To complicate matters further, the data sets for ED 519 – Coverley, were identical to ED520 – Fairy Valley. One possible explanation is that the data for the 2 areas (Coverley and Fairy Valley) have been combined (see Figure 2). It is also important to note that the 2010 census would not have captured the demographic changes in Coverley, the most recent of which would be the Villages at Coverley.

The sub-sections below present the demographic profiles of the communities in closest proximity to the proposed project location based on the 2010 data. In the past ten years there is likely to have been some in and out migration, and since the population of Barbados is confirmed to be aging, it is likely that the percentage of persons in the older age ranges would have increased. The areas are characterized by a diverse mix of communities, including low, low-middle, middle and upper-middle income households. There is a diversity of social amenities including churches, pre- and primary schools, old people's homes, playing fields and pavilions. There are several small bars, variety shops and other micro and small businesses such as hairdressers, mechanics and body works, and cupboard makers. In each community a number of persons with disabilities were reported. According to the 2010 census, disability include persons with deafness, significant hearing impairment, blindness, significant vision impairment, who are unable to speak, significant speech impediment, severe arthritis, who are unable to walk, who are unable to climb stairs and who are unable to take care of themselves.

Figure 2: Map showing Enumeration Districts surrounding the project area



3.1 Charnocks

Charnocks is represented by ED391 which in 2010 comprised a population of 345 persons consisting of 159 males and 186 females. Nineteen individuals were registered as disabled. Table 2 displays the number of persons in the households indicating that the majority were occupied by between one and four persons.

Table 2: Number of persons in households in ED391in 2010 census

Number of persons in household	Number	Percentage
One person	25	21.2
Two persons	28	23.7
Three persons	21	17.8
Four persons	30	25.4
Five persons	7	5.9
Six persons	4	3.4
Seven persons	2	1.7
More than 7 persons	1	0.8

Table 3 and Table 4 show the employment and education status of the individuals in this ED in the 2010 census. Just over half were employed and a third had attained tertiary level education.

Table 3: Employment status in ED391in 2010 census

Employment Status	Number of individuals	Percentage of individuals
Employed	177	51.3
Students	28	8.1
Retired	29	8.4
Incapable	4	1.2

Table 4: Education status of persons in ED391in 2010 census

Education	Number of individuals	Percentage of individuals
Primary	43	12.5
Secondary	75	21.7
Tertiary	116	33.6
Skills training	36	10.4

According to the 2010 data, there were 130 houses in this ED, 118 occupied and 12 unoccupied. The houses were predominately constructed from concrete; wood houses were in the minority (See Table 5).

Table 5: Materials used to build houses in ED 391 in 2010 census

Materials used to build house	Number	Percentage
Concrete	102	78.5
Wood	18	13.8
Wood and Concrete	8	6.2
Stone	2	1.5

Based on the drive through, it was confirmed that currently the social amenities in ED391 include:

- Apartment buildings
- Bars
- Car rental services
- Churches
- Food truck
- Gas station
- Auto mechanics
- Minimart
- Tyre shop
- Variety shop
- Wholesaler
- Chicken farm

There was also some small-scaled farming.

3.2 Seawell, Coverley and Fairy Valley

As explained in Section 3, the data sets for ED 519 – Coverley, were identical to ED520 – Fairy Valley. Seawell was also captured within these EDs. Operating on the assumption that the data for the 2 areas have been combined, the ED information is presented as representing the two areas. Additional information gathered from the drive-through of the areas, is presented to offer a more updated perspective of these areas, especially Coverley, where significant housing has developed in the past decade.

During the 2010 census, EDs 519/520 consisted of a population of 599 persons comprising 291 males and 308 females. Forty-one individuals were registered as disabled. Table 6 shows that the majority of the houses contained between one and four persons.

Table 6: Number of persons in EDs 519/520 in 2010 census

Type of household	Number	Percentage
One person	66	29.5
Two persons	52	23.2
Three persons	43	19.2
Four persons	38	17.0
Five persons	12	5.4
Six persons	4	1.8
Seven persons	8	3.6
More than 7 persons	1	0.4

At the time of the 2010 census, just over half of the residents in EDs 519/520 were employed (Table 7), and the largest proportion 33.7% had attained secondary level education (

Table 8).

Table 7: Employment status in ED519/520 in 2010 census

Employment Status	Number of individuals	Percentage of individuals
Employed	305	50.9
Students	28	4.7
Retired	104	17.4
Incapable	2	0.3

Table 8: Education status in ED519/520 in 2010 census

Education	Number of individuals	Percentage of individuals
Primary	86	14.4
Secondary	202	33.7
Tertiary	99	16.5
Skills training	30	5.0
No education	1	0.2

There were 261 houses in ED519/520, 224 occupied and 37 unoccupied. The largest proportion of the houses were constructed from concrete (Table 9).

Table 9: Materials used to build houses in ED519/520

Materials used to build house	Number of houses	Percentage of houses
Concrete	129	49.4
Wood	76	29.1
Wood and Concrete	51	19.5
Stone	5	1.9

The drive-through confirmed that the social amenities in ED519/520 include:

- Several Apartment Buildings
- Bar
- Churches
- A Day Care Nursery
- A complex that includes DHL Express and Lenstec
- Gas station
- Minimart
- An Office Complex which includes a doctor's office and a pharmacy
- Wedding/event facility

The major change within ED519 since the 2010 census has been housing developments to the east and west of the highway. The houses on the west are privately owned single dwellings and apartments. To the east of the highway, there are the "Villages at Coverley" which broke ground in 2009 and started receiving residents in 2011[20]. This represents a community of more than 1000 houses and includes a diversity of amenities, namely:

- Banking facilities from First Caribbean CIBC and First Citizens Bank
- Coverley Medical Centre

[20] Information on the Villages at Coverley was gathered from https://www.terracaribbean.com/Blog/2019/10/The-Villages-at-Coverley-THEN-and-NOW.html as well as a drive through of the area.

- Radiology Services
- Massy Supermarket
- Club Fitness Gym
- Several restaurants including, BBQ House, Chicken Barn, Chutneys, R. B's and Urban Kitchen, Dragon House Chinese, Happy Tacos, Italia Coffee House, Miso, Pitta Pizza and Raw Juice
- Executive Cub Barber Shop and Beauty Salon
- Rubis Gas Station
- A Spa
- Sporting facilities including a football field, road tennis, lawn tennis and basketball courts
- Administrative and Property Management facilities

In 2018 the Villages Coverley became home to the students of the Ross University who were relocated to Barbados, following the damage to their university and homes during Hurricane Maria in Dominica in 2017.

3.3 The Grantley Adams Airport

ED 518 includes the Grantley Adams Airport, as well as parts of Wilcox, Thyme Bottom and Fairy Valley. In the 2010 data set, ED 518 had a reported population of 511 persons comprising 249 males and 262 females. Fifty-six individuals were registered as disabled. Table 10 shows that the majority of the houses contained between one and four persons.

Table 10: Number of persons in ED 518 in 2010 census

Type of household	Number	Percentage
One person	35	20.7
Two persons	39	23.1
Three persons	38	22.5
Four persons	33	19.5
Five persons	11	6.5
Six persons	6	3.6
Seven persons	2	1.2
More than 7 persons	5	3.0

Just under half of the residents in ED518 were employed (Table 11), and the largest proportion had attained secondary level education (Table 12).

Table 11: Employment status in ED518 in 2010 census

Employment Status	Number of individuals	Percentage of individuals
Employed	235	46.0
Retired	61	11.9
Students	31	6.1
Incapable	4	0.8

Table 12: Education status in ED518 in 2010 census

Education	Number of individuals	Percentage of individuals
Secondary	167	32.7
Primary	61	11.9
Tertiary	48	9.4
Skills training	25	4.9
No education	9	1.8

In 2010, there were 186 houses in ED 518, 169 were occupied and 17 unoccupied. Half of the houses were constructed from concrete (Table 13).

Table 13: Materials used to build houses in ED518 in 2010 census

Materials used to build house	Number	Percentage
Concrete	93	50.0
Wood	59	31.7
Wood and Concrete	32	17.2
Stone	2	1.1

The drive through confirmed that currently ED518 includes:

- Aeropost Office
- Apartments
- Appliance Repair
- Bar
- Barbados Agricultural Development and Marketing Corporation (BADMC),
- Barbados Light Airplane Club
- Barbados National Terminal Company
- Barbados Postal Service
- Beauty Supplies and Convenience Store
- Body work shop
- Chemical Industries Ltd.
- Anglican Church
- Doctor
- Gas station
- Food truck
- Goddard Catering Group
- Mechanic
- Minimarts
- Supermarkets
- Office Complex
- Paint ball concepts
- Play park
- Playing field with pavilion
- Regional Police Training Centre
- Restaurant
- The Barbados Defence Force Paragon Base
- Travel Agency
- Variety shops
- Police Station
- Cargo Handlers
- Garment Factory
- Shipping Company
- Private Hangar
- Iron Works
- Seawell Air Services

4 Valued social components and potential impacts

Based on the information obtained from the google maps, the drive-through and the 2010 census data, the valued social components (VSC), i.e. the significant elements in the social environment that may be impacted by the project's activities during the construction and operational phases are listed in Table 14. Justification for each VSC is provided.

Table 14: Valued Social Components

Social components	Justification
Residents, businesses and social amenities in close proximity to, as well as down-wind of the project's activities.	Noise, dust, odours and vibrations from the construction activities as well as other activities during the operations phase could affect the residents, businesses and users of social amenities in adjacent communities. Potential concerns about the impacts of the array on the aesthetics of the area.
Residents, businesses and social amenities along the routes to be traversed by the construction vehicles.	Noise, dust, odours and vibrations from construction vehicles could affect the residents, businesses and users of social amenities.
Worker health and safety.	There is always a risk associated with work on construction sites, e.g. falls, chemical spills, accidents with equipment etc. In addition, there are several pollutants occurring in solar cells and parts which include arsenic, chrome, lead and cadmium in batteries[21].
Public health and safety.	There is always a risk to adjacent communities and the general public with respect to construction sites.

The proposed construction of a Photo Voltaic "solar farm" by the BNTCL provides the opportunity to produce a clean, reliable, environmentally friendly and infinite source of energy in comparison to traditional fossil fuels. By so doing, it can contribute to an increase in national energy independence and promote the diversification and security of the energy supply. Thus it is consistent with the goal of the Barbados National Energy Policy 2019 – 2030 which is to transition the island to being 100% renewable energy and carbon-neutral by 2030.

The proposed solar farm can facilitate job creation during both the construction and operational phases of the project. During construction, there will be work for skilled and semi-skilled labour as well as support for local businesses that provide supplies for the renewable energy sector. The construction phase can also be a boost for the persons operating small retail businesses in the area, especially food and beverage, because the construction workers will provide them with additional customers. The project therefore can be a boost to the economy and have a positive effect on local livelihoods. This is a particularly positive impact in the current economic context, where the prolonged Covid-19 pandemic has resulted in a decline in tourism arrivals, the closure of many businesses and the loss of several jobs.

There are also positive health benefits from improved air quality compared to the emissions from fossil fuel sources of energy.

[21]Kumarankandath, A. (2016, July 8). What about recycling for solar PV? Down to Earth. Retrieved from https://www.downtoearth.org.in/news/energy/whatabout-recycling-for-solar-pv—54797

However, it is not necessarily a completely green source of energy, as there are potential environmental and socio-economic impacts associated with solar power. From a health and safety perspective, the effects of noise dust and vibrations during construction from vehicles and machinery can be psychologically stressful as well as physically problematic to individuals with a sensitivity to dust. There are also potential negative visual impacts if persons or groups perceive the arrays to negatively affect the aesthetic of the existing landscape. Sometimes, there can be initial opposition to projects from residents and businesses in close proximity to the project site. Persons can be concerned, for example, about the effects of the project on their property values. The suspicions and objections can often be the result of insufficient information sharing and stakeholder engagement by the project proponents during the initial stages of the project before construction commences.

During construction there are risks associated with worker health and safety on the site such as falls, and injuries that might arise from the inappropriate use of machinery, and the storage and handling of chemicals or flammable substances. There is also the potential for chemical spills, accidents with equipment etc. It is noted that there are several pollutants occurring in solar cells and parts which include arsenic, chrome, lead and cadmium in batteries. There are also potential risks to adjacent communities and the general public. For example, from the public gaining unauthorised entry to the site and getting hurt.

Table 15 summarises the potential positive and negative effects that the construction and operational phase activities are likely to have on the valued social components.

Table 15: Project activities and potential effects

Project effects - negative	Project effects- positive
CONSTRUCTION PHASE	
• Noise and vibrations from construction vehicles and equipment • Impaired air quality from dust and other emissions from construction vehicles and equipment • Health and safety risks to on-site workers • Health and safety risks to adjacent communities and general public • Perceived negative aesthetic impacts from the array • Suspicion or objection towards the project.	• Construction related jobs will be created for skilled labour • Increased retail business, primarily food related from construction workers
OPERATIONAL PHASE	
• Potential health and safety impacts on workers and adjacent communities • Accidents (non-routine) events • Perceived negative aesthetic impacts from the array	• Employment opportunities for skilled labour. • Advances the renewable energy policy to increase energy conservation and efficiency, and contribute to mitigation efforts in reducing GHG emissions.

4.1 Recommended mitigation measures

The solar farm will be a new addition to an existing industrial estate. However, some residents could be concerned about the potential change to the aesthetics of the area. This should be addressed through a carefully planned and implemented public awareness campaign, that addresses the typical concerns raised in relation to the construction of a solar farm. The campaign should clearly explain the design of the farm, as well as the potential benefits that could accrue to Barbados.

Potentially adverse effects from the construction of the farm must be minimized and mitigated to the extent feasible to reduce impacts on the residents, and users of social amenities and commercial enterprises. It is also essential to ensure that the project is compliant with the legal and statutory labour requirements, to safeguard Community and Worker Health and Safety.

Construction should therefore be based on an approved construction management plan that includes measures to reduce the impacts of noise, dust and vibrations. Details for the management of noise, dust and vibrations are contained in the Environmental Management Plan. However, at a minimum, these measures should include:

- Dust management measures such as:
  - Fitting machinery with emission control devices compliant with International Design Standards.
  - Using waterproof boxes to minimize spillage along roadways
  - Covering all trucks that are hauling material
  - Washing truck tyres before exiting the construction site onto existing paved roads
  - Construction vehicles traversing the adjacent areas should strictly observe the speed limit
  - Cleaning spillages on roadways and property accesses promptly to minimize spread of sediment and dust
  - Reducing or eliminating stockpiles as much as practical
- Noise management measures such as:
  - Installation of mufflers and appropriate sound attenuation devices on construction equipment
  - Conducting work onsite within specifically set times
  - Switching off construction equipment and vehicles when not in use
  - Construction vehicles traversing the adjacent areas should strictly observe the speed limit, and horns should be minimally used (only as necessary)
- With respect to vibrations, it is expected that the Contractor would have the required insurance policies to cover any legitimate claims made as a result of any damage that may occur during the construction phase.

There should also be an approved Traffic Management Plan to control on-site traffic as well as the practices of construction drivers to and from the construction site.

Contractors should be required to operate approved occupational health and safety plans which detail the safety provisions according to the type of machinery and materials being utilized. Workers should be required to use protective gear to guard against on-the-job injuries. Ergonomic devices should be available, e.g., for lifting and carrying. Only trained and/or certified persons should use specialized equipment and handle dangerous chemicals. There should be appropriate supervision to ensure that workers do not cause harm to themselves or others on the site.

There should be adequate 24-hour security to prevent curious onlookers from wandering into the construction zones. As required, sufficient and appropriate lighting, clearly visible signage that meet the universal design environmental access requirements/standards for persons with disabilities, and open and unobstructed passageways should be installed to enforce safety in and around the construction zone.

Public service announcements should be provided to ensure that commercial operators, residents, and the public are updated on the construction activities, especially those that could be disruptive, e.g., construction activities planned outside of typical work hours such as late evening or night.

When operational, the solar farm should meet the highest of international and national standards to ensure the health and safety of workers, passengers, and the surrounding communities.

The environmental management plan will address all of the impacts associated with noise, air quality, vibrations, and worker health and safety and general public health and safety. However, the Social Management Plan detailed in Section 5 below, comprises a stakeholder engagement plan and a grievance redress mechanism to ensure that the best interest of all the relevant stakeholders is taken into account during the project. It will also identify critical aspects for mainstreaming of gender equality. In addition, Section 6 comprises a Social Monitoring Plan

Social Management Plan

5 Social Management Plan - Introduction

The majority of the potential social impacts result from the effects of the noise, dust and vibrations associated with the construction vehicles and equipment. There are also potential impacts associated with occupational health and safety and public health and safety. The environmental management plan contains the measures required to avoid or reduce these effects. This social management plan therefore focuses on the engagement of the stakeholders to ensure that there is a mechanism in place to provide information on the project to the public and to encourage participation of all affected groups in a consultation process. The social management plan comprises two components: 1) the social engagement plan which facilitates open and continuous communication and consultation between various groups including construction contractors, stakeholders, and the general public; and 2) the grievance redress process which ensures that legitimate concerns of the stakeholders are recorded, investigated and addressed.

5.1 The Stakeholder Engagement Plan

There are four critical steps in a stakeholder engagement process:

1. Identification of required resources
2. Identification and analysis of the stakeholders
3. Developing key messages and selecting appropriate engagement channels
4. Implementing, reviewing and revising the engagement plan

5.1.1 Identification of required resources

It is critical to understand the situation in which the engagement is to take place and to ensure that the required resources are available. One of the first questions to be considered is whether the implementing agency, in this case the BNTCL, has a stakeholder engagement policy already in place, as well as staff who are trained to design and undertake the required tasks. In this case there is none and therefore the plan is being prepared and implemented by Consultants. However, the opportunity presents for the BNTCL to work alongside the Consultants and build capacity for future projects.

The stakeholder engagement process should be led by a project liaison (PL) who can communicate with all of the internal and external stakeholders. The roles and responsibilities of the PL leading the process, as well as the required skills and expertise, include *inter alia:*

Roles and responsibilities

- Implementation, review and revision of the stakeholder engagement plan
- Stakeholder mapping
- Preparation of communications to stakeholders
- Regular field visits to meet with stakeholders
- Responding to stakeholder enquiries
- Working collaboratively with members of the project team
- Providing briefings to the project team
- Arranging and attending stakeholder meetings with the project team and ensuring feedback of stakeholder responses and requests are responded to within agreed timescales
- Providing monthly reports for the Project Manager

Experience and Skills Required:

- Experience of managing engagement with stakeholder groups
- Experience in developing and successfully implementing stakeholder engagement plans
- Proven ability to work and multi-task under pressure, respond quickly to changing situations in complex project environments, prepare responses/narrative quickly and clearly and use personal initiative
- Good interpersonal and networking skills, highly articulate team player
- Strong people management skills
- Good oral and written communication skills
- Ability to schedule work and deliver to tight deadlines

The PL should be supported by the project team who will provide the relevant information and resources to ensure that the process is efficiently implemented. The provision of a dedicated telephone line or cell phone to receive calls from the public, and a website where information can be made available, are amongst the other key resources needed to support the implementation of the stakeholder engagement plan. Table 16 provides a provisional budget for one year for the implementation of the Stakeholder Engagement Plan.

Table 16: Provisional budget for the Stakeholder Engagement Plan

Resource	**Costing (BDS$)**
Project Liaison	20,000.00
Cell phone (hardware and monthly bills)	2,000.00
Expenses for 2 public meetings (rental of venue, PA system, advertisements in local papers)	14,000.00
Public Service Announcements in local newspapers or on radio (unless done via GIS)	10,000.00
Total	46,000.00

5.1.2 Identification and analysis of the stakeholders

Stakeholders are the persons, groups, or institutions with an *interest* in the project or the ability to *influence* the project outcomes, either positively or negatively. Stakeholders are diverse and may be directly or indirectly affected by the project. They may support or be opposed to the proposed project. They can include target beneficiary groups, locally affected communities or individuals, government agencies, non-governmental organizations (NGOs) the private sector, unions, media and other special interest groups.

The "stake" that each of the groups has in the project will vary. Determining this is a key aspect of stakeholder analysis, i.e. what is each groups' interest in the project and ability to influence the project. Critical questions that facilitate the identification process include:

- Who are the people/groups/institutions that are interested in the project?
- Who are the potential beneficiaries of the project?
- Who might be adversely impacted by the project?
- How will the project affect male and females?
- Who is responsible for the project?
- Who might be opposed to the project?
- Who has the power to influence the project?

- Who currently uses the resources required by the project?
- Who is currently denied access to the resource(s) required by the project?
- Who owns or has rights and responsibilities over the use of the resource(s) required by the project?

The initial list of potential stakeholders has been developed from the rapid assessment process along with discussion with the project engineers. This list should be expanded once the PL is hired and begins the actual field work in the surrounding communities associated with the engagement process. The process of stakeholder identification is not a one-off activity, but is a process that remains open to allow continued involvement of the key persons who need to be consulted during the process of planning and implementing the project.

Table 17 displays the initial list of stakeholders in this project explaining their varied relationships to the project. It also indicates the extent to which there is a gender concern with respect to accessing project benefits or vulnerability to adverse project impacts.

Table 17: Preliminary stakeholder identification

Stakeholders	Relationship to the project	Gender analysis
BNTCL	Overall project management	Both males and females in this group benefit from this project. The current information does not suggest a gender bias.
Engineering Consultants	Quality control for the construction	Both males and females in this group benefit from this project. The current information does not suggest a gender bias.
Contractors and construction companies	Responsible for the project's construction	The preponderance of male workers in the construction industry means that males have more employment opportunities in this project.
Residents in nearby communities	Could potentially be adversely impacted by the noise, dust and vibrations from the construction	Both males and females will be affected by the construction. Of specific concern are the residents in the old people's home, the day nursery and other elderly residents and persons with disabilities.
Businesses in nearby communities	Could potentially be adversely impacted by the noise, dust and vibrations from the construction	Both males and females will be affected by the construction. There is no current information to indicate the percentage of businesses that are male/female owned or the number of males/females employed in the businesses.
Town and Country Development Planning Office and Prime	Regulatory agencies responsible for ensuring the development is	Not applicable

Stakeholders	Relationship to the project	Gender analysis
Minister's Office Planning Unit (PMOPU)	consistent with the Physical Development Plan and other national Plans and laws	
Division of Energy	Regulatory agency responsible for monitoring and regulating the energy sector, RE and energy conservation	Not applicable
Environmental Protection Department	Regulatory agency responsible for ensuring compliance with national or international standards for air quality, noise etc.	Not applicable
Labour Department	Regulatory agency responsible for ensuring decent work standards in the island	Not applicable
Unions	Responsible for protecting workers rights on the island	Not applicable
Media	A likely option for residents who are affected to share their complaints Will publicly report the residents' complaints Can provide a channel for sharing information about the project with the public	Not applicable

Analysing the influence of the various stakeholders over the project is the next step. This will highlight their motivations and also facilitate the process of identifying the most appropriate forms of engagement for the varied groups. Critical questions to ask at this stage include:

- To what extent can each stakeholder group affect project outcomes?
- What is the importance of each stakeholder group to the success of the project?
- Which groups should be engaged first, and why? (e.g. enhance project design, assist in early project scoping, avoid adverse impacts)
- Are special measures needed to protect the interests of marginalised stakeholder groups?
- Does opposition from any of the stakeholders or stakeholder groups put the project at risk? If so, are there ways to engage with them to ensure that their concerns are being addressed?

It is critical to understand the importance of the stakeholders to the success of the project as well as those who can actually influence the project outcomes. Put more directly, it is important to know who can make the process of the project smooth and efficient and those who can slow it down or stop it entirely. Table 18 shows an assessment of the varied influence that the stakeholders have over the project. Ratings of high and low are given to demonstrate their relative power over the project. Note that the ratings within a group can vary from high to low depending on their specific circumstances.

Table 18: Stakeholders' interest and influence

Stakeholder	Interest in the project High – critical to the process and outcomes Moderate – under some circumstances they would have an interest in the project Low – Very low interest in the process or outcomes	Power to influence the project process and outcome High – critical to the success of the project Moderate – under some circumstances they could influence the project Low – no power to influence the project
BNTCL	High The project managers have a high stake in the timely and successful implementation of the project within the allocated budget	High The management of the various players and resources is critical to the timely delivery of the project
Engineering Consultants	High Quality control of the construction project is critical to ensuring that highest standards are maintained for construction practice and materials, and that health and safety standards are constantly observed.	High The Engineering Consultants can request work to be re-done or halted if the standards are not acceptable
Contractors and construction companies	High They are required to provide a high quality output based on use of high quality materials, skills and standards	High Any deviations from the highest of quality materials and skills could lead to less than desirable product
Residents in nearby communities	High Those who are being impacted by the construction will be concerned about its effects on their health and property Low Those who are not being impacted by the construction may have no real interest in the project	Low Even though they may complain about the project, they are unlikely to be able to impact on its implementation in a way that would slow it down or stop it
Businesses in nearby communities	High Those who are being impacted by the construction will be concerned about its effects on their health and property Low Those who are not being impacted by the construction may have no real interest in the project	Low Even though they may complain about the project, they are unlikely to be able to impact on its implementation in a way that would slow it down or stop it.

Stakeholder	Interest in the project High – critical to the process and outcomes Moderate – under some circumstances they would have an interest in the project Low – Very low interest in the process or outcomes	Power to influence the project process and outcome High – critical to the success of the project Moderate – under some circumstances they could influence the project Low – no power to influence the project
Town and Country Development Planning Office and Prime Minister's Office Planning Unit (PMOPU)	Moderate As lead regulatory agencies their approval of the project is a critical step in its initiation	High If the project is determined to be non-compliant with a relevant law or regulation, they have the power of placing a Stop Notice until the matter is resolved
Division of Energy	Moderate Provision of policy and strategic planning for the development of RE projects	Moderate Provision of ongoing policy and strategic guidance to the project
Environmental Protection Department	Moderate They are the regulatory agency responsible for monitoring of air quality and other environmental parameters	High If the project is determined to be non-compliant with a relevant law or regulation, they have the power of placing a Stop Notice until the matter is resolved
Labour Department	High if workers' conditions are non-compliant with local laws Low if workers' conditions are compliant with local laws	High If the project is non-compliant with the local laws they can require changes to the operations that could impact on the timetable and expenses.
Unions	High if workers' conditions are non-compliant with local laws Low if workers' conditions are compliant with local laws	High If workers are unionized they can call for a go-slow or a full strike
Media	High – if something "story-worthy" occurs, e.g. repeated complaints by the residents or an accident on site Low – if nothing occurs	Low They can influence local perceptions of the project, but they cannot slow down or stop the project.

5.1.3 The Communication Strategy

Once the stakeholders have been identified and their interest and influence analysed, communications must be established. There is preliminary communication to inform stakeholders of the Project and solicit their participation, as well as ongoing communication to keep them informed of the progress of the Project. There are varying ways to communicate with the stakeholders, depending on the objectives and resources available. A critical step in deciding on a communication approach/technique is to determine the objectives of the activity and the audience to be targeted. Identification of the objectives allows for an assessment of the success of the chosen technique after it has been utilised.

The regulatory agencies will already be aware of the project. Therefore, the main targets of the preliminary contact are the residents and businesses in the immediate vicinity of the project site and the wider public. Two steps are recommended. The first is an article in all of the local newspapers describing the project, its goals and objectives and the duration of the construction. The second is to invite all of those in the vicinity of the project to a meeting to provide them with information about the project, respond to any ongoing concerns, and inform them of the future process of engaging them and dealing with their project related challenges. Individual letters of invitation should be sent to all of the residents and business places within the immediate vicinity of the project site. These have already been identified through the rapid social assessment. The project liaison could deliver the letters, or the General Post Office can provide this service for a fee. In addition, an advertisement explaining the purpose of the meeting, its date, venue and time should also be placed in the local newspapers and run on the radio two weeks and one week before the meeting.

Critical planning elements for the public meeting include:

- Confirmation of date, time and venue
- Advertising of the meeting
- Designing and distributing the invitations
- Developing an agenda
- Preparation of presentations
- Meeting room preparation (ensuring head table, chairs, PA system and audio-visual equipment)
- Meeting recording
- Preparation of meeting report
- The provision of light refreshments for the participants is optional.

Once the preliminary contact is established, the stakeholders need to be kept abreast of the Project's activities. They also need a mechanism by which they can continue to make input into the Project. There are several communication techniques that can facilitate this. Ideally, it is best to utilize a diversity of approaches, since each one will have benefits and challenges. Table 19 lists a number of options and the most effective ways to utilize them.

Table 19: Communication options

Stakeholder Groups	Recommended Engagement Technique	Topics	Engagement Frequency
Government Authorities	• Formal meetings • Site visits • Progress reports • Project website and social media	• Update on project progress and activities • Plans for next period • Issues and changes	Quarterly / When changes occur
Local Residential and Business Community	• Informal/Formal face-to-face meetings • Email bulletins	• Update on project progress and activities	Monthly / When changes occur

Stakeholder Groups	Recommended Engagement Technique	Topics	Engagement Frequency
	• Print media, text/instant messaging and radio announcements • Project website and social media • Grievance mechanism	• Plans for next period • Issues and changes • Job opportunities • Invitations to participate in meetings	
Suppliers of goods and services	• Media advertisements • Project website and social media	• Local procurement	When the need arises
Project Employees	• Formal meetings • Phone / email / text messaging • Workshops • Corporate/Project website and social media	• Update on project progress and activities • Plans for next period • Issues and changes	Quarterly / When changes occur
Local Media	• Emails to points of contact • Press releases • Project website and social media	• Update on project progress and activities • Local procurement and employment data • Invitations to attend meetings	When changes occur / as the need arises

Establishing a project website or social media sites is an easy way of providing updates to all of the stakeholders. A dedicated telephone line (land or mobile) should also be made available so that the public or any other stakeholder can call and receive a quick response to a query or file a complaint.

The project liaison is central to the implementation of the communication strategy. This individual will be a vital link between the BNTCL, the contractors and the community. The PL will be required to make introductory visits to the residents and businesses to share his/her contact details (telephone/email/address) and to explain his/her role as liaison. After the preliminary meeting the PL will be expected to make regular trips to the community to provide updates on the progress of the project, and to report any concerns to the BNTCL and the contractor.

Ongoing public service announcements should be prepared by the PL with the approval of the BNTCL and submitted to the media to keep the public updated on the project, inform them of any project activities that could cause adverse impacts, e.g. late night construction, as well as invite them to subsequent public meetings. It is anticipated that a public meeting will be convened at least every six months with the residents of communities surrounding project to update, and obtain feedback from stakeholders, on the status of project implementation. The PL will also maintain a record of activities and meetings with the community and submit monthly reports on all activities to the BNTCL.

It is important to note that grievances can arise because of misunderstandings, lack of information, or delayed, inconsistent, or insufficient information. The consistent provision of accurate and adequate information about a project and its activities, plus an approximate implementation schedule, can therefore serve as an effective means of eliminating or reducing complaints from the potentially affected members of the public.

5.1.4 Monitoring and revision of the Stakeholder Engagement Plan (SEP)

The stakeholder engagement plan should be periodically reviewed to determine whether the engagement is being effective. To this end, reporting is an essential source of information that can be used for the evaluation of the engagement process. Records of every activity provide evidence that the stakeholder engagement is taking place, facilitate the monitoring and revision of the SEP and also provide continuity in instances where staff change during the Project. Every meeting or consultation should be recorded. This should include – the date; time of start and closure of the meeting; persons present; the agenda; the main items discussed and decisions made; actions to be taken and persons responsible. It is also essential to maintain a stakeholder register, which would record all stakeholders disaggregated by gender, disability or other criteria to ensure that vulnerable groups are being represented at the meetings, as well as contact details, dates of engagement with comments and including follow up requirements.

Objectives and targets should be defined for each initiative against which the evaluation can be measured. Critical questions to be asked are:

- What contribution did the specific activity make to the engagement process?
- Was the technique used appropriate for the group that was targeted?
- Were the objectives of the meeting/session achieved?
- Did women, children, the elderly, the disabled or their representatives attend the sessions?
- Were the issues of vulnerable groups represented in the session?

Feedback from the stakeholder groups and grievances recorded are evidence that can be used in assessing the effectiveness of the SEP. Very short questionnaires can be used at the end of every session to obtain feedback on the content and process. Alternatively, asking for verbal feedback on what worked or did not work during a meeting or session can also provide useful responses that can be used to adjust the SEP and make it more effective.

5.1.5 Reporting

The PL should submit monthly reports to the Project Manager. Each report should include the record of all the engagement activities, as mentioned above, and an assessment of the effectiveness of the activities along with recommendations for improving effectiveness of the plan. The Project Manager should provide updates on the SEP at Steering Committee meetings, reporting on the progress of the stakeholder engagement, highlighting challenges experienced or benefits derived from its implementation.

5.1.6 Risks

Stakeholder engagement is not without its challenges and risks. Some of the challenges that may present during the Project are:

1. Covid 19: The Covid-19 pandemic may delay the implementation of the face to face community level engagement with the residents and businesses in the vicinity of the project site. This means that the media presence should be intensified e.g. articles in the paper about the project including contact details so that residents can lodge their complaints or grievances and the process of

resolution can occur. If a project website is available, information can be placed there for access by the public.

2. It takes time and resources: It takes time to develop and build trust-based relationships with stakeholders. The consensus from practitioners is that from the outset, relationships with stakeholders should be nurtured. Additional stakeholders might be identified that also want to be engaged. No willing stakeholder should be excluded from the process of engagement. Some stakeholders will need to be educated about the concept of engagement itself, as well as on the complex issues requiring specialised and technical knowledge. These demands can increase the cost of consultation required to meet external expectations, and often this occurs at a time when a project lacks the internal capacity and resources to implement a broad engagement strategy.
3. It raises expectations: Stakeholders can have unrealistically high expectations of benefits that may accrue to them from a project. The BNTCL and the PL must be clear about the project boundaries and limitations from the outset.
4. Consultation fatigue: Stakeholders can easily tire of consultation processes especially when promises are unfulfilled, and their opinions and concerns are not taken into consideration. In addition, stakeholders are often engaged in several projects simultaneously, and unable to give their fullest commitment to any one initiative.

5.2 The Grievance Redress Mechanism

People adversely affected by a project will complain about actual or perceived impacts in order to find a satisfactory solution. Affected persons (APs) must be able to raise their grievances and be given an adequate hearing, and satisfactory solutions should be found that mutually benefit both the APs and the project. It is therefore very important that APs have access to legitimate, reliable, transparent, and efficient institutional mechanisms that are responsive to their complaints[22](Asia Development Bank, 2010).

Several benefits are derived to the project and to the APs from grievance redress mechanisms (GRM). Within affected groups, GRMs provide cost-effective ways to report complaints and grievances. They establish a forum whereby APs can report their concerns with dignity and with access to a fair hearing and remedy. They allow APs to negotiate and influence decisions of the projects that could adversely affect them and they facilitate access to information. From the project's perspective, GRMs provide a structured and systematic way of resolving grievances and disputes relatively quickly before they escalate to an unmanageable level. They facilitate effective communication between the project and affected persons and can help to win the trust and confidence of community members thereby creating productive relationships between the parties. GRMs aid in ensuring equitable and fair distribution of benefits, costs, and risks, especially amongst vulnerable groups such as women, children, the disabled and the elderly. These mechanisms ultimately can mitigate or prevent adverse impacts of the project on communities and produce appropriate corrective or preventive action, thereby avoiding project delays and cost increases, and also improving the quality of work (Asia Development Bank, 2010).

Based on the rapid social assessment, it can be anticipated that there will likely be complaints about the dust and noise from the project, especially from the residents and businesses in closest proximity to, and downwind of the construction zone. This GRM provides guidance to the BNTCL to be able to address these and any other concerns that might arise during the project. It recommends a procedure that should be followed for the management of complaints and grievances that arise during the project. It describes the scope and procedural steps and specific roles and responsibilities of the parties involved. It should be revised and updated based on the experience and feedback from the stakeholders.

NOTE: This GRM is designed to deal with matters that can be addressed at the project level. Matters that escalate to the level of lawsuits are not addressed by this mechanism.

5.2.1 GRM Definitions[23]

An **affected person** (AP) is a person that is adversely affected temporarily or permanently as a result of the project works.

A **complaint** is a statement (verbal or written) or expression of displeasure that an impact or effect arising from a project related activity is unsatisfactory or unacceptable to the complainant. A complaint is a concern

[22] Asian Development Bank. 2010. Designing and Implementing Grievance Redress Mechanisms. A Guide for Implementers of Transport Projects in Sri Lanka. Available online: https://www.adb.org/sites/default/files/institutional-document/32956/files/grievance-redress-mechanisms.pdf. Assessed April 2020.

[23] These definitions were taken from the Grievance Redress Mechanism for the Vanuatu Infrastructure Reconstruction and Improvement Project. Prepared by the Ministry of Infrastructure and Public Utilities of Vanuatu. Financed by the World Bank. March 2018.

about a minor impact or effect that is short term, low in risk, often temporary, that typically does not require an investigation but **does** require a specific response to remove or remediate the unsatisfactory or unacceptable impact or effect. Unresolved complaints may become grievances if not dealt with appropriately and within a short timeframe (typically 2 days but a maximum of 14 days). Complaints able to be dealt with or resolved immediately can be referred to as minor complaints.

A **grievance** is a statement about an action, impact or effect arising from a project related activity that adversely affects the rights, health and/or well-being of an affected person or people to the extent that it forms legitimate grounds for grievance and if upheld, may result in compensation, legal action or a change to the sub-project in order to resolve the grievance. A grievance will require a specific response and potentially formal intervention by the supervisor or client for resolution and such resolution must be formally agreed and recorded. Grievances may be raised verbally or in writing but must be reported using the Grievance Report Form which must be completed in every instance.

5.2.2 GRM Principles

The grievance mechanism is guided by the following principles:

1. Accessible – all stakeholders should know that the mechanism exists and how they can utilise it. It should therefore be publicised.
2. Legitimate – all stakeholders should know that they can express grievances without fear of victimisation or negative consequences.
3. Transparent – the process should be reported on so that stakeholders know that the mechanism is working.
4. Culturally appropriate – the process should be designed to take into account specific cultural attributes as well as traditional mechanisms for raising and resolving issues.
5. Confidentiality – whilst general information should be shared to ensure transparency, personal and other important details must be kept confidential.

5.2.3 GRM Resources

The grievance mechanism must be adequately resourced with:

1. People – trained staff or external resources experienced in dealing with community concerns and complaints.
2. Systems – systems for receipt, recording, and tracking of the process.
3. Processes – a written procedure for handling grievances and responsibilities assigned for each step as well as for management oversight.
4. Budget – estimating, allocating, and tracking costs associated with grievance handing.

5.2.4 GRM Institutional Arrangements

A Project Grievance Committee (PGC) must be established comprising the Project Manager, another staff member of the BNTCL, and the project liaison (PL). The PGC is responsible for managing the GRM including updating the grievance database to track the progress of formal grievances for the duration of projects. The tasks will include:

- Receiving grievances
- Investigating the grievances and liaising with the stakeholders

- Developing resolutions and actions to rectify any issues
- Tracking progress of individual grievances
- Documenting any interactions with external stakeholders
- Making sure the grievance mechanism procedure is being adhered to and followed correctly
- Making sure resolution actions are completed
- Maintaining a grievance register and monitoring any correspondence
- Monitoring grievances/trends over time and reporting findings to the Project Steering Committee
- Raising awareness of the grievance mechanism among project personnel and stakeholders

The Contractors must be briefed on the GRM and are expected to follow its requirements as part of the oversight of their work. The Contractor is responsible for logging all complaints in the site daybook (or equivalent) for inspection by the Project Engineer or BNTCL. The Contractor is also responsible for ensuring that all minor complaints are dealt with and resolved directly without any undue delays.

The Project Liaison can be designated to take the lead on implementing the complaints and grievance procedures. However, since that individual will be a contracted consultant, the BNTCL can opt to designate a member of staff to take the lead role.

5.2.5 GRM Process

Figure 3 shows a typical grievance resolution procedure[24]. Once a grievance is received, it must be recorded, screened to determine the level of severity and action required, acknowledged, and investigated. Appropriate action must be taken and there must be follow-up with the complainants to ensure that the actions taken had the desired effect for resolving the issue. Complaints are more minor and can typically be more easily and swiftly addressed than grievances that require more time for investigation.

Key to addressing any complaint or grievance is having an efficient system in place and effective communication with the stakeholders. All project personnel and stakeholders should be made aware of the grievance mechanism. The notification should include:

- A summary of the mechanism and how it should be used
- Who can raise complaints
- Details of the process, such as who is responsible for receiving and responding to grievances
- The sort of response that can be expected
- Safeguards in place to ensure confidentiality
- Contact details for lodging a complaint

Communication about the grievance mechanism can be done via any of the channels recommended in the stakeholder engagement plan for the ongoing communication about the project's activities. These include the project website, all forms of media, public meetings, and individual face to face meetings with the stakeholders. The notification process can facilitate feedback on how the GRM procedure could be tailored for the project.

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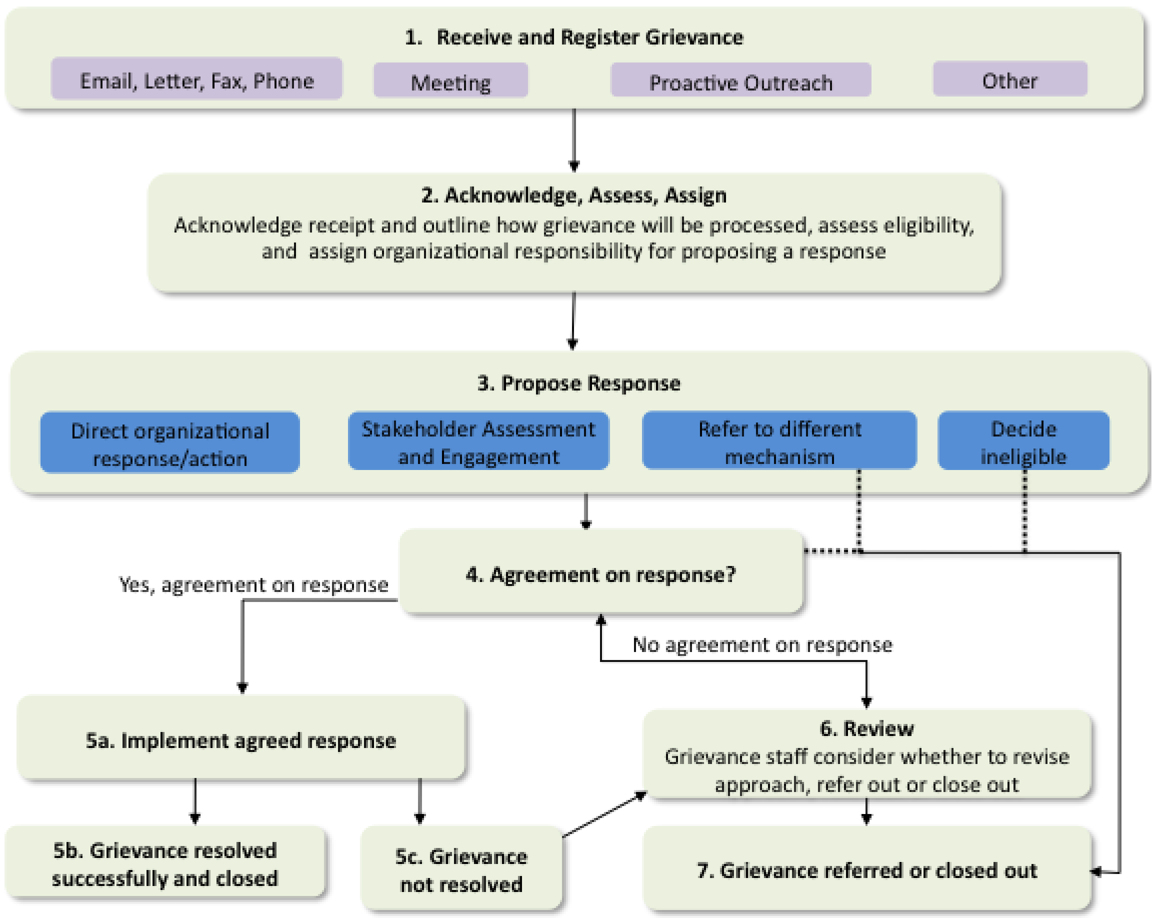
[24] UNDP Social and Environmental Standards. Stakeholder Engagement Supplemental Guidance: Grievance Redress Mechanisms. October 2017

The Project Liaison will be a critical asset in the grievance management process. Interactions with the stakeholders will provide early insight into potential problems that can be averted. Ongoing meetings will serve to assure the stakeholders that their concerns are being addressed.

Specific attention must be paid to any situations that are disadvantaging or adversely affecting women and children or other vulnerable groups such as the elderly or disabled. Any such matters must be prioritized for swift resolution.

Figure 3: Grievance resolution procedure (Source UNDP)



5.2.6 Dealing with complaints

Complaints will often be communicated to, or received by anyone associated with the project. That individual is required to refer the complaint to a member of the PGC who will note it in the Complaints Record (CR), even if the matter has been resolved. For example, a complaint can sometimes be easily dealt with through the provision of information. However, maintaining a record of this is important in the event that the matter becomes more serious over time and subsequent action becomes necessary. Complaints received via the print, social or electronic media, should be followed up by a member of the PGC and recorded in the CR.

All complaints must be recorded in a Complaints Record (CR) even if minor and resolved immediately. Table 20 provides a template that can be used for the design of the project CR.

Table 20: Complaints record template

Complaints Record	
Date:	
Complainant:	Name: Address: Telephone: Email:
Received by:	Name: Designation: Telephone Email:
Action Taken:	
Further action recommended:	

Complaints are typically of low level severity and should be resolved within a week of receiving the report. The PGC should follow up by acknowledging the complaint. If the matter was dealt with immediately by the person receiving the complaint, the purpose of the follow-up call, email or letter, is to confirm that the action taken was satisfactory and that the matter is closed. If the matter is still to be addressed, the PGC should confirm the nature of the complaint and indicate the action that will be taken and the length of time anticipated for the matter to be resolved. Once the action is taken, the PGC should communicate this to the complainant and confirm that the matter is resolved. If the matter escalates to a more serious level, the grievance procedures will be utilized.

5.2.7 The grievance procedures

All grievances must be reported to the PGC and recorded on a Grievance Complaint Form (GCF). Table 21 provides an example of a template for a GCF that can be used the project.

Table 21: Grievance complaint form template

Grievance template
Date of complaint
Time of complaint
Name of person taking the complaint
Job title of person taking the complaint
Signature of person taking the complaint
Name and signature of supervising officer
Complainant information:
Name of complainant
Telephone number of complainant
Address of complainant
Email address of complainant
Details of the complaint:
Nature of complaint: (*In recording the complaint please prompt for the following information where available – dates and times the incident(s) occurred; who was involved in the incident(s); gender*

Grievance template
and age of people impacted; cost of problem if possible (e.g. cost of doctor's visit and medication; cost of repair to vehicle, cost of repair of third party property, impact of utility outage, etc.)
Signature of person making the complaint: (*Complaints can be made by email or in person and should be signed. If made by phone the complainant should be encouraged to come into the office and sign off on the complaint*. ***In the event that complainants wish to remain anonymous, the issue should still be investigated and a report compiled***.)
Details of the investigation:
Investigation recommended: – Information to be gathered – Persons/agencies to be contacted – Assessment of resolution mechanisms to be utilized, e.g. mediation, compensation, etc.
Reporting:
Record of the results of the investigation and actions recommended Cost of recommended solutions
Report of action taken including the signature of the person investigating the complaint
Date complainant contacted with the results of the investigation and action taken

Grievances are mid to high level severity. They tend to be repeated, extensive and of high profile and could jeopardize the project. Prompt and transparent handling of grievances serve to de-escalate the situation.

The PGC should formally acknowledge any grievance within five working days of receipt. Communication should be made in written form. The acknowledgement should include a summary of the grievance, the method that will be taken to resolve the matter and an estimated timeframe in which the matter will be resolved and a request for further information if required.

An investigation must be launched which may require collecting relevant documents, making site visits, consulting appropriate project personnel, contacting stakeholders, and other activities. Records must be kept of all associated meetings, discussions and activities. Information gathered during the investigation should be thoroughly analyzed to assist in determining how the grievance will be resolved.

Where necessary, outside parties should be engaged, e.g., lawyers or insurance companies, especially in cases of damage claims. Subsequent meetings with the complainant may be required to collect more evidence, conduct further investigation, and launch a dialogue towards resolution.

5.2.8 Action to Resolve the Grievance

Following the investigation, the PGC will use the findings to create an action plan outlining the steps to be taken in order to resolve the grievance. The Committee is responsible for assigning actions, monitoring actions undertaken and ensuring that deadlines are adhered to. Resolutions to complaints should be commensurate with the nature of grievances. Regardless of the outcome of the investigation, the response should be communicated to the complainant, preferably in writing. The response must clearly state the results of the investigation and the status of the complaint. It should also detail the actions that will be taken, by whom and when, and the outcome expected. If no further action will be taken, this too must be communicated, with a detailed and respectful explanation, as well as any compelling evidence of why the decision has been made.

5.2.9 Follow Up and Close Out

The Committee or its designate should make contact with the complainant within a month after the grievance is resolved to verify that the outcome was satisfactory, and also gather any feedback on the grievance process. Minutes of the meeting with the complainant should be recorded. As required, the Committee or its designate may need to follow up with the complainants on numerous occasions to confirm all parties are satisfied, and to obtain a collective agreement to close out the claim.

Cases should only be closed out when an agreement with complainants is reached. It is a good practice to collect proof that corrective actions have taken place. This can be accomplished through photos, videos or other documentary evidence that demonstrate how the grievance was resolved.

The grievance record form and the grievance register should be fully updated with all of the necessary details. This should include confirmation from the complainants that the matter has been satisfactorily resolved.

5.2.10 Appeal

If the complainant is unhappy with the resolution and/or does not agree with the proposed actions, then the PGC needs to escalate the matter to the Project Steering Committee (PSC). The committee will review the grievance and all documentation gathered throughout the investigation and determine whether further actions are required to resolve the grievance. If necessary, the PSC may seek advice from other independent parties, e.g., lawyers etc.

5.2.11 Reporting

The Project Steering Committee should receive quarterly updates on stakeholder grievances from the Project Grievance Committee. Information outlining the number of grievances, time to resolution and outcomes of grievances should be communicated utilizing a grievance register similar to the one shown in Table 22.

Table 22: Grievance register template

Stakeholder	**Date received**	**Officer who received the grievance**	**Grievance level**	**Grievance description**	**Cause of grievance**	**Outcome**	**Grievance status: Resolved Unresolved Abandoned**	**Additional comments**

5.2.12 Review evaluate and revise the GRM

It is essential to always assess the effectiveness of the GRM. Critical questions to focus the review include:

- Are stakeholders using the GRM
- Are complaints and grievances increasing, decreasing or remaining the same?

Feedback should be obtained from all stakeholders. The PL and project staff should provide feedback and offer suggestions for improving the GRM. The following is an example of a short questionnaire that complainants can be asked to complete to rate the GRM as part of the close out process:

1. How did you learn about the GRM?

Project Website	
Project Liaison	
By calling the BNTCL	
Word of mouth	
Other (please specify)	

2. Please rate the following indicators based on your experience with using the GRM.

Indicator	**Poor**	**Average**	**Good**	**Excellent**
The time it took for your complaint to be acknowledged				
The quality of the project officers communication with you during the process				
The length of time it took for your complaint to be resolved				
The resolution of your complaint				

3. Would you recommend the GRM to others?

Yes (why)	
No (why not)	

4. What would you recommend to improve the GRM?

6 Social Monitoring Plan

The following tasks are to be undertaken by the Contractors to ensure that any negative social and gender impacts during the construction works for the 5MW PV Power Plant Project are minimised or eliminated and positive impacts enhanced. Reporting documents are to be submitted on a monthly basis to facilitate the monitoring process.

6.1 Public Communication

Contractors should liaise with the Project Manager and Project Liaison to coordinate communication with the public about the project.

6.1.1 Public Service Announcements

Contractors are required to inform the public of the works programme and schedule in instances where disruptions or nuisances are likely to be experienced. This should take the form of Public Service Announcements (PSA) which should be delivered via the most effective media, e.g. announcements on local radio and television, information on social media, information on the contractor's website, information on the BNTCL website. In the unlikely event of road closures or and diversions, the PSA should be made no less than 48 hours in advance, preferably seven days prior to the closure or diversion.

6.1.2 Precautionary signage

Contractors should erect clearly visible precautionary signs throughout the project site. These signs would indicate safety procedures for all users. Use of barricades to prevent site access to non-construction personnel is essential. Examples of signage are provided below:

Figure 4: ***Examples of precautionary signage***

6.2 Mitigation of Noise Dust and Vibration Impacts

The Contractor is required to adhere to the plan for mitigation of noise, dust and vibration impacts as provided in the environmental management plan.

A Register of Location of Sensitive Receptors should be provided paying specific attention to education facilities; health facilities; facilities for the elderly etc. Special attention must be paid to these receptors during the works to ensure that the impacts are minimised. Table 23 provides a template of the form that should be completed to list all potential sensitive social receptors – schools, clinics etc. Information from the Rapid Assessment can be used to assist in the completion of this form.

Table 23: The location of receptors sensitive to dust noise or vibrations

Site Ref #	**Site/sensitive receptor**	**Distance from construction**	**Potential dust impact (*Check is applicable*)**	**Potential noise impact (*Check is applicable*)**	**Potential vibration impact (*Check is applicable*)**	**Comments**

6.3 Complaints and Grievances

The Contractor is required to comply with the Grievance Redress Mechanism contained in the Social Management Plan. All complaints received should be logged on a Complaints Record form (See Table 24).

Table 24: Complaints record template

Complaints Record	
Date:	
Complainant:	Name: Address: Telephone: Email:
Received by:	Name: Designation: Telephone Email:
Action Taken:	
Further action recommended:	

Complaints are typically of low level severity and should be resolved within a week of receiving the report. If the matter was dealt with immediately by the Contractor or their representative, a copy of the Complaints

Record Form must be shared with the Project Grievance Committee (PGC). The PGC will follow-up by telephone, email or letter to confirm that the action taken was satisfactory and that the matter is closed. If the matter is still to be addressed, the PGC will take the lead and confirm the nature of the complaint and indicate the action that will be taken and the length of time anticipated for the matter to be resolved. Once the action is taken, the PGC should communicate this to the complainant and confirm that the matter is resolved.

If the matter escalates to a more serious level, the grievance procedures will be utilized. For more serious matters, a Grievance Complaint Form (GCF) must be completed (See Table 25). The PGC will take the lead on grievances.

Table 25: Grievance complaint form template

Grievance template
Date of complaint
Time of complaint
Name of person taking the complaint
Job title of person taking the complaint
Signature of person taking the complaint
Name and signature of supervising officer
Complainant information:
Name of complainant
Telephone number of complainant
Address of complainant
Email address of complainant
Details of the complaint:
Nature of complaint: (*In recording the complaint please prompt for the following information where available – dates and times the incident(s) occurred; who was involved in the incident(s); gender and age of people impacted; cost of problem if possible (e.g. cost of doctor's visit and medication; cost of repair to vehicle, cost of repair of third party property, impact of utility outage, etc.)*
Signature of person making the complaint: (*Complaints can be made by email or in person and should be signed. If made by phone the complainant should be encouraged to come into the office and sign off on the complaint*. ***In the event that complainants wish to remain anonymous, the issue should still be investigated and a report compiled***.)
Details of the investigation:
Investigation recommended: – Information to be gathered – Persons/agencies to be contacted – Assessment of resolution mechanisms to be utilized, e.g. mediation, compensation, etc.
Reporting:
Record of the results of the investigation and actions recommended Cost of recommended solutions
Report of action taken including the signature of the person investigating the complaint
Date complainant contacted with the results of the investigation and action taken

6.4 Site Safety

Contractors are expected to operate within the requirements of the Safety and Health at Work Act. A Health and Safety Officer should be on site and responsible for ensuring that the requirements of the companies' Health and Safety Policies are implemented at the project site. All incidents on site must be recorded on an incident report form. An example of an incident report form is provided in Table 26.

Table 26: Example of a health and safety incident report form

The incident			
Reported by:			
Contact details: Company: Email: Phone:			
Date of occurrence:			
Time of occurrence:			
Type of incident:	Accident Violence Other (Please specify)	Incident Ill health	Near miss Safety
Description of incident:	(*Include details that may have contributed to the incident (e.g. poor lighting, absence of signage*)		
Description of the outcome:	(*Harm/health effects/damage*)		
Description of the corrective measures taken to address immediate hazards related to the incident:			
The affected person:			
Description:	Male Worker	Female Visitor	 Contractor

	Other (please specify)
Name:	
Address:	
Date of birth:	
Telephone:	
Email:	
Witness details	
Name:	
Address:	
Telephone:	
Email:	
First aid	
First aid provided:	☐ Yes ☐ No ☐ Not applicable
Time of attendance:	
By whom:	Name: Address: Telephone: Email:
Details of provision:	
Post incident:	
Where did the person involved in the incident go next:	Hospital Clinic Private doctor Home Returned to work Other (please specify)
Was the health and safety officer notified of the incident	☐ Yes ☐ No
Additional information:	

6.5 Gender Equity in Employment

One of the potential positive social benefits of the project is the immediate employment opportunities provided by the construction to local residents. Of concern is that the construction sector is male dominated. The Contractor is required to provide a list of locals who are employed during construction, as well as the nature and duration of the employment. A full list of employees should be provided to demonstrate the ratio of local employment to non-local employment. The list should indicate gender and age. Table 27 is an example of the information that should be provided about the employees.

Table 27: List of employees' template

Employee	Gender (Insert M of F)	Age	Barbadian National	Non-national	Nature of employment	Duration of employment

6.6 Monthly Reporting Requirement

The Consultants Project Engineer is required to complete the following form on a monthly basis:

PROJECT MONITORING CHECKLIST – SOCIAL AND GENDER			
Public Consultation Monthly reporting requirement:			
The contractor is required to submit copies of the Public Service Announcement (PSA) text as well as copies of the receipts from the placements of the PSA in the local media as proof that these PSAs were transmitted.	Public Service Announcements transmitted (Yes or No)	Copies of PSA and/or received available (Yes of No)	Additional Comments
The Contractor is required to utilise precautionary signage on site.	Precautionary signage is in place and clearly visible (Yes or No)	Action recommended if signage is not in place and visible	Additional Comments

PROJECT MONITORING CHECKLIST – SOCIAL AND GENDER			
Air quality (dust, noise and vibrations) monthly reporting requirement:			
The Contractor is required to comply with the specifications of the environmental management plan	Evidence that the Contractor is operating in compliance with the environmental management plan (Yes or No)	Action Recommended if there is evidence of non-compliance or if the measure is not effective	Additional comments
The Contractor has completed a Register of Location of Sensitive Receptors	Register has been completed (Yes or No)	List the specific locations that have been affected in the past month	Additional comments (*should indicate any actions taken to address problems*)
Complaints The contractor is required to submit copies of all the completed complaints forms to the Project Grievance Committee.	Complaints made and copies of forms were completed and delivered to the Project Grievance Committee. (Yes or No)	If complaints were made, review the complaints form and summarise the status of the situation	Additional comments
Site safety monthly reporting requirement:			
Contractors are required to operate within the requirements of the local Safety and Health at Work Act	**Yes**	**No**	**Comments**

PROJECT MONITORING CHECKLIST – SOCIAL AND GENDER			
Health and Safety Officer is on site:			
Staff on site are using PPE correctly:			
On site safety signage is in place:			
Sanitary facilities are suitable and convenient:			
Facilities for staff to access and or consume meals are available:			
Incident log is in use:			
Incidents which occurred within the month have been/are being appropriately addressed:			
Emergency Plan is in place:			
Emergency numbers are visibly located on site:			
Evidence of employment of locals:			
The contractor is required to provide a list of locals who are employed during construction, as well as the nature and duration of the employment.	The list of employees is available (Yes or No)	Copy of employee list obtained (Yes or No)	Additional comments

7 List of references

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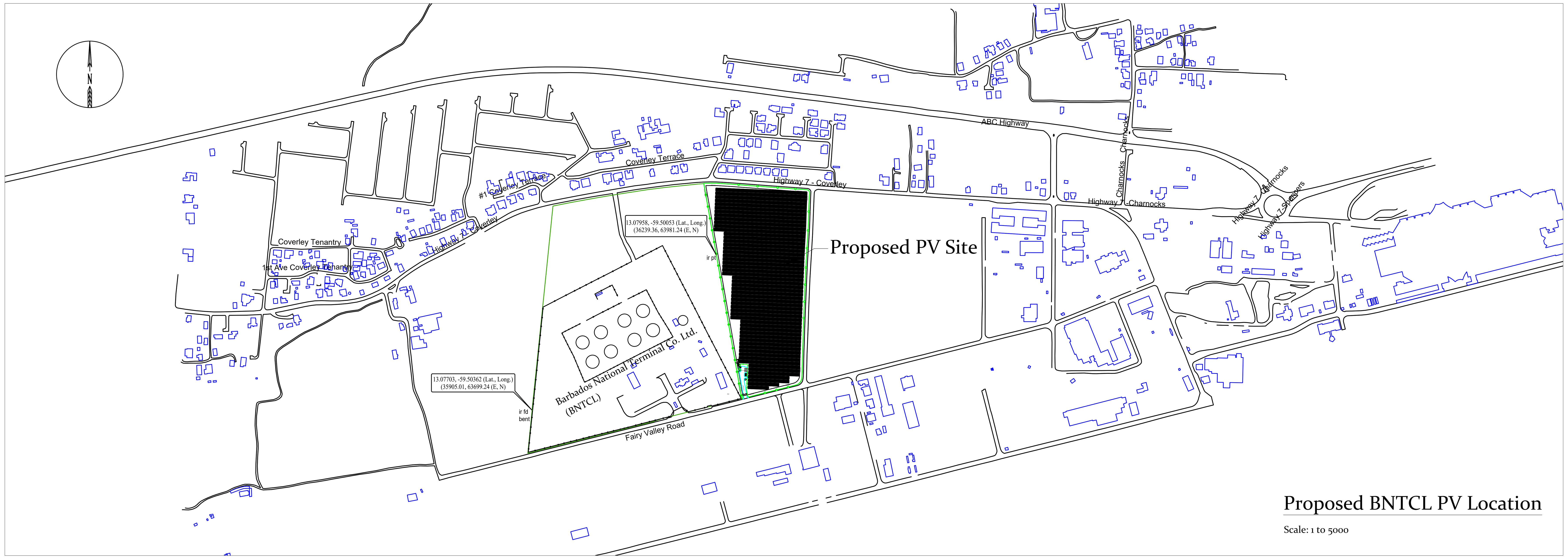
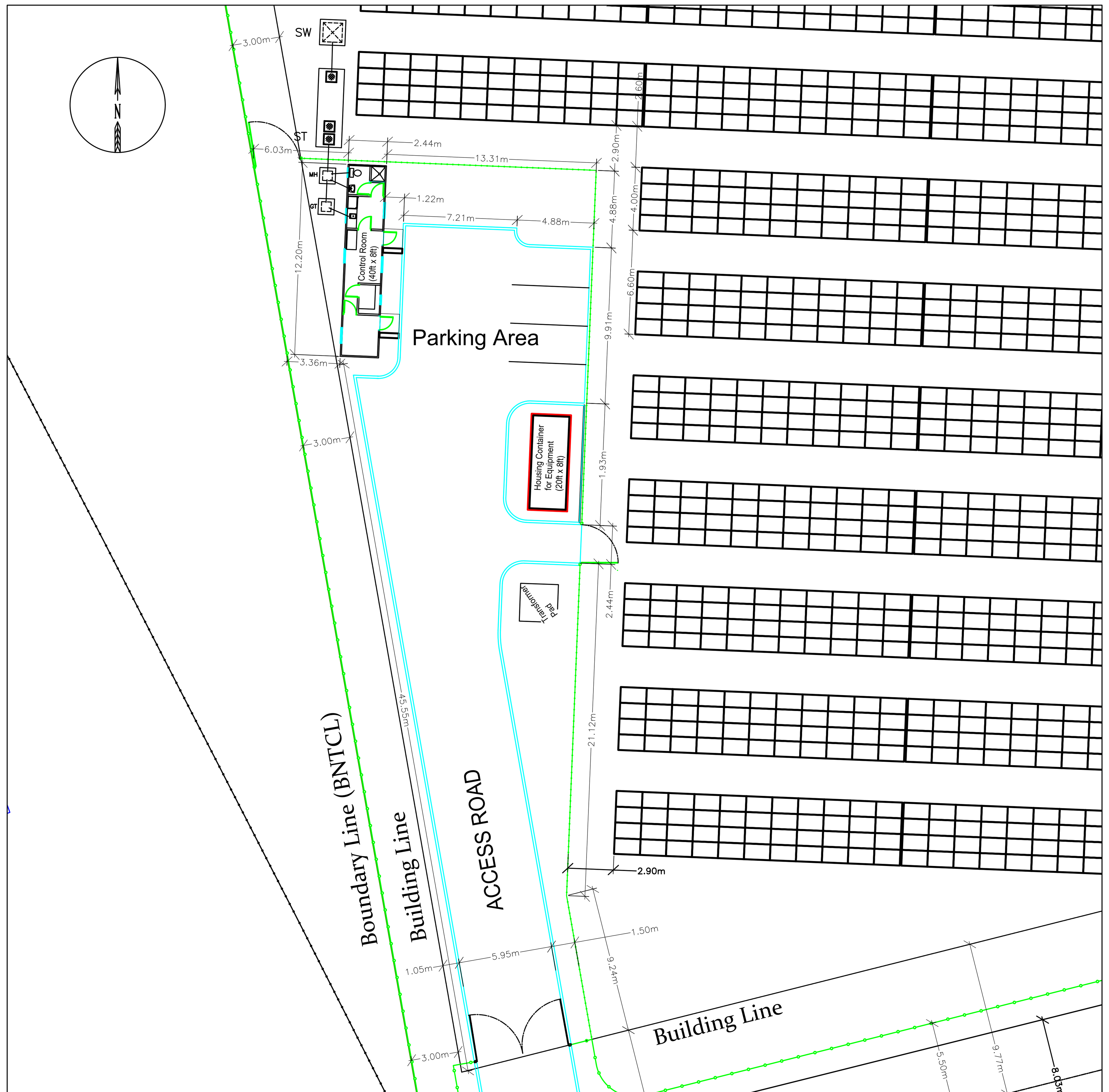
Appendix D

TCDPO PLANNING APPLICATION DRAWINGS



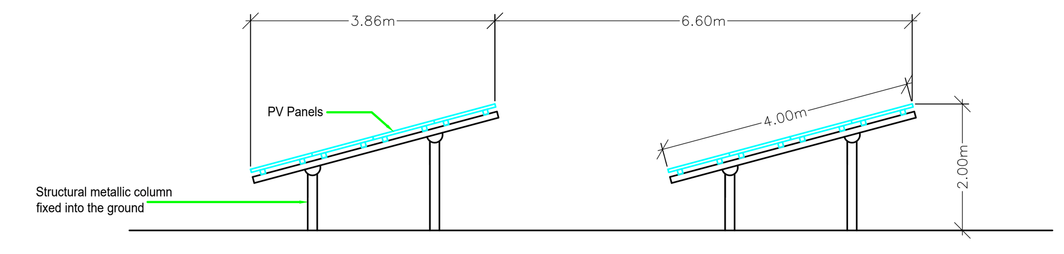
Proposed BNTCL PV Location

Scale: 1 to 5000

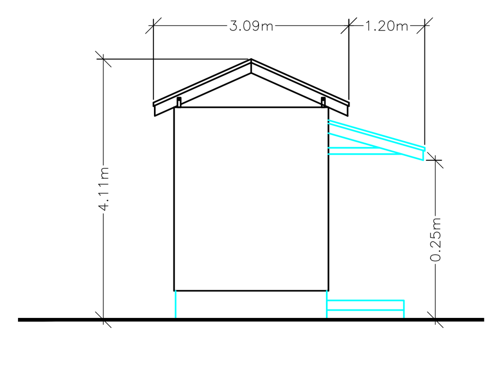


Site Plan - Structures Layout

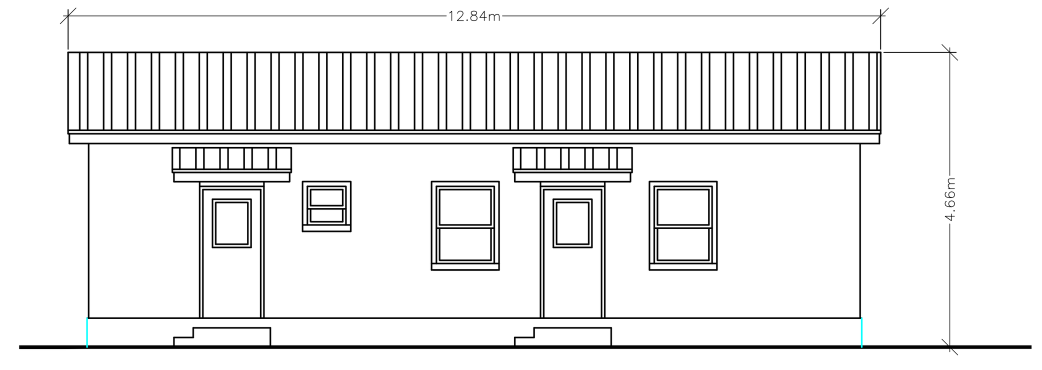
Scale: 1 to 250



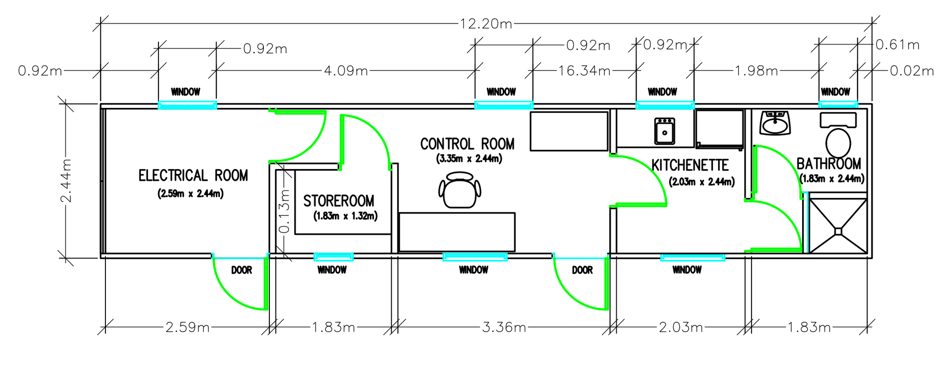
Typical Ground Mount PV System



Control Room South Elevation



Control Room East Elevation



Control Room Floor Plan

Site Details No.1

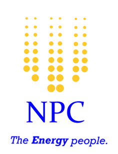
Scale: 1 to 100

General Notes

- PV Modules/Array
- Fence line
- Crude Oil Storage Tanks
- Buildings/Homes
- Roadway
- MH – Manhole
  GT – Grease Trap
- ST – Septic Tank
- SW – Suckwell

TCPDO Application

No.	Revision/Issue	Date



Firm Name and Address

National Petroleum Corporation
Wildey, St. Michael
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Tel: (246) 430 4000
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Email: bimgas@caribsurf.com
Drawn by: Vincent Knight

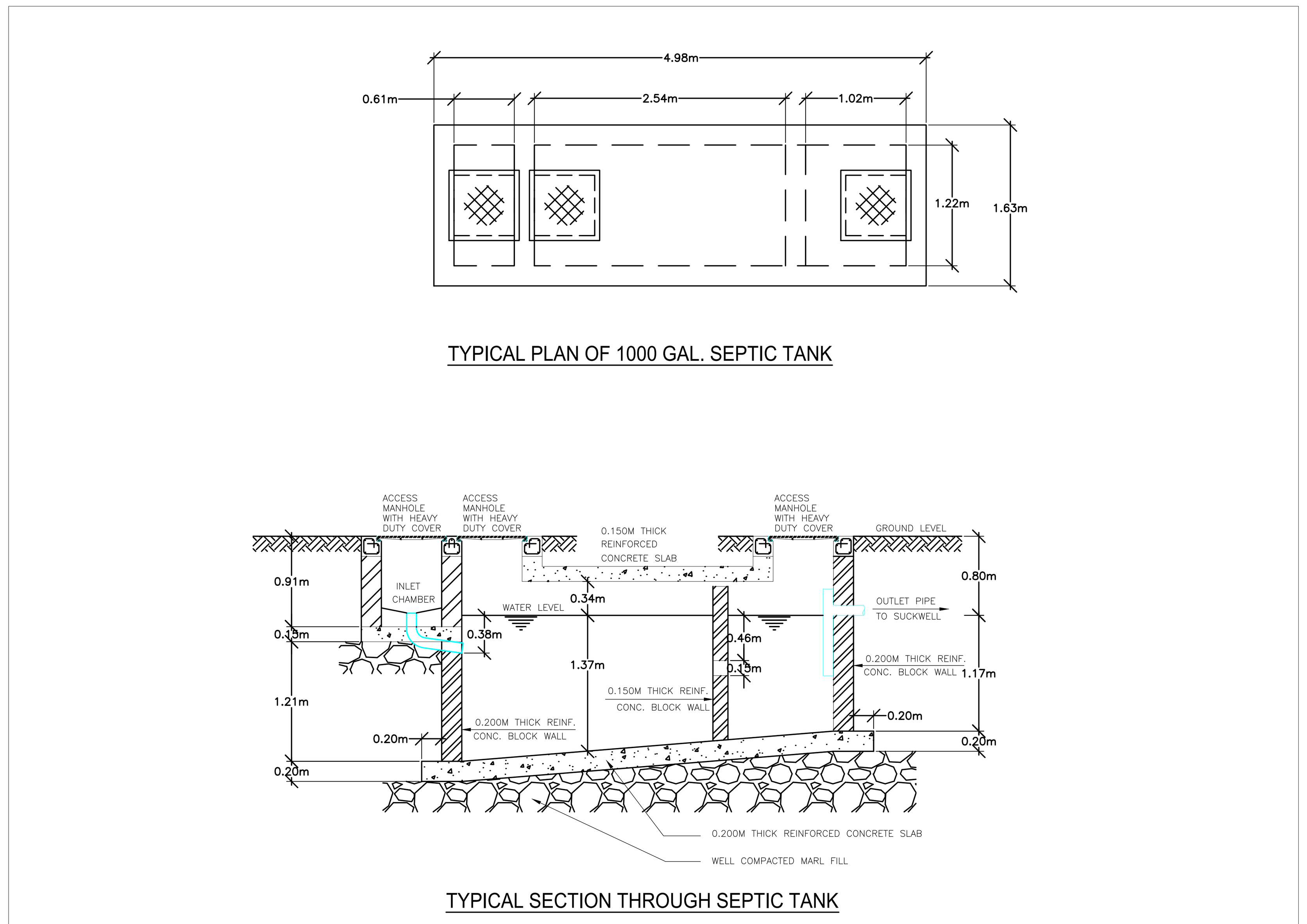
Project Name and Address

BNTCL SOLAR ENERGY
Barbados
Christ Church
Fairy Valley

Project: Location Plan
Date: 24.04.2019
Scale: As Noted
Sheet: 01

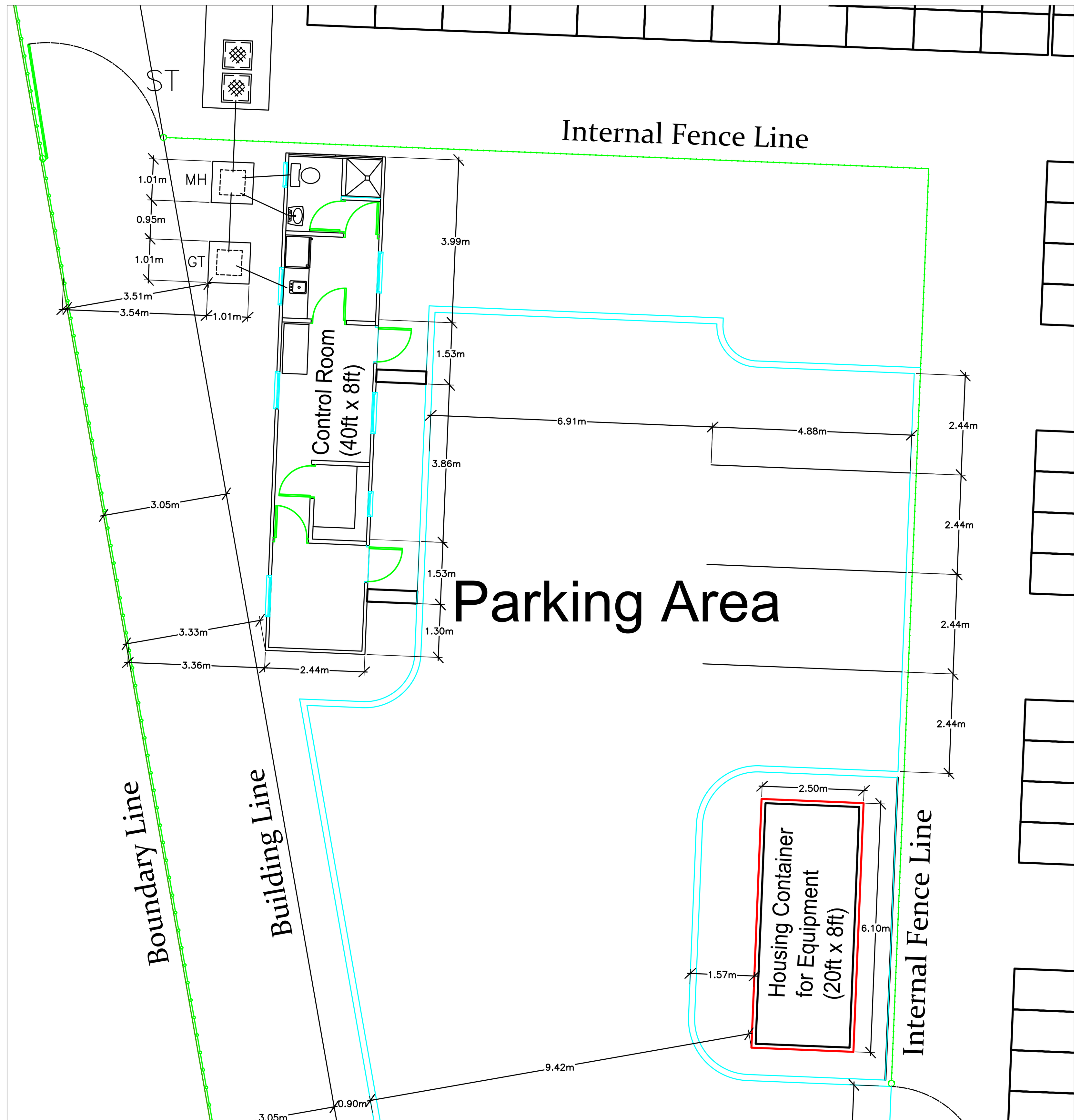
Overall Site Plan

Scale: 1 to 1000



Septic Tank Details

Scale: 1 to 50



Site Plan - Structures Layout No.2

Scale: 1 to 100

General Notes

- PV Modules/Array
- Fence line
- Crude Oil Storage Tanks
- Buildings/Homes
- Roadway
- MH – Manhole
- GT – Grease Trap
- ST – Septic Tank
- SW – Suckwell

TCPDO Application

No.	Revision/Issue	Date

Firm Name and Address

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Fairy Valley

Project	Sheet
Site Plan	02
Date: 24.04.2019	
Scale: As Noted	