Environmental and Social Impact Assessment for the Renewstable® Barbados Hybrid Solar Power Plant with Hydrogen Storage

Final Report

May 24, 2022

Prepared for:

Renewstable (Barbados) Inc.

Prepared by:

Stantec Consulting Caribbean Ltd.
Winslow House
Black Rock
St. Michael
Barbados BB12056

File: 128019054

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR THE RENEWSTABLE® BARBADOS HYBRID SOLAR POWER PLANT WITH HYDROGEN STORAGE

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

Executive Summary

Renewstable (Barbados) Inc. (RSB) is proposing to construct and operate a baseload hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados (the Project). The Project will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas. The Project will generate approximately 56,000 megawatt-hours per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually (based on an average electricity consumption of 3,480 kilowatt-hour per inhabitant per year).

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 help Barbados achieve its renewable energy and carbon neutrality targets. Where other solar PV approaches provide intermittent power with little or no storage, the Project offers a baseload solution that combines solar power with hydrogen and lithium technologies.

The electricity generated by the Project will be purchased by Barbados Light & Power Company at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. The tentative Project schedule is for construction to occur between April 2023 and April 2025. Operation and maintenance would begin in May 2025 with the designed operational lifetime of the Project being up to 30 years. The decommissioning phase of the Project will commence following the conclusion of Project operations and is anticipated to last approximately 12 months.

The energy facility components of the Project will consist of a solar PV power plant and associated battery and hydrogen energy storage systems. These components will be controlled and optimized via an integrated Energy Management System. The Project will convert sunlight into electricity via the solar PV power plant. A capped and consistent level of output from the power plant will be directed to the grid, while the remainder will be used to split water molecules into hydrogen and oxygen via an electrolyser system. The resultant hydrogen will be stored as compressed gas. Fuel cells will then be used to produce electricity whenever needed from the stored hydrogen gas, thereby enabling the delivery of stable power to the national grid. The power plant will occupy a plot totaling 73.6 ha, among it approximately 59.1 ha and will consist of an array of 96,154 solar panels, equipped with PV cells, which will be ground-mounted in a fixed-tilt, south-oriented configuration. This configuration has been selected because it is well-adapted to solar grazing and is efficient for energy generation while limiting land use requirements.

The Project will be designed to accommodate at least 1,830 Blackbelly sheep. On-site agricultural facilities will include sheep pens, a barn for hay storage, a feed silo, water storage tanks, a designated waste skip area on a concrete pad, and a farm building/staff facility, all of which will occupy a total of approximately 2.3 ha. The sheep will be allowed to graze between and beneath the solar panels of the power plant within a solar grazing area that is approximately 57.4 ha in size to which shall be added approximately 10 ha dedicated to agricultural activities: grazing and/or fodder pasture.

Project construction will be managed by an international engineering, procurement, and construction contractor that will subcontract with the local workforce. It is estimated that the construction phase of the Project will provide temporary employment for up to approximately 150 local people. Following construction, it is estimated that approximately 20 full-time-equivalent local jobs will be created to support Project operation, maintenance, and security requirements. The sheep farming aspect of the Project is expected to create 10 full-time-equivalent local jobs as farmers and farm staff. In addition to their pay, Project personnel will also gain valuable experience and training.

This Environmental and Social Impact Assessment (ESIA) has been prepared to support RSB's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project. It has been developed in consideration of the Terms of Reference for the ESIA and relies on several Project-specific studies that have been conducted in support of the impact assessment, including baseline surveys, various modelling studies, and a quantitative risk assessment for accidental events.

The ESIA describes the routine activities and components of the Project, the existing baseline conditions at the Project Property. It also discusses the potential physical, biological, and social impacts associated with routine Project activities, and mitigation measures to reduce the potential for adverse impacts during each phase of the Project. In addition, the ESIA assesses potential impacts that could occur as a result of accidents, malfunctions and disasters, as well as the potential cumulative impacts of the Project in combination with other past, present and reasonably foreseeable activities. Further, the ESIA identifies the proposed management and monitoring plans (including emergency response procedures) that would be in place to protect the environment and human health and safety.

Specifically, the ESIA assesses potential Project impacts for the following valued components (VCs):

- Atmospheric and Acoustic Environment
- Surface Water and Groundwater Resources
- Flora and Fauna
- Visual Environment
- Agriculture and Other Land Uses
- Health and Safety
- Human Capital
- Economy
- Cultural Values
- Infrastructure and Services
- Social Dynamics

The assessment predicts that for routine Project activities during construction, operation and/or decommissioning, residual adverse effects (following consideration of proposed mitigation measures) are negligible to moderate in magnitude, reversible and not significant, with a high degree of confidence. With application of mitigation, the potential cumulative environmental impacts of the Project in combination with other planned developments are predicted to be adverse in direction, low to moderate in magnitude, reversible and not significant, with a moderate degree of confidence. For accidents, malfunctions and disasters, specifically accidental spills or leaks of hazardous materials or a loss of containment of flammable vapours or hydrogen gas, the impacts from a worst-case event could be significant for several VCs, including surface water and groundwater resources, agriculture and other land uses, and health and safety. An Emergency and Disaster Management Plan has been prepared as part of the Environmental and Social Management Plan (ESMP) to identify procedures and protocols to be carried out in the event of a natural, accidental or human-made disaster at the facility that will serve to respond to and reduce the potential impacts of the events. The plan includes protocols for emergencies and disasters such as explosions, fire, spills, and hurricanes.

The ESMP also incorporates and operationalizes the design mitigation and environmental protection procedures that have been identified in the ESIA, both as general construction and operation environmental protection procedures and VC-specific mitigation measures. The ESMP is intended to be a “living” document that is revised as necessary to remain relevant to the applicable stage of Project planning, design, and execution. Through the ESMP, RSB will manage and reduce the potential adverse environmental and social impacts of the Project and enhance benefits to the community and Barbados as a whole. RSB is committed to developing and operating this Project in keeping with best practices and in a manner that is protective of the environment and public health and safety.

ABBREVIATIONS

°	degree(s)
µS	microsiemens
AIA	Agricultural Impact Assessment
AMSL	above mean sea level
AOI	Area of Influence
ARC	anti-reflective coating
ASCE	American Society of Civil Engineers
BAMC	Barbados Agricultural Management Company
BBD	Barbadian dollar(s)
BESS	battery energy storage system
BLPC	Barbados Light & Power Company
BMSL	below mean sea level
BNEP	*Barbados National Energy Policy 2019–2030* (Government of Barbados 2019)
Board, the	Planning and Development Board
BREA	Barbados Renewable Energy Association
BWA	Barbados Water Authority
C	Celsius
CAC	criteria air contaminant
CIA	Cumulative Impact Assessment
cm	centimetre(s)
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPC	conventional plant cane
CTP	Chief Town Planner
dBA	decibel, A-weighted
DC	direct current
EIA	Environmental Impact Assessment
EIA Committee	Environmental Impact Assessment Committee
EIS	Environmental Impact Statement
EMS	Energy Management System
ENSO	El Niño Southern Oscillation
EPD	Environmental Protection Department
EPFI	Equator Principles Financial Institution

ESCP	Environmental and Social Commitment Plan
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Assessment and Management System
FTC	Fair Trading Commission
GCM	General Circumation Model
GHG	greenhouse gas
GWh	gigawatt-hour(s)
H_2	molecular hydrogen / hydrogen gas
H_2O	water
ha	hectare(s)
HVAC	heating, ventilation, and air conditioning
HyPCe	Hydrogen Power Centre
IADB	Inter-American Development Bank
IBA	Important Bird Area
KOH	potassium hydroxide
kWh	kilowatt-hour(s)
L	litre(s)
L_{eq}	equivalent continuous sound pressure level
Lithium-ion	Li-ion
L_{max}	maximum sound pressure level
LOC	loss of containment
L_{peak}	peak sound pressure level
m^3	cubic metre(s)
MBtu	1,000 British thermal units
mg	milligram(s)
MSL	mean sea level
MW	megawatt(s)
MWh	megawatt-hour(s)
MWp	megawatt peak
NFPA	National Fire Protection Association
NPFA 59a	S*tandard for the Production, Storage, and Handling of Liquefied Natural Gas* (NFPA 2019)
O	oxygen
OHS	occupational health and safety

Order, the	*Town and Country Planning Development Order, 1972*
P&D Act	*Planning and Development Act, 2019*
P&D Amendment Act	*Planning and Development (Amendment Act), 2020*
PDA	Project Development Area
PDD	Planning and Development Department
PDP	*Physical Development Plan* (Government of Barbados 2003)
PEM	proton-exchange membrane
PPA	power purchase agreement
Project, the	Renewstable® Barbados Project
PV	photovoltaic
QRA	Quantitative Risk Assessment
RCM	Regional Circulation Model
RER	Renewable Energy Rider
RMI	Rocky Mountain Institute
RoW(s)	right(s)-of-way
RSA	Regional Study Area
RSB	Renewstable (Barbados) Inc.
SGHAT	Solar Glare Hazard Analysis Tool
SIA	Social Impact Assessment
SMP	Social Management Plan
SPL	sound pressure level
t	metric tonne(s)
TCDO	Town and Country Development Planning Office
TCPA	*Town and Country Planning Act*, Cap. 240
TWA	time-weighted average
UNEP	United Nations Environmental Programme
UWI	University of the West Indies
VC	valued component
VIA	Visual Impact Assessment
WC	watercourse
WHO	World Health Organization
WHO Guidelines	*Guidelines for Community Noise* (WHO 1999)

1.0 INTRODUCTION

Renewstable (Barbados) Inc. (referred to herein as "RSB" and "the Proponent") is proposing to construct and operate a hybrid solar photovoltaic (PV) energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados. The Renewstable® Barbados Project (referred to herein as "the Project") will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas.

This Environmental and Social Impact Assessment (ESIA) has been prepared to support the Proponent's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project.

1.1 PROJECT OVERVIEW, CONTEXT, AND RATIONALE

The Project will generate approximately 56,000 megawatt-hours (MWh) per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually[1]. The electricity generated by the Project will be purchased by the privately-owned utility Barbados Light & Power Company (BLPC), which is currently the sole electricity utility provider in Barbados, at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. During the term of this agreement, the Project will deliver the following power supplies to Barbados' national grid daily:

- 13 megawatts (MW) between the hours of 8:00 and 17:00;
- a two-hour dispatchable block of 13 MW firm to meet the end-of-day peak, when the marginal cost of generation in Barbados is the highest (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid); and
- 3 MW firm the rest of the time (i.e., during the night).

To achieve this, the Project will entail construction and operation of the following key components:

- A ground-mounted solar PV power plant that generates a carbon-free primary source of electricity;
- A long-term energy storage solution using hydrogen that includes electrolysers, a gaseous hydrogen storage tank farm, and a fuel cell system; and
- A short-term energy storage solution using batteries.

[1] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

The Project involves dual land uses, as the site of the solar PV power plant will also accommodate a commercial Blackbelly sheep farm that is specifically designed to be financially viable and environmentally sustainable in the long-term and is proposed to be the largest in Barbados. The agricultural facilities associated with the Project will be used to raise sheep livestock; for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets.

With the release of the *Barbados National Energy Policy 2019–2030* (BNEP) (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. However, over 90% of the energy used for electricity production in Barbados is currently derived from imported fossil fuels (Ministry of Energy and Water Resources 2019). BLPC and the Barbados Renewable Energy Association (BREA) have advised that the government's BNEP goals cannot be achieved without baseload renewable power implementation (HDF 2019).

As a baseload clean asset, the Project will help Barbados achieve its 100% renewable energy and carbon neutrality targets. Where other solar PV approaches provide intermittent power with little or no storage, the Project offers a baseload solution that combines solar power with hydrogen and lithium technologies. Thus, the Project will enable:

- carbon-free and renewable baseload generation;
- the storage of a large quantity of energy for long-term service over extended time periods; and
- the reliable delivery of non-intermittent power on a 24 hours per day seven days per week basis,
- the delivery of power to help periods of peak consumption.

1.2 PURPOSE AND SCOPE OF THE ESIA

As indicated above, this ESIA has been prepared to support the Proponent's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project. It has been developed in consideration of the Terms of Reference (TOR) for the ESIA (Appendix A), which were finalized and accepted by the government in November 2021. The purpose of the ESIA is to describe the planned activities and components of the proposed Project, to identify the potential impacts associated with these activities, and to develop appropriate mitigation measures and controls to reduce the potential for adverse environmental impacts during each phase of the Project. Further, the ESIA identifies the proposed management and monitoring plans (including emergency response procedures) that would be in place to protect the environment and human health and safety.

The scope of this ESIA includes the construction, operation / maintenance, and decommissioning of the Project. Further information on the scope of this assessment is found in Section 6.

1.3 PROJECT, PROPONENT, AND CONSULTANT INFORMATION

Table 1.1 presents the title of the Project and provides contact information for the Proponent and the Consultant.

Table 1.1 Project, Proponent, and Consultant Information

Project Title	Renewstable® Barbados Project (“the Project”)
Project Proponent	Renewstable (Barbados) Inc. (“RSB” or “the Proponent”)
Proponent Contact	Thibault Ménage
Consultant	Stantec Consulting Caribbean Ltd.
Consultant Contact	Justin Jennings-Wray

RSB is a special purpose vehicle company that at the time of writing is jointly owned by Rubis Caribbean Holdings Inc. and HDF Energy.

HDF Energy is a global pioneer in hydrogen power develops and operates high-capacity, large-scale hydrogen-to-power infrastructure to provide firm or on-demand electricity from renewable energy sources (wind or solar), combined with high power multi-megawatt fuel cells.

Rubis Caribbean is a subsidiary of Rubis Energie, which is a public company headquartered in France and traded on the Paris Euronext exchange. Rubis Caribbean’s operating areas include the marketing, sale and transport of petroleum, petroleum products and aviation fuels within the Caribbean region.

Table 1.2 provides an overview of ongoing Renewstable® power plant projects around the world, including the CEOG Project in French Guyana, which is a power plant with a similar structure to RSB. HDF Energy is an accelerator of the global energy transition by offering grid-friendly and stable decarbonized electricity solutions that make 100% renewable energy grids possible.

Table 1.2 Renewstable® Power Plant Projects in Development

Project Name	Project Location	Project Details	Project Website
CEOG	French Guiana	• The world's first multi-megawatt hydrogen power plant • Firm power of 10 MW day and evening / 3 MW night • Will provide 24/7 clean and reliable electricity to 10,000 French Guiana Households • Start of construction: Autumn 2021 • Commissioning: 2024	www.ceog.fr
Energía Los Cabos	Mexico	• Firm power 40 MW day and evening / 9 MW night • Land secured, permitting development • Start of construction 2023 • Commissioning: 2025	www.energia-loscabos.com
SUMBA	Indonesia	• Pipeline of projects under development • Firm power > 20 MW • Commissioning: 2025	www.renewstable-sumba.com
CYR	Australia	• Firm 2 MW power • First renewable project in Cape York	www.cape-york-renewstable.com

Table 1.2 Renewstable® Power Plant Projects in Development

Project Name	Project Location	Project Details	Project Website
CAGOU	New Caledonia	• Firm 160 MW baseload • Tender to substitute fossil fuel power plant	www.cagou-energies.com
RSWK	Namibia	• Firm Power 30 MW day and evening peak / 6 MW night • Land approved by council; permitting in progress • Start of construction: 2023 • Commissioning: 2025	www.renewstable-swakopmund.com
Source: HDF 2022.			

This ESIA was prepared by Stantec Consulting Caribbean Ltd. (Stantec; the Consultant), an independent third-party consultant that has been engaged by RSB to assist with the ESIA and management in support of the Project. The team of consultants for this Project (Table 1.3) also includes Dr. Janice Cumberbatch, who has been sub-contracted by Stantec as a Social and Gender Specialist to lead the Social Impact Assessment (SIA) portion of the ESIA. In addition, RSB has engaged Richard Gill Associates Limited as the Planning Application consultant for the Project and ENSMART as the Electrical Grid Consultant for the Project.

Table 1.3 Team of Consultants

Consultant	Role
Stantec Consulting Ltd.	Environmental and Social Impact Assessment and Management
Dr. Janice Cumberbatch	Social and Gender Specialist
Richard Gill Associates Limited	Planning Application Consultant
ENSMART	Electrical Grid Consultant

1.4 REPORT OUTLINE

As indicated in Section 1.2, the content of the ESIA has been guided by the requirements of the TOR (Appendix A). The ESIA includes the following sections:

1. Introduction – provides background on the Project and scope of the ESIA, as well as a description of RSB and the Study Team.
2. Legal, Policy and Administrative Frameworks – provides the national legal and policy frameworks that are potentially applicable to the Project, as well as international standards and guidelines that were considered during preparation of the ESIA. This section also discusses the associated environmental regulatory processes and approvals that may be required to enable the Project to proceed.

3. Project Description – provides a description of the Project, including the proposed location, components, activities, and schedule. It also contains a description of anticipated emissions, discharges and wastes for each Project phase and the environmental protection procedures that would be in place. An assessment of Project alternatives is also provided.
4. Energy Production and Benefits of the Project – describes both the environmental, social and economic benefits of the Project.
5. Public and Stakeholder Consultation and Engagement – identifies stakeholders and potential issues of concern, as well as providing an overview of the public and stakeholder consultation and engagement activities that have been undertaken to date in support of the Project, the outcomes of those consultation and engagement efforts, and future plans for Project-related consultation and engagement.
6. ESIA Scoping Considerations and Impact Assessment Methods – further describes the scope of the Project to be assessed, the selection and scoping of Valued Components (VCs), the spatial and temporal boundaries for the assessment and the overall impact assessment approach.
7. Existing Environment – provides an overview of the existing conditions in the vicinity of the Project, including the biological and ecological environment (climate, acoustic environment, topography, geology and surficial soils, surface water and drainage, groundwater resources and flora and fauna), anthropogenic environment (land use and visual environment) and social environment. This information was collected from previously completed studies, publicly available literature and reports, and a site survey to document flora and fauna.
8. Environmental Impact Assessment and Mitigation – outlines the environmental impact assessment methods, assesses potential environmental impacts that could arise as a result of Project activities, and identifies the mitigation and monitoring measures that have been developed to manage these potential impacts. The impacts of routine Project activities are assessed for each VC. The potential impacts of accidents and malfunctions are also assessed in Section 8.7.
9. Social Impact Assessment and Mitigation – provides the results of the social baseline survey and assessed the potential impacts on the social environment during construction and operation, as well as potential cumulative effects. Mitigation measures are identified.
10. Cumulative Impact Assessment and Mitigation – assesses the cumulative impacts of the Project on the biophysical and social environment in combination with other past, present and reasonably foressable activities and undertakings. Potential cumulative impacts are assessed in cases where the residual impacts of the Project on a VC have potential to overlap spatially and temporally (and therefore interact cumulatively) with the residual impacts of another past, present, or reasonably foreseeable future project or activity on the same VC. Mitigation measures are identified.
11. Monitoring and Management Plans – describes the Environmental and Social Management Plan, which is appended to this ESIA and includes a Construction Management Plan and Emergency and Disaster Management Plan.
12. Conclusions and Recommendations – summarizes the results of this ESIA and relevant recommendations.
13. References – provides the literature, reports, and personal communications cited in the ESIA.

Table 1.4 provides a table of concordance between this ESIA and the key requirements of the TOR (Appendix A).

Table 1.4 Table of Concordance with TOR

TOR Requirement	Relevant Section of the ESIA
Description of the Proposed Project	Chapter 3
Legislative and Regulatory Considerations	Chapter 2
Project Alternatives	Section 3.9
Description of the Environment	Chapter 7
• Physical	Sections 7.1.1 to 7.1.6
• Biological	Section 7.1.7
• Social and Cultural	Sections 7.2 and 7.3
Potential Impacts to be Studied	Chapter 8
• Land Use Impacts	Section 8.6
• Social Impacts	Section 9.2
• Visual Impacts	Section 8.5, Appendix G
• Reflection (Glint and Glare) Impacts	Section 8.5, Appendix H
• Ecological Impacts	Section 8.4, Appendix F
• Agricultural Impacts	Section 8.6, Appendix C
• Noise Impacts	Section 8.2, Appendix E
• Stormwater Drainage	Section 8.3, Appendix B
• Hydrogeological Impacts	Section 8.3
• Waste Disposal Impacts	Section 3.6, Section 9.2, Appendix C
• Construction, Site Management and End-of-Life	Chapter 8, Appendix C, Appendix I
• Energy Production and Potential Benefits	Chapter 4
Hazard Study	Section 8.7, Appendix D
Environmental Management and Monitoring	Section 11.1, Appendix I
Emergency (Disaster) Management Plan	Section 11.3, Appendix I
Construction Management Plan	Section 11.2, Appendix I
Deficiencies and Challenges	Sections 8.2.5, 8.3.5, 8.4.5, 8.5.5, 8.6.5

2.0 LEGAL, POLICY, AND ADMINISTRATIVE FRAMEWORK

2.1 BARBADIAN LEGISLATION AND POLICIES

Table 2.1 provides an overview of key Barbadian legislation and policies that are potentially relevant to the Project and this ESIA. In addition to Table 2.1, Sections 2.1.1 to 2.1.5 below provide further information regarding the aspects of selected laws and policies that are considered most relevant to the Project, as well as associated environmental regulatory processes and approvals that may be required to enable the Project to proceed. A relatively greater level of detail is provided regarding the selected laws and policies due to their relevance to Project activities and implications for Project planning and permitting.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Legislation Associated with Renewable Energy in Barbados	
Electric Light and Power Act, 2013 and associated amendments and *Fees Regulations*	"An Act to revise the law relating to the supply and use of electricity, to promote the generation of electricity from sources of renewable energy, to enhance the security and reliability of the supply of electricity and to provide for related matters." • Allows for the generation and supply of electricity by independent power producers. • Establishes the requirement for licences to supply, distribute, store, transmit, and dispatch electricity. • Sets out licence application fees. • Allows for the public utility to make interconnections for electricity supply. • Allows for the Minister to set targets for the supply of electricity from sources of renewable energy. • Sets out licencees' powers, obligation, and restrictions in respect of electricity supply (e.g., in relation to the carrying out of works, the placement of electrical lines, etc.).
Fair Trading Commission Act, Cap. 326B	"An Act to provide for the establishment of a Fair Trading Commission to safeguard the interests of consumers, to regulate utility services supplied by service providers, to monitor and investigate the conduct of service providers and business enterprises, to promote and maintain effective competition in the economy, and for related matters." • Establishes a Fair Trading Commission to enforce the *Utilities Regulation Act.* • Allows for the Commission to set maximum rates and determine standards of service for providers of utility services, including the supply and distribution of electricity. • Empowers the Commission to investigate suspected breaches of the *Utilities Regulation Act* and take appropriate enforcement action.
Utilities Regulation Act, Cap. 282	"An Act to provide for the regulation of utility services." • Sets out requirements and principles for setting utility rates. • Establishes a duty to provide adequate utility service. • Allows for joint use of equipment by more than one service provider.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Electricity Act, Cap. 277	"An Act to provide for the inspection and control of electrical works and for other purposes in connection therewith." • Establishes requirements for inspection of electrical installations prior to the supply of electricity, and for inspection of alterations and extensions to installations. • Establishes requirements for reporting of accidents involving electrical works and circuits.
Legislation Governing Physical Development in Barbados	
Town and Country Planning Act, Cap. 240	"An Act to make provision for (a) the orderly and progressive development of land; (b) the grant of permission to develop land; (c) powers to regulate land use and development; and (d) related matters" • Regulates physical development, defined as "the carrying out of building, engineering, mining or other operations in, on, over or under any land, the making of any material change in use of any buildings or other land or the subdivision of land". • Establishes requirements for environmental impact assessments. • Superseded by the *Planning and Development Act, 2019*.
Planning and Development Act, 2019 and associated amendments and regulations	"An Act to make provision for (a) the orderly and progressive development of land; (b) the grant of permission to develop land; (c) powers to regulate land use and development; and (d) related matters" • Regulates physical development, defined as "the carrying out of building, engineering, mining or other operations in, on, over or under any land; the making of any material change in use of any building or land; or the subdivision of land". • Establishes requirements for environmental impact assessments. • Establishes a new Planning and Development Board and a new Planning and Development Department.
Safety and Health and Work Act, *2005* Cap. 356	"An Act to make provision (a) for securing the health, safety and welfare of persons at work; (b) for protecting other persons against risks to health and safety in connection with the activities of persons at work; (c) for controlling certain emissions into the environment; (d) to consolidate the law relating to health, safety and (e) for related matters." • Sets out general duties of occupiers and employers as well as duties and requirements in relation to safety, health, employee welfare, medical examinations. • Includes specific provisions for building operations and works of engineering construction; storage, handling and use of hazardous substances and articles in the workplace; processes involving special risks to safety and health of employees; use and management of pressure vessels.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Health Services Act, *1969*, Cap. 44 and associated amendments and regulations	"An Act relating to the promotion and preservation of the health of the inhabitants of Barbados." • Includes provisions for the abatement of nuisances and the removal or correction of conditions injurious to public health. • Authorises the Minister to compel works in the interest of public health. • The associated *Health Services (Nuisance) Regulations* allow for the control of nuisance, including any "matter, thing, deposit, or accumulation of liquid or solid matter" deemed unsanitary, injurious, or dangerous to health, or likely to become so; unpermitted discharge of industrial waste or other noxious matter; conditions that promote the proliferation of public health disease vectors. • The associated *Health Services (Building) Regulations* regulate the construction, extension, or alteration of buildings, with specific reference to drainage, sanitation, and ventilation.
Emergency Management Act, 2006	"An Act to provide for the effective organization and management of disasters and other emergencies in Barbados." • Authorises disaster hazard inspections in the event that the "condition of any premises is reasonably suspected of posing a danger of serious injury to persons outside of the premises in the event of an emergency or an impact of a hazard."
Trees (Preservation) Act, *1981*, Cap. 397	"An Act to provide for the preservation of trees." • Restricts the removal of trees over a certain size. • Authorises the Chief Town Planner to require planting, re-planting, maintenance, and protection of trees to preserve and enhance the amenity of "any land abutting upon, adjoining or near a public road".
Marine Pollution Control Act, 1998, Cap. 392A	"An Act to prevent, reduce and control pollution of the marine environment of Barbados from whatever source. " • Prohibits release of any pollutant into the environment if such releases violate standards, conditions or requirements specified under the Act or associated regulations. • Scope includes land-based sources of marine pollution.
Policies Associated with Renewable Energy in Barbados[1]	
National Strategic Plan of Barbados 2006–2025	The *National Strategic Plan of Barbados 2006–2025* 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. The objective included programs to expand the supply of renewable energy. Specific targets included meeting 30% of energy requirements from renewable energy by 2025 and substantially increasing the number of renewable energy businesses by 2025 (Government of Barbados 2007).
National Sustainable Development Policy	The *National Sustainable Development Policy* attempted to encourage an integrated and holistic approach to sustainable development. In addition, the Policy emphasized that measures to support and promote the adoption of renewable energy, energy efficiency, and energy conservation would help Barbados to meet its obligations as a party to the *United Nations Framework Convention on Climate Change* (Government of Barbados 2004).

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
Sustainable Energy Framework for Barbados	The Sustainable Energy Framework is an ongoing technical assistance program with the Inter-American Development Bank, the objective of which is to promote renewable energy and energy efficiency to reduce fossil fuel dependency while enhancing energy security and environmental sustainability. The most recent instalment of the program includes a focus on further development and modernization of the electricity framework in Barbados to support adoption of renewable energy technologies (Government of Barbados 2019b).
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. It sought to increase efficiency and sustainability in the energy supply and demand. In addition, the Policy aimed to encourage economically viable utility-scale renewable energy, promote energy cost reduction technologies, reduce fossil fuel dependency, and decrease the impacts of global warming (Government of Barbados 2019c).
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 Policy sought to ensure affordable energy security, a sustainable energy sector, and increased renewable energy and energy efficiency (Government of Barbados 2019d).
Barbados National Energy Policy 2019–2030 (BNEP)	The BNEP 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 (Government of Barbados 2019a).
Renewable Energy Rider (RER) Program	The former RER Program allowed domestic customers to sell energy back to the electrical grid at 1.6 times the level of the Fuel Clause Adjustment. In 2016, the RER credit rate began to be calculated using a resource cost approach, rather than being tied to the Fuel Clause Adjustment (Howard 2019). In 2019, the RER was replaced by a feed-in tariff, and RER agreements were grandfathered for a period of 20 years (FTC 2019).
Policies Associated with Physical Development in Barbados	
National Groundwater Protection Zoning Policy, 1963 (revised in 1973 and 2010) and Green Paper on the 2020 Water Protection and Land Use Zoning Policy	The *National Groundwater Protection Zoning Policy* delineates the island into five zones. Public water supply wells are located in the most restricted Zone 1 areas (Stantec 2022). The Green Paper (i.e., a tentative government consultation document of policy proposals for debate and discussion, which was produced by the Ministry of Energy and Water Resources, the Government of Barbados, and the Barbados Water Authority [BWA]) proposes that the groundwater protection zones introduced in the *National Groundwater Protection Zoning Policy* be re-configured for the following purposes (Stantec 2022): • To boost groundwater water quality protection due to the presence of more recalcitrant persistent pollutants. • To release more lands in the current Zone 1 protection areas for development.

Table 2.1 Relevant Barbadian Legislation and Policies

Legislation or Policy	Description
	More specifically, the Green Paper states the following (Stantec 2022): • The existing *National Groundwater Protection Zoning Policy* is over 50 years old and does not protect against persistent chemical pollutants. • The existing Zones 1 to 5 are proposed to be 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. • As described in Appendix B, the Project is currently located within a Zone 3 groundwater protection zone as per the existing Policy. If the Policy is revised as proposed in the Green Paper, the Project will be located within a Zone D groundwater protection zone.
Physical Development Plan (PDP) and associated 2003 amendment and draft 2017 amendment	The purpose of the PDP is to promote sustainable growth and development within Barbados by setting out policies and regulations to guide proponents of proposed developments, including requirements related to the conduct of an Environmental Impact Assessment (EIA) or ESIA.
Note: [1] The information regarding policies associated with renewable energy in Barbados was adapted from Evelyn (2020). Other sources are cited throughout the table where applicable.	

Critical to implementing the legislation and policies identified herein are the competent authorities with regulatory responsibilities to monitor the construction and operation of projects in Barbados. These authorities are listed in Table 2.2.

Table 2.2 Relevant Barbadian Regulatory Authorities

Agency	Responsibilities
The Prime Minister's Office Planning Unit	• Enforces the Barbados *Physical Development Plan*. • Regulates EIA in Barbados. • Controls the development of land having regard to proper planning standards and environmental management practices.
Planning and Development Department (PDD; formerly the Town and Country Development Planning Office [TCDPO])	• Governed by the *Town and Country Planning Act.* • Enforces the Barbados *Physical Development Plan*. • General development planning, control, and regulation, including ongoing monitoring of the implementation of construction activities (TCDPO n.d.). • Implementation of the *Trees (Preservation) Act*.

Table 2.2 Relevant Barbadian Regulatory Authorities

Agency	Responsibilities
Fair Trading Commission	• Enforces the *Utilities Regulation Act* and associated regulations. • Monitors and establishes the rates to be passed to consumers while determining a maximum rate charge (REEEP 2013).
Environmental Health Department, Ministry of Health and Wellness	• Enforces the *Health Services Act, 1969* and associated *Health Services (Nuisance) Regulations*.
Environmental Protection Department (EPD), Ministry of Environment and National Beautification	• Enforces the *Marine Pollution Control Act* • Enforces the *Health Services Act (Building) Regulations.* • Monitors and controls "conditions likely to affect environmental quality and environmental well-being" (Government of Barbados 2019e).
Government Electrical Engineering Department, in the Ministry of Transport, Works, and Water Resources	• Enforces the *Electricity Act.* • Carries out inspections of electrical installations, including inspections for the purpose of determining whether installations meet requirements of safety from personal injury and fire. • Is to be notified of, and is authorised to investigate, accidents (including but not limited to explosion and fire) occurring in connection with electrical installations, works, and circuits, as per the *Electricity Act*. • The Department's Chief Electrical Officer approves the provision of electricity interconnection services at points along the public grid, as per the *Electricity Act*.
Ministry of Energy, Small Business, and Entrepreneurship	• The Minister assigned responsibility for Energy is responsible for the issuance, renewal, amendment, revocation, etc. of electricity supply licences under the *Electric Light and Power Act, 2013*. • Is required under the *Electric Light and Power Act, 2013* to maintain a register, open to public inspection, that includes a list of all renewable energy generation systems installed in Barbados and their installed capacity.
Department of Emergency Management	• Enforces the *Emergency Management Act.*
Labour Department	• Enforces the *Safety and Health at Work Act.* • Ensures decent work standards.
Energy Conservation and Renewable Energy Unit, Ministry of Energy, Small Business, and Entrepreneurship	• Enforces the Barbados National Energy Policy and associated *Implementation Plan.* • Mandates includes "advising on policy and legislation through ongoing research and analysis; programmes to promote a viable, competitive and sustainable energy sector; and deepening collaborations across the many internal and external stakeholders across the public and the private sectors" (Government of Barbados 2021a).

2.1.1 National Energy Policy

The *Barbados National Energy Policy 2019–2030* (BNEP) (Government of Barbados 2019a) outlines the Government of Barbados' goal of achieving 100% renewable energy usage and carbon neutrality by 2030. It provides a framework for moving Barbados from a fossil fuel-based economy to one completely reliant on renewable energy sources. Related transformational goals that the BNEP is designed to achieve include (Ministry of Energy and Water Resources 2019):

- Providing reliable, safe, affordable, sustainable, modern and climate friendly energy services to all residents and visitors;
- Eliminating the domestic consumption of fossil fuels economy-wide;
- Exporting of all hydrocarbons produced both on land and offshore;
- Maximizing local participation (individual and corporate) in distributed renewable energy generation and storage (democratization of energy);
- Minimizing the outflow of foreign exchange; and
- Creating a regional centre of excellence in renewable energy research and development.

The Project supports Barbados' transition away from reliance on its existing fossil fuel burning power plants and towards achieving the goals of the BNEP.

2.1.2 Town and Country Planning Act

Historically, physical planning in Barbados has been directed by the former *Town and Country Planning Act* (TCPA), Cap. 240, which was established in 1968 and amended in 2007. The TCPA makes provisions "for the orderly and progressive development of land in both urban and rural areas 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."

According to Part IV, section 14 of the TCPA, proponents must obtain Planning Permission from the Town and Country Development Planning Office (TCDPO) prior to carrying out "any development of land within any area in respect of which an order is made or is deemed to have been made under section 15" of the Act. The *Town and Country Planning Development Order, 1972* (the Order) states that "no development shall be undertaken upon any land in Barbados without the permission of the Chief Town Planner [CTP] or the Minister or an application made in that behalf". Section 17(1) of the TCPA empowers the CTP to require that an "assessment of the impact that the development […] is likely to have on the environment of Barbados" be undertaken as part of the Planning Permission application process, while Section 17(1B) of the TCPA gives the CTP additional authority to require the applicant to submit such further information as the CTP deems necessary.

The TCPA and the Order specify certain exclusions, limitations, and modifications; however, none of these exclusions, limitations, or modifications exempt the Project from the requirement to obtain Planning Permission. Accordingly, an Application for Planning Permission was initiated for the Project in November 2021 and an ESIA is being conducted as part of that process. The former TCPA was repealed and replaced by the new *Planning and Development Act, 2019* (P&D Act) in December 2021, and it is

anticipated that the modified permitting and assessment processes established under the new P&D Act (as outlined in Section 2.1.3 below) will apply to the Project going forward.

2.1.3 Planning and Development Act

Issue No. 87 of *The Official Gazette* of Barbados, published on December 7, 2021, includes a proclamation indicating that the new 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." The Project therefore triggers EIA requirements under the P&D Act due to its inclusion of a solar PV power plant with a capacity of 13 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[2], 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 approximately 73.2 ha of agricultural land (as described in Section 3.1 below).

2.1.4 Physical Development Plan

The *Physical Development Plan* (PDP) was developed in 1970 under the former TCPA and subsequently amended in 2003. Although a 2017 amendment to the PDP (Government of Barbados 2017) has been prepared, it is still in draft pending amendments to align it to recently approved planning legislation. As such, the proposed development must comply with the existing 2003 version of the PDP (Government of Barbados 2003). The purpose of the PDP is to promote sustainable growth and development within Barbados by setting out policies and regulations to guide proponents of proposed developments.

The Project, as a proposed electricity generating plant, falls within the classes of development that are identified in both versions of the PDP (i.e., under section 2.5 of the 2003 PDP and under section 5 of the 2017 draft amended PDP) as requiring an impact assessment to be completed and submitted to the PDD (formerly the TCDPO) for review and approval. The 2003 PDP specifies the requirement to conduct an

[2] 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."

EIA, whereas the 2017 draft amended PDP specifies the requirement to conduct an ESIA. The matters to be included in an ESIA are outlined in section 5 of the 2017 draft amended PDP and include the following (TCDPO 2017):

- Identification of nearby natural features and their associated functions
- Identification and assessment of the potential environmental and social impacts of the Project
- Identification and assessment of potential mitigation measures
- Identification and assessment of opportunities for restoration and assessments
- Identification and assessment of net or residual effects

As described in Section 3.1, the Project will be located at Harrow Plantation. Both the 2003 PDP and the 2017 draft amended PDP designate Harrow Plantation as agricultural land and contain policy requirements related to the conservation of designated agricultural lands. Refer to section 2.3 of the Agricultural Impact Assessment (Appendix C) for an overview of key agricultural land conservation policy requirements in both versions of the PDP that are relevant to the Project. For example, the draft 2017 amended PDP includes a Food and Agriculture Land Use Designation and a Soil Protection Overlay as two of four proposed protection measures proposed 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 of Barbados will encourage the return of idle agricultural lands to productive use (Bain 2021).

2.1.5 Building Development Application

In addition to the Application for Planning Permission and ESIA submissions to the PDD (formerly the TCDPO) that are required under the P&D Act (Section 2.1.3) and the PDP (Section 2.1.4), an application for a building development approval must also be submitted to Barbados’ Environmental Protection Department (EPD) prior to commencing construction of the Project. However, a proponent is not required to submit an application for building development approval if the Application for Planning Permission made to the PDD under the P&D Act (Section 2.1.3) includes the required six copies of plans, one of which will be submitted to the EPD by the PDD.

The building development application is required to outline a detailed process description that explains the activities to be conducted, hazardous chemicals stored, the hazards associated with each activity, and the mitigation measures to be employed.

2.2 RELEVANT INTERNATIONAL STANDARDS AND GUIDELINES

The Proponent has partnered with the Inter-American Development Bank (IADB)-Invest to fund the ESIA. To this end, the ESIA has been conducted in consideration of international financial institution standards, such as those mandated by the IADB, where practicable and relevant. The following international policies and standards were considered in the development of this ESIA:

- the IADB’s *Environmental and Social Performance Standards* (IADB 2020)
- the Caribbean Development Bank's *Environmental and Social Review Procedures* (CDB 2014)

- the United Nations Environmental Programme's *Goals and Principles of Environmental Impact Assessment* (UNEP 1987)
- the International Finance Corporation's *Performance Standards* (IFC 2012)
- the World Bank's *Environmental and Social Framework* (World Bank Group 2017) and *Environmental, Health, and Safety Guidelines* (World Bank Group 2007a)
- the *Equator Principles* (EPA 2020)

3.0 PROJECT DESCRIPTION

3.1 PROJECT LOCATION

The Project will be located at Harrow Plantation, in the Parish of Saint Philip, Barbados, which is situated on the southeastern end of the island (Figure 3.1).

Harrow Plantation consists of approximately 123.0 hectares (ha) of privately-owned land, of which approximately 73.2 ha will be leased by RSB for the purpose of carrying out the Project. The RSB leasehold area (referred to herein as "the Project Property") will encompass the following proposed Project components and activities:

- Approximately 59.1 ha will be used for the solar PV power plant, including associated rights-of-way (RoWs) and various restrictions, such as drainage reserves. Most of this land (approximately 57.4 ha) will also support solar grazing (i.e., the practice of grazing livestock, in this case Blackbelly sheep, between and beneath the solar panels of the power plant).
- Approximately 1.6 ha will be used to implement energy storage and management systems in support of the solar PV power plant. These systems will be contained within an area referred to as the "Hydrogen Power Centre" (HyPCe).
- Approximately 2.3 ha will be used for buildings and facilities associated with the on-site Blackbelly sheep farm as well as general office and storage facilities.
- Approximately 10.3 ha will be left as green space (i.e., undeveloped land that is covered with grass) to be used for additional grazing and as a fodder pasture for grass harvesting and bailing.

The approximate geographic coordinates of the centre of the Project Property are as follows: 13.127548, -59.472712.

The land within the Project Property is existing agricultural land that is currently used for sugarcane farming augmented by rotational crops (e.g., cotton). Cultivation of existing sugarcane fields and rotational crops within the Project Property will continue until the start of Project construction.

3.2 PROJECT COMPONENTS

Figure 3.2 depicts the proposed site layout for the main components of the Project, including the solar PV power plant, the HyPCe area containing the energy storage and management systems for the power plant, and the agricultural facilities associated with the Blackbelly sheep farm.

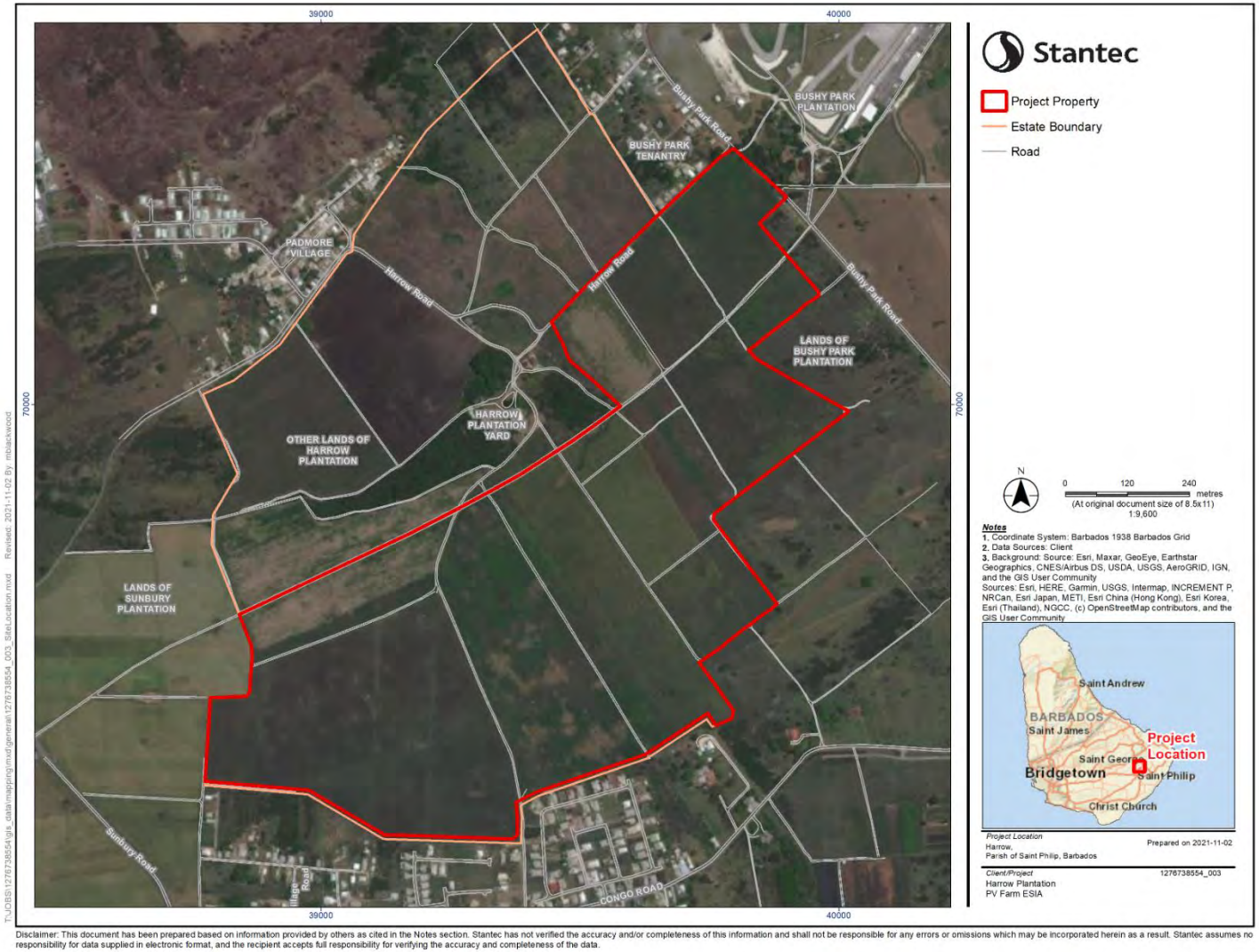


Figure 3.1 Project Location

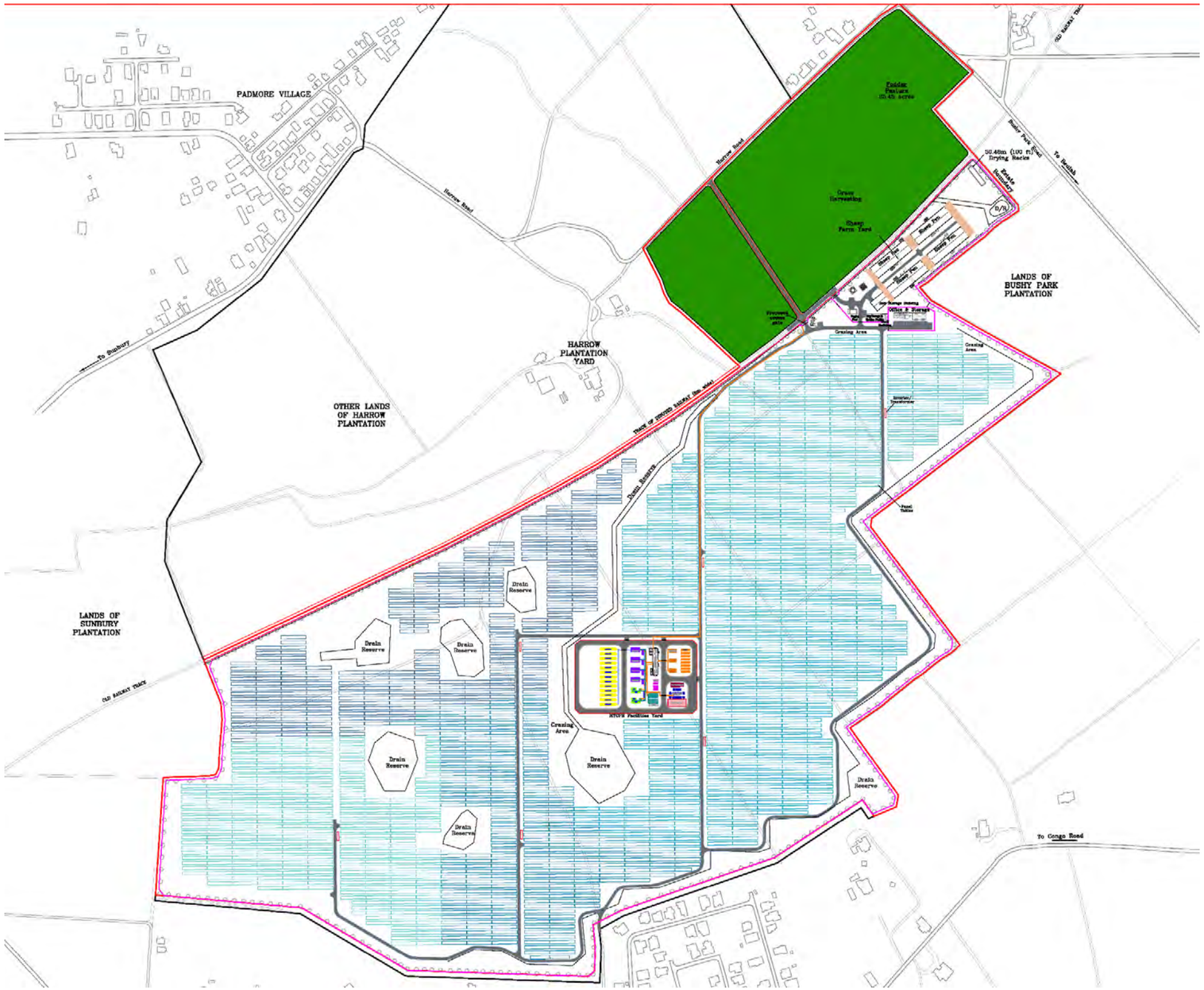


Figure 3.2 Overall Site Plan

3.2.1 Energy Facility

The energy facility components of the Project will consist of a solar PV power plant and associated battery and hydrogen energy storage systems (Figure 3.3). These components will be controlled and optimized via an integrated Energy Management System (EMS). The term “power plant” refers only to the solar PV power plant (as described in Section 3.2.1.1 below), while the term “energy facility” refers collectively to the solar PV power plant, energy storage systems (as described in Section 3.2.1.2 below), and EMS (as described in Section 3.2.1.3 below).

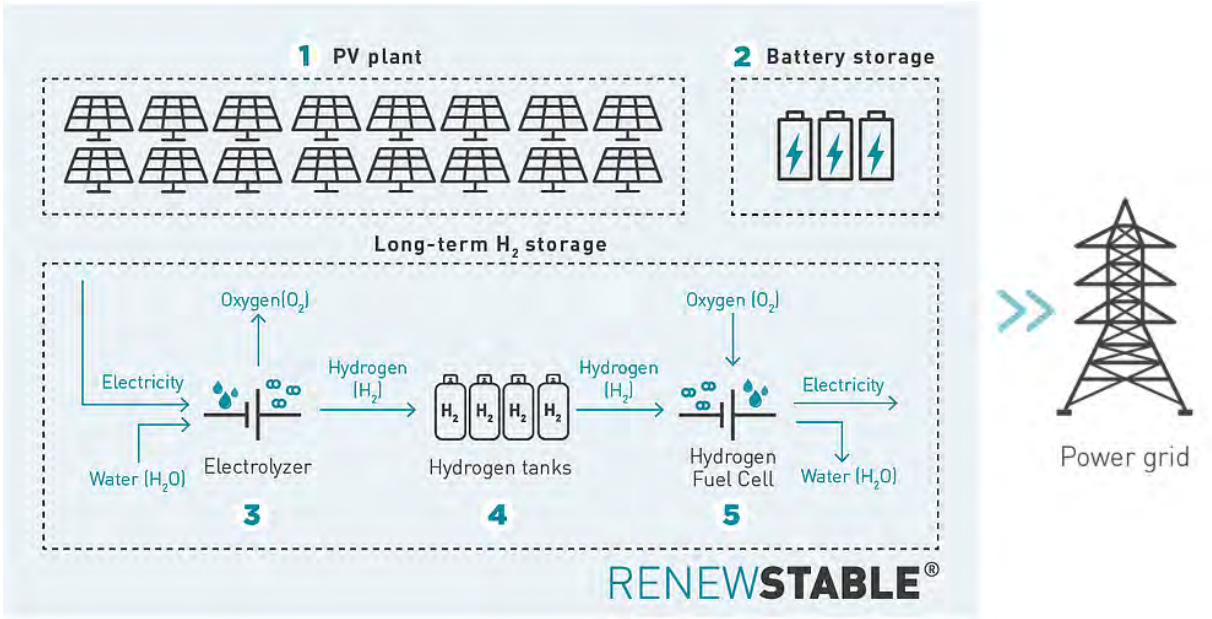


Figure 3.3 Energy Facility Components of the Project

The Project will convert sunlight into electricity via the solar PV power plant. A capped and consistent level of output from the power plant will be directed to the grid, while the remainder will be used to split water molecules (H_2O) into hydrogen and oxygen via an electrolyser system. The resultant hydrogen will be stored as compressed gas. Fuel cells will then be used to produce electricity when needed from the stored hydrogen gas, thereby enabling the delivery of stable power to the national grid. The Project process for hydrogen production and use involves breaking water molecules down in the electrolysers and then recomposing them in the fuel cells (Figure 3.4). The water treatment and storage facilities required to support this process are described in Section 3.2.3.5.

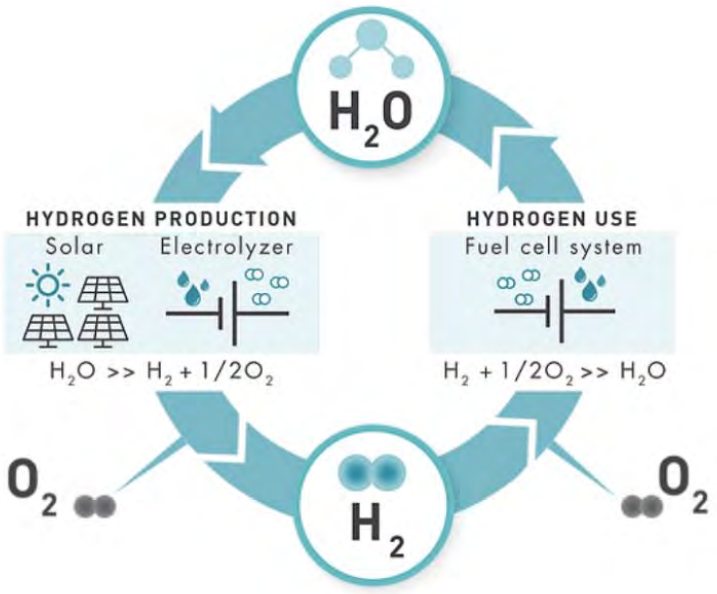


Figure 3.4 Overview of Project Process for Hydrogen Production and Use

3.2.1.1 Solar Photovoltaic Power Plant

The primary source of energy for the Project will be a 50-megawatt peak (MWp) solar PV power plant.

The power plant will occupy approximately 59.1 ha and will consist of an array of 96,154 solar panels, equipped with PV cells, which will be ground-mounted in a fixed-tilt, south-oriented configuration. This configuration has been selected because it is well-adapted to solar grazing and is efficient for optimizing energy generation while reducing land use requirements.

Solar panels (or PV modules) consist of several layers of materials. The top layer is typically composed of glass with high transmissivity and low reflectance values. This layer can be specially treated with an anti-reflective coating (ARC) to lower the reflectance of the panel and improve its efficiency by increasing the amount of light absorbed into the cell. An ARC can be applied to smooth or textured glass. Textured glass was predominantly used to reduce the reflectivity of solar panels before ARCs became more affordable. The benefits of using textured glass in this application include improved solar energy capture efficiency and reduced glare, as incoming light is reflected off the raised surface of the glass and is re-directed to other portions of the surface. However, the disadvantages of textured solar PV glass structures include higher cost (due to additional material requirements) and potential reductions in the amount of transmitted energy and the device's efficiency (if dirt becomes trapped in the textured surface).

Semi-conductor solar PV cells and electrical circuitry are usually between the glass and the back sheet and bound together by encapsulating materials on the front and back of the PV cell layer. The PV cells consist of two or more layers of silicon or similar semi-conducting material. Electrical charges are generated when the semi-conductor in the cell is exposed to light, and these charges are conveyed away as direct current (DC). A metal frame is used to further stabilize and protect the edges of the solar panel.

Solar panels work best when their absorbing surface is perpendicular to the rays of the sun. 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 (Figure 3.5). To maximize exposure to the direct sun rays, panels should be oriented towards the terrestrial equator. Since Barbados is in the Northern Hemisphere, the solar panels for the Project will face southwards. The tilt of a solar panel is the angle between the panel surface and the earth's surface. The currently proposed tilt of the solar panels for the Project is 13 degrees; this will be confirmed or refined during detailed design.

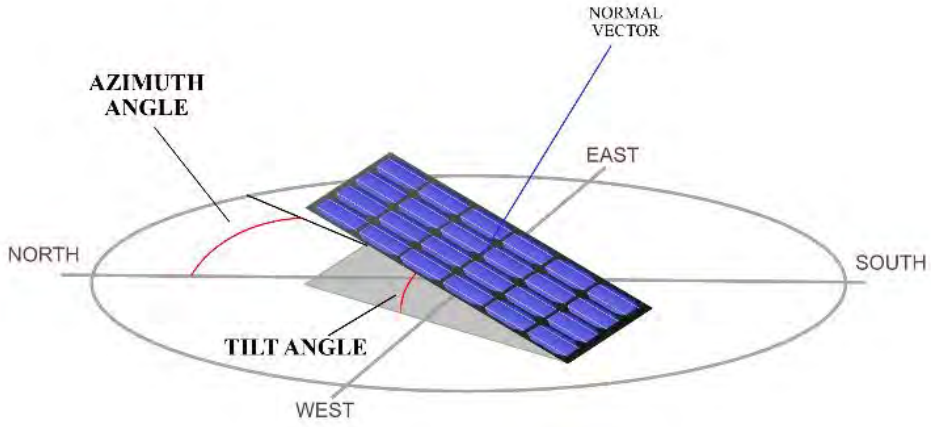


Figure 3.5 Solar Panel Orientation

The solar panels will be fixed to a galvanized steel frame or racking to form solar panel tables, as illustrated on Figure 3.6. The racking will be constructed from steel channels fixed and propped to a pole mount spaced typically at 2–3 m. Transverse steel channels will span between pole-mounted support and associated channels. Solar panels will be fixed to transverse channels. To prevent the pull out of pole supports during high wind scenarios, poles will be fixed to the ground via connection to steel piles that are augered or driven into the soil and/or rock. Cement binder may be used to reinforce the foundations, if necessary.

Generally, the power cabling between the solar panel tables will run under the racking for each table and will be held together and in place by proprietary hangers or within cable trays spanning between pole mounts. An accurate design and construction of cable pathways is important to facilitate solar grazing. Cables will be run in trenches from the solar panel tables to the power conversion station.

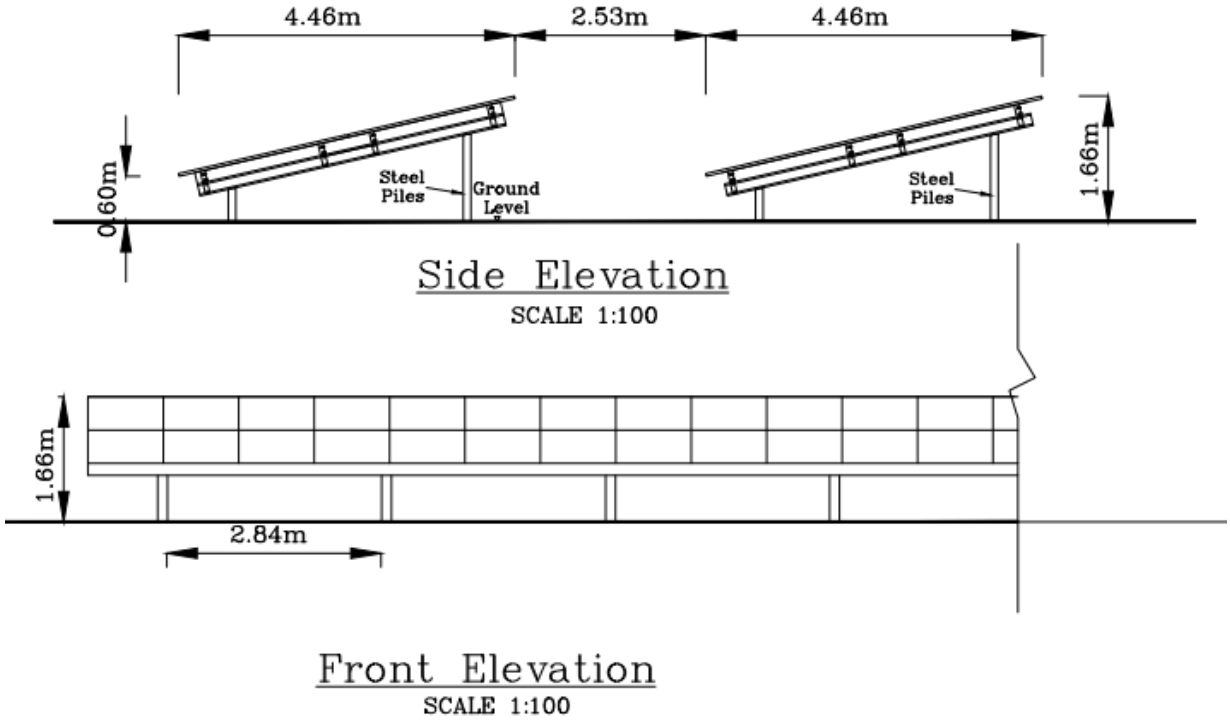


Figure 3.6 Typical Solar Panel Tables

The solar panel structures for the Project will be designed in accordance with local and international standards, and in particular to withstand Category 4 hurricanes. A certified engineer will review the selected structures for compliance with applicable codes from the American Society of Civil Engineers (ASCE).

3.2.1.2 Energy Storage Systems

The Project will include a short-term battery energy storage system (BESS) and a long-term hydrogen energy storage system (HESS).

The BESS and HESS, as well as related utilities and auxiliary systems, will be centralized and contained within a fenced HyPCe area that will be approximately 1.6 ha in size and located near the middle of the Project Property (refer to Figure 3.2 and Figure 3.7). The HyPCe area will be specifically designed to mitigate the risks associated with the energy storage equipment (e.g., fire or explosion due to a battery malfunction or hydrogen leak), for the protection of Project personnel and the surrounding community. A large setback, with a radius of more than 200 m between the HyPCe area fenceline and the Project Property boundary, is proposed as a safety zone. Further information regarding Project-related hazards and risks is provided in the Quantitative Risk Assessment (QRA) (Appendix D) that was conducted for the Project. The results of the QRA have been incorporated into the assessment of potential impacts that could occur in the event of an accident, malfunction, emergency, or disaster (Section 8.7).

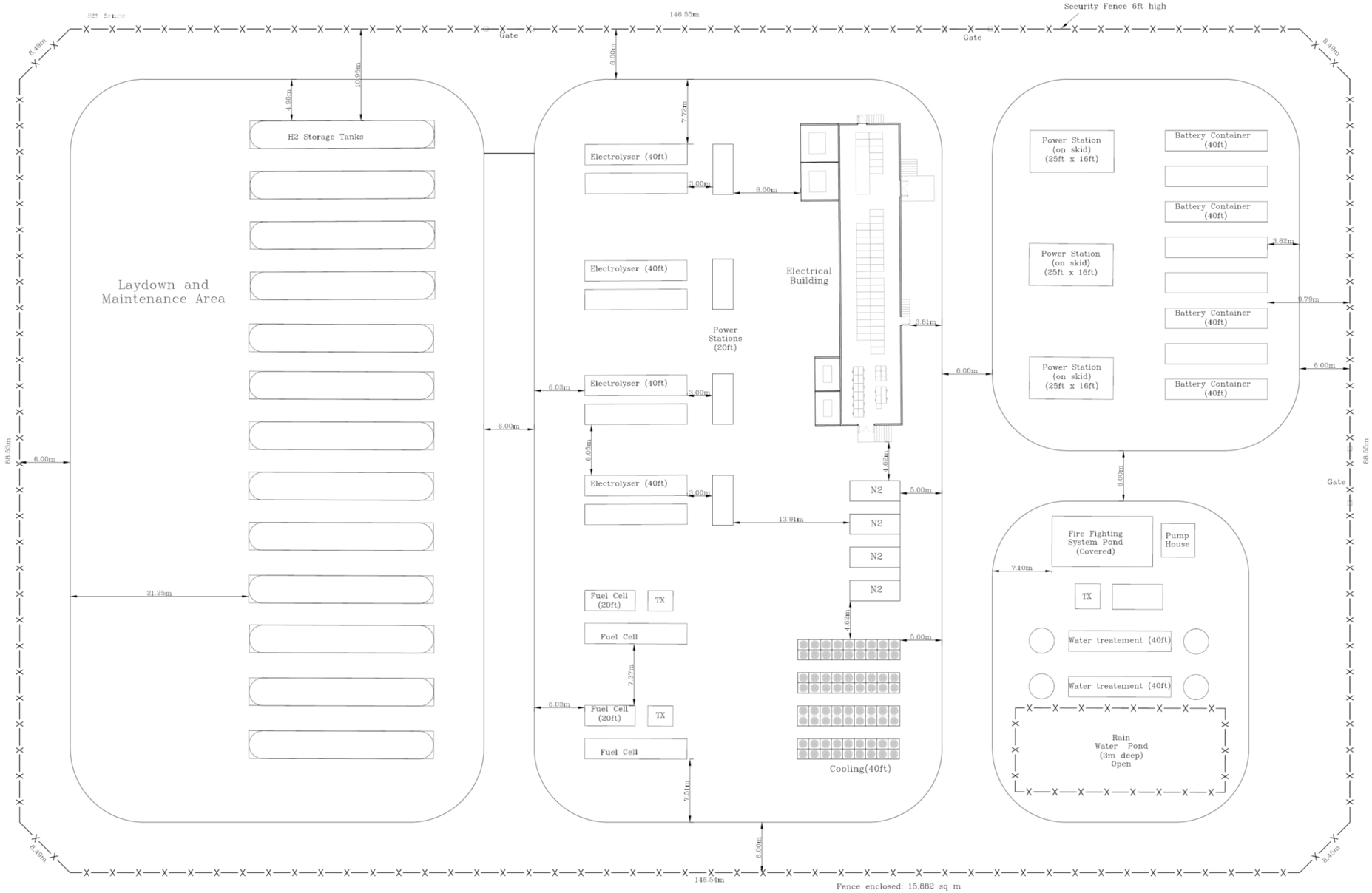


Figure 3.7 HyPCe Area

Battery Energy Storage System

The BESS will consist of eight units housed in cabinets (Figure 3.8). These units will include the Li-ion battery cells, as well as associated management systems, auxiliaries, cooling, fire safety, security systems, and comprehensive fault detection in charge/discharge cycles. The dimensions of each unit will be approximately 16.2 m x 2.9 m x 2.6 m and the maximum capacity of each unit will be 2 MW / 6 MWh.

Figure 3.8 Examples of in Prefabricated Enclosures for Battery Energy Storage System Units

The BESS will provide a total installed power of 14 MW, with a capacity of 3 hours of short-term energy storage. The enclosure will be a cabinet unit of typically 4–5 MWh. The units will be integrated in at least three independent modules. The role of the BESS will be to:

- Deliver a two-hour dispatchable block of 13 MW firm power to meet the end-of-day-peak demand (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid).
- Provide a quick energy response as needed to mitigate potential temporary sources of intermittency (e.g., high cloud cover) and deliver stable and optimized energy service during the day.
- Provide additional power for absorbing peak power during the day when the electrolysers are running at maximum power and solar power is available in excess.

The BESS will be designed in accordance with applicable international standards, including NFPA 855 (the National Fire Protection Association's *Standard for the Installation of Stationary Energy Storage Systems*). Each unit will be individually sealed and separated to avoid fire propagation between units, with fusing and electrical protection adapted to shut-down each module individually if necessary. Each unit will have a fire resistance rating of at least two hours, in accordance with ANSI/CAN/UL 9540A: 2019 (*Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*). The battery cells will be designed to withstand temperatures of up to 50 degrees Celsius (°C). At the system level, heating, ventilation, and air conditioning (HVAC) and building management control systems will be able to shut the units down and put them in safe mode in the event that the range of safe operating conditions is exceeded. The ventilation system will also enable the safe evacuation of gases and flames through the top of the unit and passive deflagration venting to control the risk of fire and

explosion. Fire detection systems will typically include integrated sensors and multi-spectrum infrared systems, or similar technology, capable of detecting fire-related thermal or gas emissions.

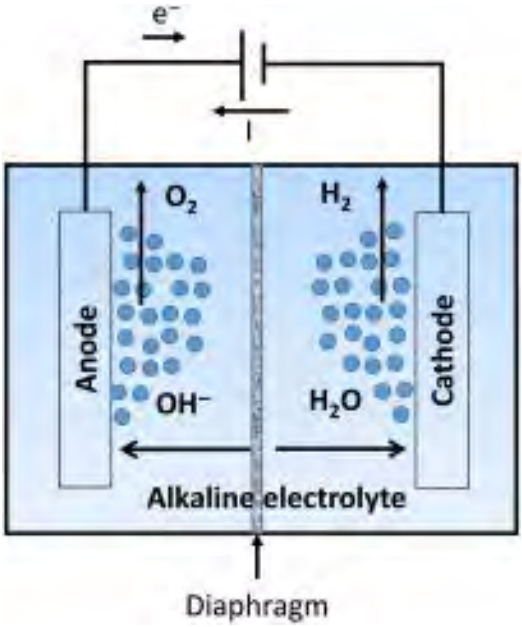
Hydrogen Energy Storage System

The HESS will provide long-term storage of energy generated from the solar PV power plant, thereby facilitating baseload generation over extended time periods and enabling the Project to supply stable (non-intermittent) power 24 hours per day, seven days per week. As illustrated on Figure 3.9, this will be achieved by using electrolysers and water to convert electricity from the power plant into hydrogen, storing the hydrogen, and then using it when needed to produce water and electricity again through fuel cells.

The HESS will be composed of:

Electrolysers with a total capacity equivalent to 16 MW: The electrolysers will absorb energy output from the solar PV power plant and generate hydrogen for long-term storage. The system will employ alkaline-technology electrolysers and DC power to induce an electrochemical reaction (i.e., water electrolysis) that causes the water molecules (H_2O) in demineralized water to split apart into separate hydrogen (H_2) and oxygen (O_2) molecules (Figure 3.10). The final products of the water electrolysis process will be hydrogen gas, which will be stored, and oxygen, which will be released to the atmosphere. The electrolysers will be housed in prefabricated and containerised enclosures for easy integration into the HyPCe area of the power plant (Figure 3.11). These enclosures will be equipped with H_2 detectors (set to 20% of the lower explosive limit) and ventilation switch detectors, and will be actively ventilated to maintain a non-explosive atmosphere.
Up to 100 m^3 of 25% potassium hydroxide (KOH) solution, or caustic potash, will be used in the process of alkaline electrolysis. The KOH will not be consumed during electrolysis since it will serve as an electrolyte in a closed-loop process. In this type of application, KOH typically needs to be replaced approximately every 10 years.

- **Compressors and pressurized containers:** The hydrogen gas produced from the electrolysis process will be compressed and stored in cylindrical steel tanks that are arranged horizontally and stacked two-by-two, as shown on Figure 3.12. The HESS will include a total of 26 tanks, each of which will have a storage capacity of 115 m^3 and will measure 22 m in length and 2.8 m in diameter. These tanks will enable the long-term storage of approximately 7,300 kg of hydrogen, representing the equivalent of 90 MWh of energy. The maximum operating pressure and temperature of the tanks will be 30 barg and 40°C, respectively.
- **Hydrogen fuel cells with a total capacity equivalent to 3 MW:** The fuel cells will employ proton-exchange membrane (PEM) technology to combine the stored hydrogen with the oxygen that is available in the surrounding air; this will essentially reverse the electrolysis process by transforming the hydrogen and oxygen back into electricity and pure water vapour (i.e., gaseous H_2O) that is anticipated to be free of contaminants. The fuel cells will be housed in prefabricated and containerised enclosures for easy integration into the HyPCe area of the power plant (refer to Figure 3.13). As will be the case for the electrolyser enclosures, the hydrogen fuel cell enclosures will also be equipped with H_2 detectors (set to 20% of the lower explosive limit) and ventilation switch detectors, and will be actively ventilated to maintain a non-explosive atmosphere.



Source: Coutanceau et al. 2018.

Figure 3.9 Alkaline Water Electrolysis – Chemical Principle

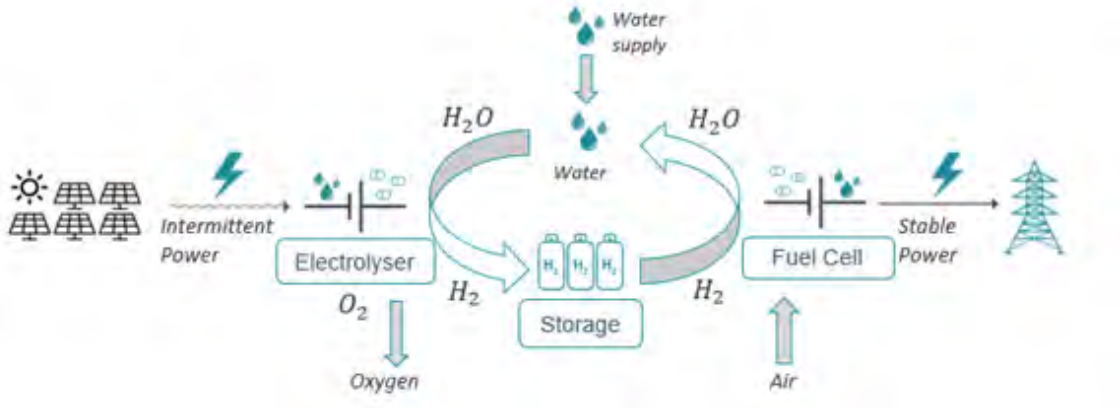


Figure 3.10 Overview of Hydrogen Energy Storage System

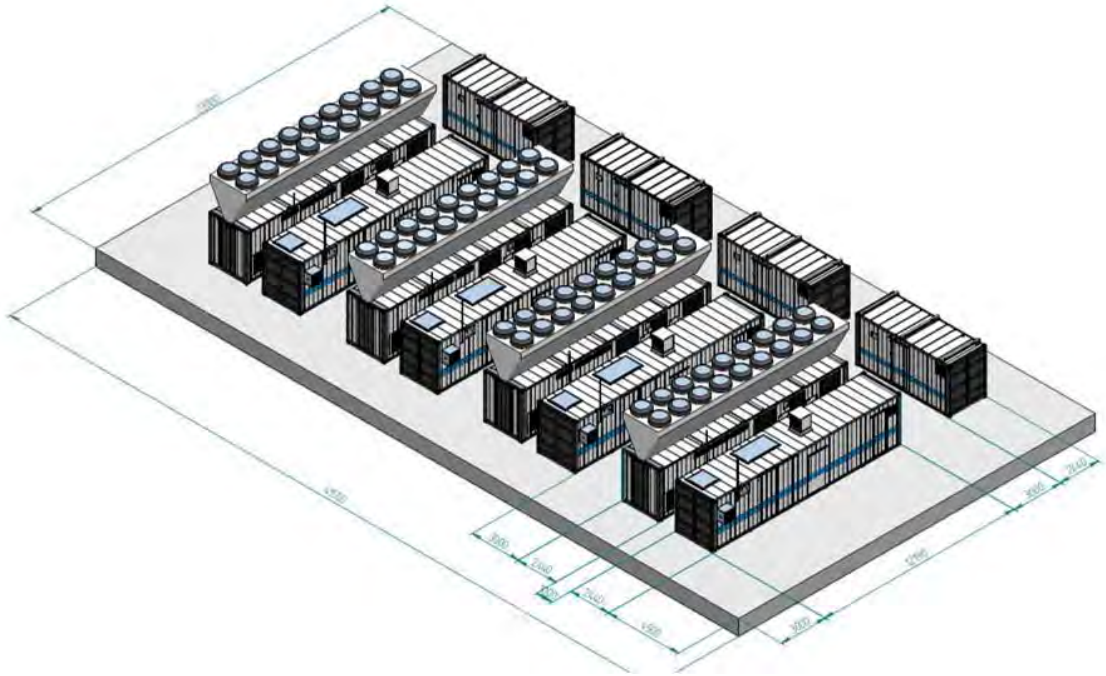


Figure 3.11 Example of Containerised Electrolysis System with Capacity Equivalent to 20 MW

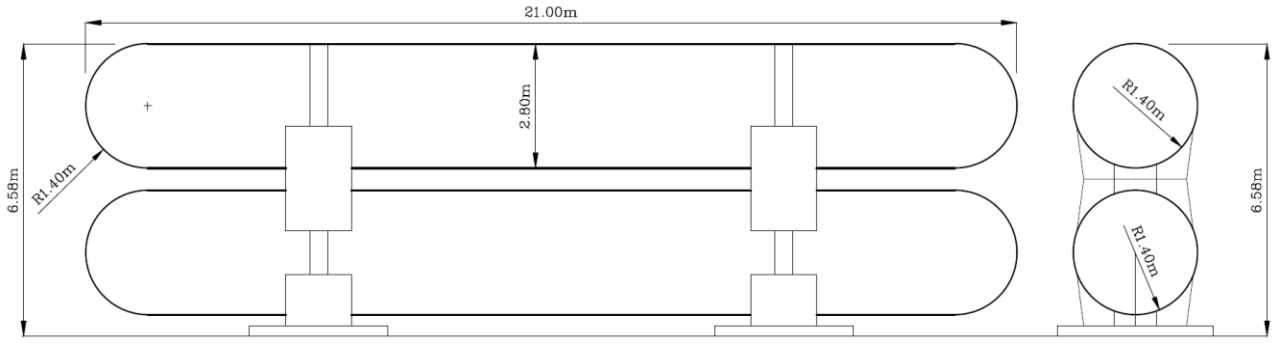


Figure 3.12 Proposed Arrangement of Hydrogen Storage Tanks – Side View (Left) and Front View (Right)

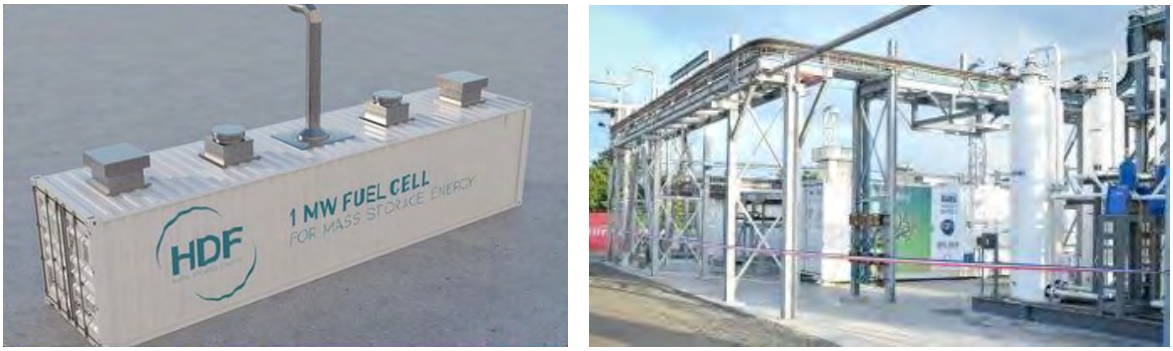


Figure 3.13 Examples of Containerised Fuel Cell (Left) and Containerised Fuel Cell System with Hydrogen Purification System (Right)

3.2.1.3 Energy Management System

The EMS will be located in the HyPCe area (Figure 3.7) and will serve as the "brain" of the Project energy facility. EMS software will compute the solar irradiance forecast in advance and control the power plant and its energy storage systems (i.e., the BESS and HESS) in real-time to deliver the optimal amount of power to the grid and reduce energy losses. When the power plant is producing energy, the EMS will distribute the energy as necessary to deliver power to the grid and to charge the energy storage systems (Figure 3.14). When the energy generated by the power plant is insufficient to deliver the required amount of power to the grid (e.g., in cases of low solar resources), the EMS can draw on the Project's energy storage systems and adapt the generation profile as necessary to increase the power supply to the grid and comply with contractual obligations (Figure 3.14).

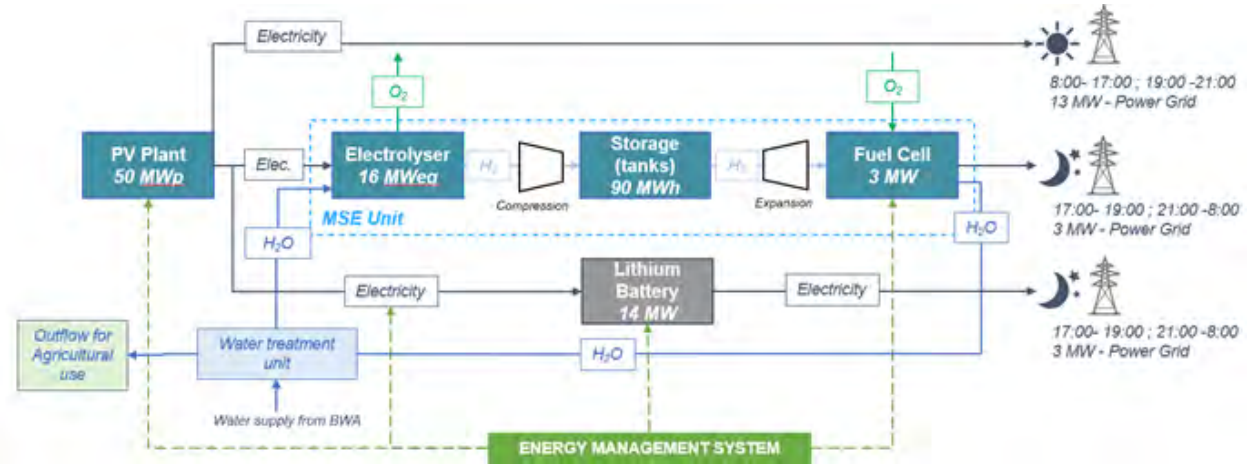


Figure 3.14 Energy Management System Process Flow Diagram

3.2.2 Agricultural Facilities

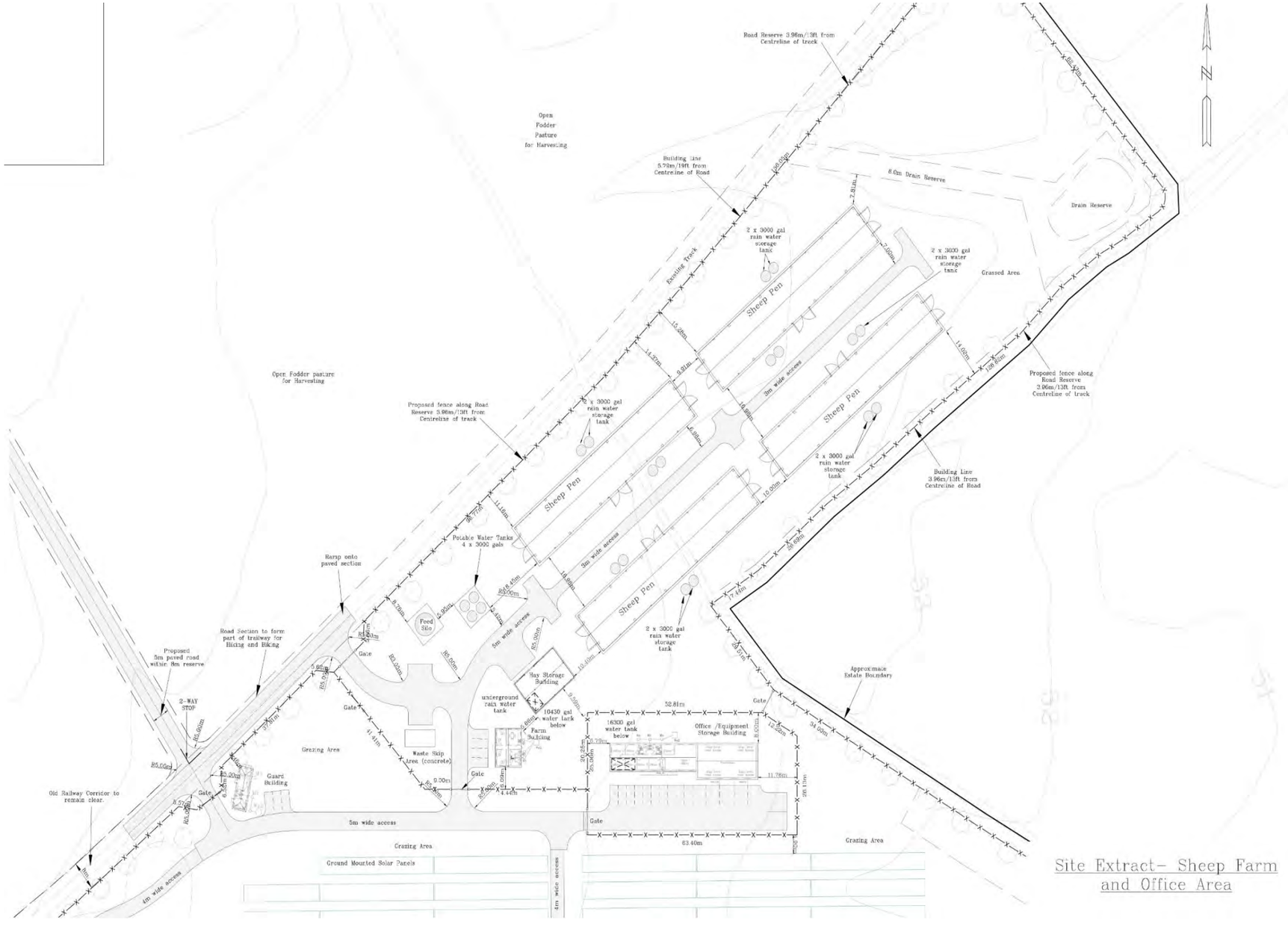
The Project Property will also be used to support what is proposed to be the largest commercial Blackbelly sheep farm in Barbados. The agricultural facilities will be used to raise sheep livestock for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets. However, no butchering will take place on-site.

The individual who has been pre-selected to carry out the agricultural aspects of the Project is an established commercial sheep farmer with previous experience raising sheep as part of dual land use projects. This farmer has expressed a strong desire (including through submission of a letter of preliminary commitment to RSB) to expand his operations as part of the Project.

The Project will be designed to accommodate at least 1,830 Blackbelly sheep. On-site agricultural facilities will include sheep pens, a barn for hay storage, a feed silo, water storage tanks, a designated waste skip area on a concrete pad, and a farm building/staff facility, all of which will occupy a total of approximately 2.3 ha. The sheep will be allowed to graze between and beneath the solar panels of the power plant within a solar grazing area that is approximately 57.4 ha in size. A further approximately 10.3 ha of the Project Property will be left as green space, which will provide a supplementary grazing area, as well as an open fodder pasture for grass harvesting and bailing. The farmer will use the fodder produced from this area to feed the sheep through the dry season. Thus, approximately 96% (or 70 ha) of the Project Property will be available for agricultural use and approximately 92% (or 67.7 ha) of the Project Property will be grazable.

The soil quality at the Project Property (Class IIb) is suitable for growing high-protein grass and hay as feed for livestock. Although no irrigation supply wells are available on the Project Property, the mineralized water by-product from the water treatment plant, process water from the HESS, and/or harvested rainwater could be used to irrigate struggling grass areas as needed (refer to Section 3.2.3.5).

Figure 3.15 shows the proposed site layout for the agricultural facilities associated with the Project, including a portion of the solar grazing area. However, the full spatial extent of the solar grazing area is better reflected on Figure 3.2, which shows the proposed layout of the solar panels that the sheep will be allowed to graze amongst.



Site Extract– Sheep Farm and Office Area

Figure 3.15 Layout of Agricultural Facilities and Office Area

3.2.3 Supporting Infrastructure, Facilities, and Utilities

3.2.3.1 Buildings and Yards

Several buildings are proposed for the Project Property and will be amalgamated where possible without compromising Project requirements for efficiency, power, functionality, and safety. Proposed Project buildings, which include a guard building/security booth, farm building/staff facility, hay storage barn, feed silo, and office/equipment storage building, are anticipated to occupy a total of approximately 2.3 ha within the Project Property. The approximately 1.6-ha HyPCe area (or HyPCe facilities yard) will also contain buildings such as an electrical building, power stations and various utilities on skids, a pump house, and a package water treatment plant.

Laydown areas will be required for the outdoor storage of vehicles, heavy equipment, machinery, prefabricated Project components, construction materials, and other supplies for construction, operation, and maintenance. Laydown areas will also include platforms for equipment assembly/installation.

3.2.3.2 Site Roads, Access, and Security

Access to the Project Property will be provided via Harrow Road, branching off Bushy Park Road to the east and Sunbury Road to the west. Internal site roads and parking areas throughout the Project Property will facilitate the transportation of Project personnel, equipment, and materials/supplies within and between the solar PV power plant, the HyPCe area, and the area in which the agricultural facilities will be located. These roads will range between 3 m and 5 m in width. The main access roads, HyPCe area access roads, and roads to and within the administrative area, including the parking area, will be paved; the remainder of the internal site roads will be unpaved. Near the northeastern extent of the Project Property, a 5-m wide paved access road will cross the fodder pasture to connect the internal site roads with the public Harrow Road (refer to Figure 3.2).

The Project Property will be surrounded by fencing on all sides. The access road near the northeastern extent of the Project Property will lead to an access gate with a dedicated guard building/security booth; this will serve as the primary entrance to the secure portion of the Project Property, restricting access to the power plant, HyPCe area, and agricultural facilities (other than the open fodder pasture). The HyPCe area will be further enclosed by a security fence that has a height of approximately 1.8 m (i.e., 6 feet) (Figure 3.7). Additional fencing will separate the agricultural facilities and the office/equipment storage building from the rest of the secure portion of the Project Property. Although the height, material, and configuration of this additional fencing remains to be determined during detailed design, it is anticipated that the fencing around the agricultural facilities will have deep footings to help prevent predatory animals (e.g., dogs) and pests from digging under it.

There will be adequate 24-hour security to prevent curious onlookers or passers-by from wandering into Project-related construction or operational areas. Additional provisions that will be made to enforce safety in and around the Project Property include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meets the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways.

3.2.3.3 Site Lighting

General site lighting will be a combination of power line pole-mounted fixtures and building-mounted fixtures at the guard building/security booth, farm building/staff facility, office/equipment storage building, and other miscellaneous buildings. Lighting will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Project components and facilities are not anticipated to be permanently lit; detection sensors or manual switches will be used to engage lighting when required for operational tasks, and for security or safety reasons.

3.2.3.4 Transmission Lines and Cables

The Project will power the national grid via a new transmission line connecting the proposed power plant to BLPC's existing Hampton substation, which is located approximately 3.5 km away from the Project Property. It is anticipated that BLPC will independently undertake any necessary upgrades to off-site grid infrastructure beyond the boundaries of the Project Property. It is therefore assumed that the new transmission line extending off-site from the Project Property to the Hampton substation will be assessed, owned, and operated by BLPC; as a component of Barbados' national power distribution system, this transmission line will be entirely under the care and control of BLPC.

The Project will also require connection to the local telecommunications network and will be hooked up to the existing fibre optic cable system that services the area.

3.2.3.5 Water Supply, Treatment, and Storage

During the operational phase of the Project, water will be required to enable long-term energy storage – through hydrogen production – from the solar PV power plant, as well as to support agricultural operations. Standard Project-related operational water consumption requirements are estimated to be 64.5 cubic metres (m^3) per day. However, the Project Property does not have an irrigation supply groundwater well available on-site. It is anticipated that the Project water supply will primarily be sourced from existing public water main pipelines that are owned and operated by BWA, and will be used for the following purposes:

- An average of approximately 60 m^3/day of potable water will be required to enable energy storage from the power plant. This water will be treated via reverse osmosis at an on-site package water treatment plant to remove minerals (e.g., salt, manganese, iron, fluoride, lead, and calcium) and produce approximately 30 m^3/day of demineralized water suitable for hydrogen electrolysis (as described in Section 3.2.1.2). The remaining 30 m^3/day of water will be a mineralized by-product of the treatment process that can be harvested and used for local irrigation or equipment maintenance (washdown).
- An average of approximately 4.5 m^3/day of potable water will be required for sheep farming and staff operations (i.e., for drinking water and sanitary purposes).

The maximum flow of water that will be required by the HESS to enable energy storage from the power plant is 5 m^3/hour; this amount would allow the electrolysers to operate for their entire maximum daily

operating time of 12 hours. The process water emitted from the HESS when the fuel cells convert the hydrogen and oxygen back into electricity and water (as described in Section 3.2.1.2) will be recirculated to the electrolysers for re-use in the electrolysis process.

On-site water storage tanks for operations water will smooth out the flow of withdrawal from BWA's public water mains during the day. The water in these storage tanks can be drawn upon as needed during Project operations to supplement the water supply from BWA, thereby reducing the Project's reliance on that external resource, and/or as a contingency reserve in the event of interruption to water service from BWA. Approximately 150 m^3 of demineralized water will be stored in tanks on-site in the HyPCe area. This quantity of stored water will be sufficient to allow the power plant and HESS to run for five days at full load without access to potable water from external sources. Water tanks will also be located on-site within the office area and agricultural facilities. These additional tanks will store enough water to supply five days of potable water for offices and sheep, and to provide 15 days of rainwater storage for sheep drinking and pen washdown.

Potential opportunities for the reduction and optimization of water use are being studied. The option of reducing Project-related potable water use through the harvesting of rainwater via water tanks located beneath Project buildings/infrastructure will be evaluated. Water from this storage would be captured during the rainy season for use throughout the year, thus offsetting the quantity of potable water that may be required from the public mains.

3.2.3.6 Drainage Works

Drainage reserves are included in the proposed layout of the power plant (as shown on Figure 3.2) for the management of surface run-off (refer to Section 3.6.2). The proposed drainage reserve areas will be graded and contoured to direct runoff towards suckwells (i.e., artificial shafts excavated in soft carbonates to relieve surface flooding). A hydrological assessment was undertaken to determine the proper positioning and sizing of the drainage reserves to accommodate a sufficient volume of runoff (Appendix B).

3.3 PROJECT ACTIVITIES

3.3.1 Construction

The main activities associated with the construction phase of the Project will consist of site preparation, physical construction and equipment installation, and finalization commissioning. The Project is expected to employ up to 150 people during peak construction activities, such as installation of the PV modules. Given the proximity and availability of potential accommodations in the local communities surrounding the Project Property, no workforce accommodation camps are currently proposed in support of the Project. However, the contractor may consider the use of construction camps to accommodate their workers as a means of limiting competition for housing on the island between workers and local community members.

3.3.1.1 Site Preparation

Project construction will begin with the clearing of vegetation and the levelling of soils where necessary throughout the Project Property. Only light vegetation removal will be required since the Project Property is currently mostly used for farming sugarcane and rotational crops and is therefore not forested or heavily vegetated other than with agricultural crops. Temporary laydown areas will be established for the outdoor storage of vehicles, heavy equipment, machinery, prefabricated Project components, construction materials, and other supplies. Site preparation activities will also include access road construction, internal road construction, platform levelling for the HyPCe area and other buildings, and the digging of trenches and construction of the drainage system for surface runoff management.

3.3.1.2 Physical Construction and Equipment Installation

Once site preparation is complete, physical construction and equipment installation of the main Project components will commence and will involve the following:

- Construction of solar PV power plant, including:
  - PV structure foundation construction
  - PV structure assembly
  - PV modules installation, which may require pile driving to secure panel support racking into the earth below
  - Power station installation
  - Installation of cabling, boxes, and auxiliaries connecting the PV modules to the power station and connecting the individual components of the HyPCe area to their respective power supplies
- Construction of HyPCe area facilities (i.e., BESS, HESS, and EMS), including:
  - Foundation construction
  - Electrical building construction
  - Installation of integrated systems, containers, and associated power stations for the batteries, electrolysers, and fuel cells
  - Erection of electrical and mechanical balance of plant components (e.g., cabling, piping, and auxiliaries)
- Construction of buildings associated with the agricultural facilities.
- Construction/installation of remaining supporting infrastructure, facilities, and utilities, including other Project buildings (e.g., guard building/security booth and office/equipment storage building), fencing, lighting, package water treatment plant, water storage tanks, and drainage works.

The Project components required for physical construction and equipment installation will be transported to the Project Property by truck, primarily in 12-m shipping containers, although some raw materials may be transported in bulk and the hydrogen tanks will be transported as out-of-gauge cargo. It is estimated that approximately 450 trucks will be required to transport key Project components to the Project Property, including 350 trucks for the PV modules and structures, six trucks for the power stations, 50 trucks for containerized and skid systems associated with the HyPCe area, 10 trucks for bulk spare parts (e.g., cabling), and 26 trucks for the hydrogen tanks.

3.3.1.3 Finalization and Commissioning

Finalization of Project construction will include pre-commissioning of sub-systems (e.g., solar panels and PV cells, batteries, fuel cells), connection of the power plant, and connection to the grid. The electrical and mechanical systems associated with the Project will be commissioned as construction/finalization is completed, including full commissioning of the entire power plant and associated energy storage and management systems.

3.3.2 Operation and Maintenance

As described in Section 1.1, the Project will generate approximately 56,000 MWh per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 Barbadians annually[3]. The electricity generated by the Project will be purchased by the privately-owned utility BLPC, which is currently the sole electricity utility provider in Barbados, at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. During the term of this agreement, the Project will deliver the following power supplies to Barbados' national grid daily:

- 13 megawatts (MW) between the hours of 8:00 and 17:00;
- a two-hour dispatchable block of 13 MW firm to meet the end-of-day peak, when the marginal cost of generation in Barbados is the highest (anticipated between the hours of 19:00 and 21:00, although timing may vary according to the needs of the grid); and
- 3 MW firm the rest of the time.

As described in Section 3.2, the Project will achieve this by converting sunlight into electricity via the solar PV power plant, converting the electricity from the power plant into hydrogen using an electrolyser system, storing the hydrogen as compressed gas, and then using fuel cells to produce electricity whenever needed from the stored hydrogen gas; the resultant electricity will be delivered to the national grid. These processes will occur during the operational phase of the Project.

A dedicated team of Project personnel will be responsible for carrying out Project operation and maintenance activities, with support from subcontractors as needed. The EMS will enable aspects of the power plant and energy storage systems (i.e., the BESS and HESS) to be controlled remotely during Project operations. Since Project components in the HyPCe area will be mainly automated, the primary job of the operator will be to monitor the infrastructure (including associated cooling, fire safety, security, and fault detection systems) to support their safe, secure, and efficient operation.

[3] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

Operation and maintenance of the power plant and associated energy storage and management systems in the HyPCe area will entail: regular visual inspections of the PV modules, cables, power stations, and other equipment; thermal control of electrical equipment (e.g., boxes and inverters); cleaning of the PV modules; grass cutting within the grounds of the power plant if solar grazing is insufficient to manage the vegetation in certain areas; transformer oil sampling and testing, and potential transformer retreatment (if necessary) at a specialized third party facility off-site; control of water quality (electrolysis input and output) through filtration, treatment, and product changing when necessary; and waste management.

Maintenance activities will also include corrective or preventative replacement of components such as electrolyte solution, PV modules, inverters, battery cells, and fuel cell stacks. It is expected that the KOH solution to be used as an alkaline electrolyte in the electrolysers (refer to Section 3.2.1.2) will need to be replaced at least once during the operational lifetime of the Project (i.e., approximately every 10 years during Project operations), and that the batteries, fuel cell, and electrolyser stacks will require replacement once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations).

Agricultural activities during the operational phase of the Project will include sheep husbandry (i.e., the raising and breeding of approximately 1,830 domestic Blackbelly sheep) and the provision of associated feeding, watering, and veterinary care; the solar grazing of sheep between the solar panels of the power plant; irrigation of the fodder pasture as needed; the harvesting, bailing, and storage of grass from the fodder pasture; and washdown, sanitation, and waste management activities. The sheep will be raised for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets. No butchering will take place on-site.

3.3.3 Decommissioning

The Project will be designed, built, and maintained to be in operation for at least 25 years. While decommissioning or abandonment of the new facility is not currently envisioned, the Project will at some point be decommissioned or rebuilt at the end of its useful service life, in accordance with the applicable standards and regulations that are in effect at that time. Potential future decommissioning activities will likely involve dismantling and removal of the power plant and other on-site buildings, equipment, and facilities, including possible excavation and removal of concrete pads; transferring of waste materials to disposal, recycling, and/or treatment facilities, as applicable (where re-use is not possible); backfilling of ponds and ditches and re-establishment of natural drainage patterns; and recontouring and revegetation (via natural regrowth and/or seeding with non-invasive plant species) of disturbed areas of the site as necessary to facilitate the desired end land use of the Project Property by the landowner.

3.4 PROJECT SCHEDULE

The Project planning and permitting process began in July 2021 and is scheduled be completed in March 2023. Critical tasks to be completed during this timeframe include finalizing Project financing and agreements; obtaining permission from the TCDPO to develop the land comprising the Project Property; obtaining ESIA approval for the Project; and obtaining an independent power producer licence from the Ministry of Energy, Small Business and Entrepreneurship to permit the Project to supply electricity to the national grid.

The electricity generated by the Project will be purchased by BLPC at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant.

The tentative Project schedule and approximate duration of the key Project phases are as follows:

- **Construction (June 2023 to June 2025):** Financial close and Project initiation are anticipated to occur in June 2023, at which point Project construction will commence. Detailed engineering, procurement and construction activities are expected to last 24 months (i.e., from June 2023 to June 2025), including approximately 3-month period of commissioning and testing.
- **Operation and Maintenance (July 2025 to July 2050, with possibility of extension):** The Project will be designed with an operational lifetime of 30 years, but the contractual duration of the current power purchase agreement is anticipated to be for 25 years. The potential for future extension of the contract will depend on the status of various internal and external factors at the time that such an extension is considered, if applicable (e.g., the condition of Project components; power demand in Barbados). The operational phase of the Project is therefore anticipated to begin in July 2025 and continue for at least 25 years. Maintenance activities will be conducted on an as-needed basis during Project operations.
- **Decommissioning (following conclusion of Project operations):** The decommissioning phase of the Project will commence following the conclusion of Project operations and is anticipated to last approximately 12 months.

3.5 HAZARDOUS MATERIALS

The main hazardous materials that will be present on-site are:

- **Petroleum Hydrocarbons:** Petroleum hydrocarbons, such as fuels (i.e., diesel and/or gasoline), hydraulic fluids, and lubricants, will be used in Project vehicles, heavy equipment, and machinery.

  Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays and spill berms) will be used in areas of storage and transfer. Table 3.3 in Section 3.7.2 below outlines additional relevant environmental protection procedures for spill prevention, control, and response in relation to these substances.

- **Li-ion batteries:** Li-ion batteries will be used in the BESS for the short-term storage of electricity from the solar PV power plant. Batteries are susceptible to fire, and this hazard has been assessed in a Project-specific Quantitative Risk Assessment (Appendix D). The batteries associated with the Project will be integrated in pre-assembled enclosures that will include cooling, fire detection, and comprehensive fault detection in charge/discharge cycles, and will be compliant with NFPA 855 and ANSI/CAN/UL 9540A: 2019, as described in Section 3.2.1.2.

  The Li-ion batteries will require replacement once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations). Used Li-ion batteries will be sent back to the manufacturer or to an independent approved facility for end-of-life disposal or recycling, in accordance with applicable regulatory requirements.
- **Potassium hydroxide (KOH), also known as caustic potash:** Up to 100 m^3 of a 25% KOH solution will be required for use in the electrolyser components of the HESS. The accidental spillage of this KOH solution could cause soil and water pollution. To mitigate this risk, the electrolysis process equipment will be housed in sealed enclosures in a secure area equipped with additional spill containment (e.g., spill berms). A spill retention tray will be used for storage of the KOH solution that may occur outside of the enclosure for the electrolyser process equipment, if applicable.

  As described in Section 3.2.1.2, the KOH will not be consumed; rather, it will serve as an electrolyte in the closed-loop electrolysis process. In this type of application, KOH typically needs to be replaced approximately every 10 years, although more frequent replacement may be required if it becomes contaminated. When replacement and disposal of the used KOH solution is required, RSB will manage the safe removal, handling, and transportation of the product for recycling at an approved facility, in accordance with applicable regulatory requirements.
- **Pressurized gaseous hydrogen:** Gaseous hydrogen will be produced and stored on-site as part of the HESS, as described in Section 3.2.1.2. The maximum amount of hydrogen to be stored on-site is 7,300 kg. The hydrogen will be compressed at 30 barg and stored in 115 m^3 cylindrical steel tanks.

  As explained in Section 3.6 below, there will be no hazardous emissions, discharges, or wastes associated with Project-related hydrogen storage or use; the only emissions will be small quantities of hydrogen gas (which may be purged in a controlled manner during operation and maintenance of the electrolysers and fuel cells), oxygen, and water. However, pressurized hydrogen gas tanks have potential to pose a fire/explosion risk in the event of an uncontrolled hydrogen leak. Accordingly, worst-case scenarios have been assessed in a Project-specific Quantitative Risk Assessment (Appendix D) to determine an appropriate security zone perimeter around the hydrogen tanks contained in the HyPCe area.
- **Oil in electrical transformers:** There will be 18 electrical transformers associated with the Project, including six for the solar PV power plant, three for the batteries, four for the electrolysers, two for the fuel cells, two for auxiliary systems, and one spare. A total of approximately 40 m^3 of oil will be contained within these transformers (i.e., approximately 2.2 m^3 of oil per transformer).

  At the end of its useful life, transformer oil will be collected by a local specialist oily waste contractor for disposal at the Barbados National Oil Terminal, or for disposal by other approved means, in accordance with applicable regulatory requirements.

  Standard transformer oils represent a potential danger to third parties and the environment since they can pollute soil and water and cause harm to terrestrial and aquatic biota in the event of an accidental

leak or spill. To mitigate this risk, transformers will be properly operated and maintained, and drip pans or spill containment trays will be installed where possible. Spill response kits will also be available on-site.

Refer to Section 8.7 for consideration of the potential impacts that could occur in the event of a Project-related accident, malfunction, emergency, or disaster, including potential incidents related to hazardous materials, and proposed mitigation measures.

3.6 ANTICIPATED EMISSIONS, DISCHARGES, AND WASTES

As described further below (and depending on their nature), Project-related emissions and discharges will be released to the environment, re-used, directed to on-site drainage and collection systems, or discharged to the municipal sewage system. Solid and liquid wastes that are destined for off-site disposal will be temporarily stored on-site in rubbish bins, containers, or water-tight barrels. Appropriately licensed third-party service providers will be engaged to remove non-hazardous and hazardous wastes for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. Waste containment receptacles containing food wastes will be secured to prevent the attraction of birds or other wildlife. Efforts will be made to divert solid waste materials from the landfill through re-use or recycling wherever practical to do so, and solid wastes will be sorted on-site to facilitate these efforts.

An overview of proposed environmental protection procedures, including those pertaining to waste management, is provided in Section 3.7.

3.6.1 Construction

Potential emissions, discharges, and wastes associated with Project construction activities will be relatively short-term in duration (i.e., occurring over a part or the whole of the approximately 24-month construction period) and in many cases will be the responsibility of the construction contractor, in consultation with the Proponent. They will include, but may not be limited to:

- **Air and noise emissions:** Project vehicles, heavy equipment, and machinery will burn petroleum fuel, either diesel or gasoline, which will generate greenhouses gases (GHGs) and other by-products of combustion. Fugitive dust emissions may be generated by vehicles, such as trucks delivering materials to the Project Property, or by automobiles, trucks, or heavy equipment and machinery used at the site. Potential pile driving (if required) would be associated with noise and vibration. Noise will also be generated by various other construction activities.
- **Construction and demolition waste and debris:** Construction and demolition waste and debris materials, such as concrete, steel, scrap iron, and wood, will be collected and temporarily contained on-site in a designated area until they can be transported to an approved existing disposal facility or landfill site.

- **Garbage from construction personnel:** Human activities on-site will generate garbage, which if not properly managed can lead to pollution and littering. This waste will be handled through the existing municipal solid waste disposal system in the Parish of Saint Philip. If the amount of waste generated is greater than the volumes that the existing waste disposal system can handle, the contractor will be responsible for ensuring that construction wastes are properly collected, handled, and transported to an approved landfill or disposal site.
- **Sanitary sewage from construction workers:** Contractors will be responsible for establishing portable toilet facilities for construction workers and for ensuring that sanitary sewage is appropriately collected and treated prior to disposal.

3.6.2 Operation and Maintenance

Table 3.1 indicates the types and quantities of certain solid and liquid wastes that will be produced during the operation and maintenance phase of the Project.

Table 3.1 Types and Quantities of Certain Project-Related Solid and Liquid Wastes

Type of Waste	Quantity	Storage Site
Sheep manure	1,300 t/year	Disposal bins / designated area
Municipal solid waste	10 m^3/year	Containers according to type of material
Metal scrap and cables	75 kg/year	Warehouse / designated area
Septic tank cleaning	10 m^3/year	Impermeable container
Mineralised water	30 m^3/day	Water tank
Electrolysis electrolyte	100 m^3 every 10 years	Specific tanks
Ion exchange resin	80 kg/year	Waterproof container
Activated carbon	80 kg/year	Waterproof container
Particulate air filters	200 kg/year	Waterproof container
Chemical air filters	1,000 kg/year	Waterproof container
DEOXO catalyst (palladium on alumina beads)	1,000 kg/year	Waterproof container
Used oils and greases and contaminated rags	2 m^3/year	Waterproof container
Oil separator cleaning	10 m^3/year	Waterproof container

Figure 3.16 presents a flow diagram of Project processes, inputs, and outputs associated with operation of the solar PV power plant and energy storage systems, including the main emissions and discharges. Further details regarding these anticipated Project-related emissions and discharges, as well as anticipated Project-related solid wastes, is provided below.

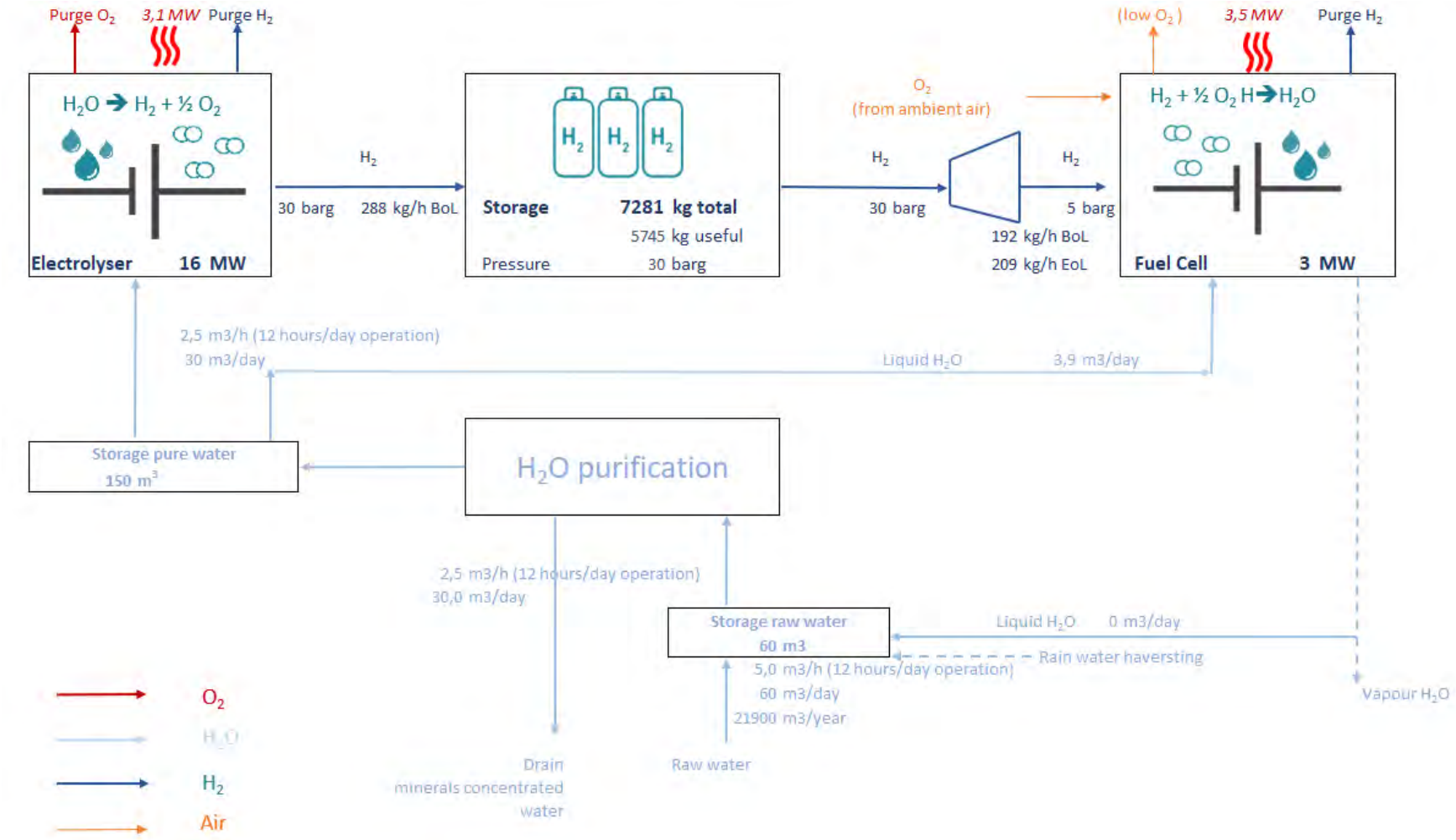


Figure 3.16 Flow Diagram of Project Inputs and Outputs

Potential emissions, discharges, and wastes associated with Project operation activities will occur continuously or periodically over a longer term and the responsibility for the control and management of these wastes will lie with the Proponent. They will include, but may not be limited to:

- **Air and noise emissions:** Air contaminants and noise will be generated from the operation of Project vehicles, heavy equipment, and machinery (including farming equipment and machinery), which will result in small increases in the overall level of air contaminants (i.e., GHGs and other by-products of combustion) in the atmosphere, as well as localized noise levels. The presence of sheep will also be associated with GHG emissions (e.g., methane), as well as noise emissions (e.g., the bleating of the sheep). According to Weeks et al. (2009), the sound pressure levels within a sheep pen containing approximately 100 sheep range from 57 to 62 A-weighted decibels (dBA). Sheep manure typically dries out and breaks down quickly without producing strong odours, unlike chicken and pig waste.

  The following gaseous emissions will be released from the HESS during the operation and maintenance phase of the Project (refer to Figure 3.16):
  - Pure oxygen will be released from the water electrolysis process.
  - Small quantities of hydrogen gas (H_2) may be purged in a controlled manner during operation and maintenance of the electolysers and fuel cells.
  - Air containing a low level of oxygen (O_2) will be released during operation of the fuel cells.
  - Water vapour (pure H_2O) will be released during operation of the fuel cells.

  These gaseous emissions are anticipated to be non-polluting.

  According to the results of a Project-specific Acoustic Assessment (Appendix E) conducted in support of the ESIA, the main noise sources during Project operations will include the transformers, inverters, electrolysers, and battery packs. Operation of these Project components is anticipated to produce sound pressure levels ranging from 78.5 dBA (for the inverters) to 106 dBA (for the fuel cells).

- **Solid wastes from Project operations:** As noted in Section 3.6.2, Project maintenance activities will include corrective or preventative replacement of non-hazardous electronic components, such as PV modules, inverters, and fuel cell stacks. For example, it is anticipated that the fuel cell stacks and electrolyser stacks will need to be replaced once during the operational lifetime of the Project (i.e., approximately during year 12 or 13 of Project operations). These types of solid waste will be handled by specialized electronics recycling/disposal facilities or returned to the manufacturer.

  The main waste stream from the sheep farm will be manure from the sheep stock. This is estimated at 1,200 metric tonnes per year, assuming a herd of 1,830 mostly adult sheep, and will be stored in disposal bins in a designated bio-waste storage area. This waste will be bagged and sold to fertilizer distributors and/or directly to local farmers, and/or will be removed and disposed of by a local bio-waste disposal company. It is anticipated that a fully operational manure bagging plant would safely manage 100% of the sheep manure generated at the farm. Other streams from the farm would be from plant equipment and vehicles, which are anticipated to be minimal, and sanitary sewage from farm employees.

  Other (standard) non-hazardous solid wastes, including solid wastes from human activities on the site, will be disposed of through the local municipal waste disposal system.

- **Sanitary sewage from Project employees:** Wastewater from sanitary uses within Project buildings will be discharged to the municipal sewage system.
- **Mineralized water by-product of reverse osmosis:** In water treatment applications of reverse osmosis, the solvent stream is purified water and the solute stream is concentrated waste. As shown on Figure 3.16 and described in Section 3.2.3.5, approximately 30 m^3/day of water concentrated in minerals will be released from the on-site package water treatment plant as the by-product of the reverse osmosis process that will be undertaken to demineralize water for use in the electrolysers as part of the HESS. Given that potable water supplies from BWA's existing public water mains will be used as the input into the reverse osmosis process, the resultant mineralized by-product water is not anticipated to contain potential contaminants other than the minerals that were removed during reverse osmosis (e.g., salt, manganese, iron, fluoride, lead, and calcium). The concentration of minerals in this by-product water is anticipated to be suitable for irrigation of the grazing and fodder pasture areas of the agricultural facilities, as well as for washdown. Table 3.1 below indicates the tolerance of different forages to electrical conductivity and total dissolved solids, according to research performed in California, USA (CCME 1987).

Table 3.2 Tolerance of Selected Crops to Electrical Conductivity and Total Dissolved Solids in Irrigation Water

Degree of Tolerance	Forages
Electrical Conductivity < 3,600 µS/cm Total Dissolved Solids < 2,500 mg/L	Oat hay Wheat hay Mountain brome Tall fescue Sweet clover Reed Canary grass Birdsfoot Trefoil Perennial ryegrass
Electrical Conductivity < 5,000 µS/cm Total Dissolved Solids < 3,500 mg/L	Barley hay Tall wheatgrass
Notes: µS/cm = microsiemens per centimetre mg/L = milligrams per litre Source: CCME 1987.	

- **Process water from the HESS:** The process water emitted from the HESS when the fuel cells convert the hydrogen and oxygen back into electricity and water (as described in Section 3.2.1.2) will be recirculated to the electrolysers for re-use in the electrolysis process (i.e., to reduce water consumption by the electrolysers).

- **Surface runoff:** Surface runoff from rainwater/stormwater and Project sources (including potential excess water from the washdown and sanitation of Project facilities and the irrigation of grazing and fodder pasture areas) will be managed through on-site drainage works (refer to Section 3.2.3.6). On-site rainwater harvesting, if implemented (Section 3.2.3.5), will also reduce runoff during precipitation events.
- **Agricultural wastes:** Sheep manure from the pens will be collected in skips and sold to soil mix and landscape companies as needed. Some will also be spread across the site as fertilizer to assist with healthy grass growth. No butchering will take place on site, and any dead animals will be removed and disposed of at approved facilities.
- **Hazardous wastes**: The main hazardous wastes associated with the Project are the Li-ion batteries that will comprise the BESS, the KOH solution that will serve as an alkaline electrolyte in the electrolyser components of the HESS, and the oil in electrical transformers. None of these hazardous wastes are process outputs (and therefore they do not pose an operating environmental risk as such), but they will nonetheless require end-of-life disposal. As described in Section 3.5, these hazardous wastes will be disposed of as follows:
  - Used Li-ion batteries will be sent back to the manufacturer for end-of-life disposal at an approved facility, in accordance with applicable regulatory requirements.
  - When replacement and disposal of the used KOH solution is required, RSB will manage the safe removal, handling, and transportation of the product for recycling at an approved facility, in accordance with applicable regulatory requirements.
  - At the end of its useful life, transformer oil will be collected by a local specialist oily waste contractor for disposal at the Barbados National Oil Terminal, or for disposal by other approved means, in accordance with applicable regulatory requirements.

3.6.3 Decommissioning

It is anticipated that the types of potential emissions, discharges, and wastes that will be generated during the decommissioning phase of the Project will be comparable to those generated during the construction phase. They will similarly be relatively short-term in duration (i.e., occurring over a part or the whole of the approximately 12-month decommissioning period) and in many cases will be the responsibility of the decommissioning contractor, in consultation with the Proponent.

It should be noted that the HESS infrastructure will be almost entirely recyclable upon completion of Project operations.

3.7 DESIGN MITIGATION AND ENVIRONMENTAL PROTECTION PROCEDURES

3.7.1 Design Mitigation

Key design mitigation features that will be incorporated into the Project include the following:

- The design of the Project as a dual land use project with integrated energy and agricultural facilities, which will enable baseload renewable energy production while preserving local agricultural activities and saving foreign exchange (refer to Section 4.2).
- The design of the BESS and HESS as consisting mainly of cabinets and containerised enclosures equipped with internal systems to maintain safe operating conditions (refer to Section 3.2.1.2) and mitigate the potential impacts of an accident, malfunction, emergency, or disaster (refer to Section 8.7).
- The design of the Project energy facility to employ clean technologies that produce baseload renewable energy without any harmful operational emissions or process outputs (refer to Section 3.6.2).
- The possible sale of animal by-products from the agricultural facilities (i.e., sheepskin and manure), in addition to the production of lamb/mutton meat (refer to Section 3.2.2).
- The planned re-use of the mineralized water by-product of reverse osmosis for irrigation and washdown purposes, which will reduce Project-related consumption of potable water (refer to Section 3.2.3.5).
- The planned recirculation of process water from the HESS to the electrolysers for re-use in the electrolysis process, which will reduce Project-related consumption of potable water (refer to Section 3.2.3.5).
- Evaluation of the viability of rainwater harvesting via water tanks located beneath Project buildings/infrastructure and the planned establishment of drainage reserves for runoff management, which reduce Project-related consumption of potable water as well as mitigate potential erosion and sedimentation impacts (refer to Section 3.2.3.5 and Section 3.2.3.6).

3.7.2 Environmental Protection Procedures and Mitigation Measures

Table 3.3 provides a preliminary list of the general standard environmental protection procedures and VC-specific mitigation measures that are proposed to be implemented during the construction, operation and maintenance, and decommissioning phases of the Project. The general standard environmental protection procedures are broadly applicable to multiple VCs (i.e., the components of the biophysical/ecological, anthropogenic, and social environment that are identified in Section 6.2), while the VC-specific mitigation measures have been compiled from the impact assessments conducted for the various VCs in Sections 8.2, 8.3, 8.4, 8.5, 8.6, 8.7, and 9.2 of this ESIA.

The list of general standard environmental protection procedures and VC-specific mitigation measures may be modified as the design of the Project progresses and becomes finalized. Various monitoring and management plans will be developed and implemented for the Project, and will also outline relevant environmental protection procedures and mitigation measures, including an Environmental and Social

Management Plan (ESMP), which will contain a Construction Management Plan and an Emergency and Disaster Management Plan (refer to Chapter 11). Note that mitigation recommendations have been included in the various studies (appended to this ESIA). As each of these studies was prepared independently, in some cases, there are slight variations in recommendations. For this reason and for consistency and clarity, the mitigation measures identified in the following table and in the ESMP (Appendix I) represent the commitments of RSB in relation to this Project and supersede recommended mitigation measures in the appended studies.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
General Standard Environmental Protection Procedures	
Waste Management	
Construction	• During construction, the contractor will deal with surplus waste materials responsibly. Relevant waste and resource management procedures will be communicated to employees during the initial site induction. This will include procedures on segregation, handling, recycling, re-use, and return methods to be used. A specific area will be set out to facilitate separation of the various types of waste. • Appropriately licensed third-party service providers / waste contractors will be engaged to remove non-hazardous and hazardous wastes for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. • Proof of appropriate waste disposal, recycling, and/or treatment at approved waste management facilities must be provided by the contractor. • Separate secure containers will be provided for the collection of food wastes and other solid wastes, and the contents of these will be regularly disposed of at an approved landfill. • Materials defined as hazardous or toxic waste will be placed in appropriate designated containers. • Metals, wood, and other recyclable waste materials will be diverted to appropriate recycling facilities. • Waste will be reused / recycled as much as practical to reduce the total volume going to the landfill. • Paper, plastic, polystyrene, corrugated cardboard, and packaging material will be collected and separated for disposal in appropriate on-site bins for recycling. • Metal banding will be folded, flattened, and placed in designated areas for recycling. • Packaging materials will be removed from site and disposed of at appropriate recycling facilities. • General debris will be removed from the Project Property and disposed of at an approved site. • Dirt, dust, and debris will be collected from the roadway drainage gutters and properly disposed of on a regular basis. • Waste materials and debris will be collected in acceptable containers on-site and disposed of off-site in an environmentally acceptable and approved site. • Volatile wastes and materials, such as fuel, mineral spirits, oil, or paint thinner will be stored appropriately and will not be permitted to enter into waterways, storm drains, or sanitary sewers. • Project-related wastes will not be deposited in a location or manner that obstructs the flows of surface drainage or natural watercourses. • Vegetation removed from the site will be chipped and used as mulch on-site and/or disposed of at an appropriate off-site waste disposal facility.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• To help prevent silt runoff and dust creation, waste soils that have been excavated from the site will be reused as backfill materials or re-distributed around the site and used for remediation and biodiversity enhancement features. • Portable toilet waste will be removed from the site by the supplier in a timely manner. • Fires and the burning of rubbish and waste materials on-site will not be permitted. • Rubbish and waste materials will not be buried on-site.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • Solid waste generated on-site will be removed on a regular basis throughout the operational phase. • Sheep manure will be removed from the sheep pens daily to prevent the infestation of flies and other insects. • A waste inventory will be developed to support the management of general and hazardous operational waste streams.
Decommissioning	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Spill Prevention, Control, and Response	
Construction, Operation and Maintenance, and Decommissioning	• Bulk fuel and lubricants will be stored in secure areas (i.e., with bund walls and impervious flooring) that have the capacity to trap more than the volume of petroleum hydrocarbons being stored; this will serve as a secondary containment should the primary containment fail. Other petroleum hydrocarbon products will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer. • Spill response kits will be available on-site. • Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorized personnel. • Fueling and servicing will be conducted at designated sites furnished with spill containment equipment. • Fueling and servicing areas will be sited away from watercourses and drainage works where possible. • The potential for spills will be reduced through the use of standard good practices, such as the use of appropriate containers, and avoiding overfilling. • In the event of a spill, dry clean up and mopping techniques will be used as appropriate. The area will not be “washed down” as this could cause the spills to spread to the surrounding environment and potentially enter drainage works or environmentally sensitive areas. • Spilled material and spent lubricants will be collected and removed from site for disposal at an approved location. • Vehicles, heavy equipment, and machinery will be properly maintained to reduce the risk of leakage. Routine preventative maintenance and inspection of hydraulic equipment and machinery will be undertaken to avoid a hazardous material release. • Soil which may have become contaminated during the course of construction will be remediated. This may be done on-site or removed from site for disposal at an approved location. • Project vehicles will be equipped with appropriately sized spill kits containing the necessary supplies to handle the quantity and type(s) of hazardous materials that are on-site. • Communication systems will be in place and functioning.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor.
VC-Specific Mitigation Measures	
Measures to Mitigate Impacts on the Atmospheric and Acoustic Environment (including Vibration)	
Construction	• Only areas required for construction will be cleared. • Where practical, Project vehicles, heavy equipment, and machinery will be sized to the smallest needed to perform the work. • Air and acoustic emissions from Project vehicles, heavy equipment, and machinery will be managed by conducting regular inspection, repair, and maintenance activities as required for operation in accordance with manufacturer's recommendations and to reduce instances of visible sooty emissions or abnormally high sound levels. Defective vehicles or equipment will be taken out of service and not permitted to resume operations until they are repaired. • Project vehicles, heavy equipment, and machinery will be outfitted with mufflers (and/or other appropriate sound attenuation devices) that meet international design standards. • Project vehicles, heavy equipment, machinery, and associated exhaust systems and mufflers (and/or other appropriate sound attenuation devices) will be regularly inspected and maintained so that they remain operating in accordance with manufacturer's recommendations. • Project vehicles, heavy equipment, and machinery will be shut down when stationary for long periods of time. The idling of vehicles and equipment will be avoided whenever practical. • Dust from Project activities will be controlled where required by using applications of water. Waste oil will not be used for dust control, but other agents, such as wood chips, calcium chloride, matting, and revegetation may be considered on a site-specific or as needed basis. • Project-related fugitive road dust will be controlled through measures such as: – Establishing speed limits of less than 20 km/hour on Project-controlled gravel roads – Conducting road watering on an as-needed basis – Washing truck tires before leaving the construction area onto existing paved roads – Requiring trucks hauling material to have tarps to cover the load • Dust emissions during Project activities will be further reduced by covers, screens, enclosures, or other similar methods, where necessary. • Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors, which will help to prevent the movement of dust onto surrounding areas. • Cleared areas will be paved or revegetated, where possible. • A cover of native grass will be planted and maintained under and between rows of solar PV panels and routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could produce dust emissions during dry conditions. • Stockpiles of topsoil, overburden, and other potentially dust-generating materials will be kept covered and used as soon as practical. • Waste materials will not be burned on-site. • Haul distances to disposal sites will be reduced as much as possible. • A construction fence will be retained along the perimeter of the site where feasible; this will act as a barrier to prevent the movement of dust onto surrounding areas. • Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• Blasting will be avoided, where possible, during construction. • If required and if feasible, augering will be conducted rather than pile driving. If pile driving cannot be avoided, it will be scheduled during daytime hours only and a vibratory hammer will be used since it is quieter and generates less vibration than an impact hammer. • Nearby residents will be notified prior to potential pile driving (if required). • With respect to potential vibration impacts, the contractor will have the required insurance policies in place to cover legitimate claims that may result from damage due to vibration during the construction phase. • Project vehicles will drive within the speed limit to reduce engine noises as vehicles travel on roadways within adjacent communities and horns will be used only as necessary for safety purposes. • Acoustical barriers (e.g., engineered materials or stockpiled overburden) will be used near loud sources during construction, if feasible. • Walled enclosures may be constructed around especially noisy activities, or clusters of noisy equipment or machinery. In cases where it is technically and economically feasible to do so, physical noise controls (e.g., an enclosure for the BESS and physical barriers for transformers and inverters) will be established and Project components with noise reduction capabilities will be preferentially selected. • Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential impacts to various receptors, including flora and fauna, surface water resources, and surrounding agricultural and other land users, residents, and businesses.
Operation and Maintenance; Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project maintenance and decommissioning activities.
Measures to Mitigate Impacts on Surface Water and Groundwater Resources	
Construction	• Existing drainage systems within the Project Property – including land slopes, watercourses, depressions, suckwells, and dry ponds – will be retained and maintained where possible. • A cover of native grass will be planted and maintained under and between rows of solar PV panels to help slow the rate of runoff, control erosion, and reduce the transport of sediment/topsoil off-site. • Paved roadways within the Project Property will consist of kerb and slipper drains, with sets of catchbasins including gully grates to drain captured runoff to culverts leading to suckwells. • A 9-m wide drainage reserve has been proposed along the entire southern boundary of the Project Property. This would involve construction of a runoff interceptor drainage system within the aforementioned drainage reserve. This system may consist of an earthen swale with sloped embankments or an infiltration trench with vertical side faces. Suckwells/infiltration wells may be added to the interceptor drain to assist with the sub-surface drainage of captured rainwater. A hydrological study will be performed during detailed design which will seek to finalise drainage mitigation measures, including final selection of any interceptor drainage system(s) that would be required. • A vegetated buffer strip will be established at the downstream site boundary to control excess runoff. • Silt screens and/or bales of hay will be installed where necessary to contain and prevent the erosion and loss of topsoil from localized areas. • Temporary boulder barriers will be installed at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands. • Temporary stockpiles of topsoil that are not required for re-instatement will be removed from site as soon as possible to avoid migration of topsoil into the natural drainage system.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor. • The drainage system for the site will be designed to limit stormflows from the site. • The drainage system design for areas on-site where impermeable areas are to be added will focus on draining runoff to suckwells, and ultimately to groundwater, to reduce the amount of surface water runoff that could potentially impact communities downstream. • During detailed design, the implementation of a dry pond will be studied. If needed, the dry pond will be constructed on land to the west of the area proposed for sheep grazing, north of the Old Train Line Road (i.e., at the location shown on Figure 17 in Appendix B), to capture a portion of runoff from the North Watershed, promote the infiltration and percolation of runoff to groundwater zones, and reduce to some extent the quantity of runoff that crosses the Old Train Line Road and enters the Project Property. The dry pond shall have shallow slopes, be grassed to facilitate grazing by sheep, and include suckwells with top and side entry inlets along its perimeter.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • Routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could result in a change of the runoff characteristics in those areas. • Paved areas within the HyPCe area and administration areas will be drained by a system of catchment basins, drainpipes, and suckwells. The use of suckwells is intended to promote on-site drainage of runoff to groundwater, rather than to natural drainage courses that convey runoff south and off-site. • The cleaning of PV panels will only be done with clean water. No detergents or cleaning chemicals will be used so that the water that runs off onto the ground does not have chemicals entrained. • Septic tanks and soakaways will be routinely inspected at least once every six months and cleaned as necessary.
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on Flora and Fauna	
Construction	• The mitigation measures identified above and in Section 8.2.2 with respect to the Atmospheric and Acoustic Environment VC will be implemented to mitigate the potential impacts of air, noise, vibration, and dust emissions on flora and fauna. In addition, Project-specific noise and dust management. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna. • Only areas required for construction will be cleared, and construction equipment and vehicles will only operate in previously disturbed areas, where possible. Sensitive areas and habitats (if identified) will be fenced off to prevent damage by Project vehicles, heavy equipment, and machinery. • The vegetation/tree screens, which are proposed for reducing visual impacts (refer to Section 8.5.2), will also reduce sensory disturbance to fauna off-site. • Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce the attraction of birds.Native plants will be used for landscaping. • Cleared areas will be revegetated, where possible.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	• To avoid attracting wildlife, wastes will be securely stored, frequently removed from site, and properly disposed of in an environmentally acceptable manner at an approved site. • Erosion and sediment control measures will be established to reduce the potential for silty water runoff from construction areas to migrate off-site and/or into environmentally sensitive areas. Further details regarding proposed erosion and sediment control measures are provided in Section 8.3.2 in the context of the Surface Water and Groundwater Resources VC. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels. • Regular monitoring for evidence of avian mortalities / collisions with Project infrastructure will be conducted. Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations.
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on the Visual Environment	
Construction	• Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted in areas where potential off-site visual impacts are of such a nature and magnitude that warrants the introduction of vegetation/tree screens. • During the growing-in period of the vegetation/tree screens, the perimeter fencing around the Project Property will be fitted with an opaque privacy screen. • Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce visual impacts.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels. • An adaptive management approach will be employed if complaints regarding glint and glare are received from local residents or other surrounding land users, potentially including implementation of some or all of the following mitigation measures: – the establishment of additional and/or taller vegetation/tree screens and/or additional opaque privacy screens to further shield or obscure offending panels so that they cannot be seen – replacement of the offending solar panels with those that have a deeply textured surface, to reduce glare intensity – removal or reorientation of the offending solar panels • More generally, if complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on Agriculture and Other Land Uses	
Construction	• Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential sensory/nuisance impacts to nearby land users (e.g., agricultural workers on the site or on adjacent lands), residents, businesses, and other off-site receptors. The ESMP also includes details of how RSB will liaise with the local community before each phase of development. • Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays). • Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors and will act as a buffer to adjoining lands.
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. Additional measures to be implemented during the operation and maintenance phase of the Project include: • RSB will consult with neighboring landowners and request that the spraying of herbicides on adjoining fields be limited to days that are not windy in order to reduce dispersion onto the operational renewable energy facility and the sheep farm. • If complaints are received from agricultural or other land users regarding perceived Project-related impacts, RSB will work with the affected land users to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.
Decommissioning	• Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.
Measures to Mitigate Impacts on the Social Environment	
	Health and Safety • Measures to mitigate potential impacts on the health and safety of Project personnel (including contractors and employees) and site visitors include: – Project personnel will conduct weekly occupational health and safety (OHS) meetings. – OHS plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans. – The Project will be compliant with the legal and statutory labour requirements, to safeguard community and worker safety and health. – Personnel will be required to use protective gear to guard against on-the-job injuries. – Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers. – Only trained and/or certified persons will use specialised equipment and handle dangerous chemicals. – There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site. – Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorised personnel. – An emergency and disaster management plan (Section 11.3) will be implemented as part of the ESMP (Appendix I), with emergency drills regularly conducted so that Project personnel are able to respond swiftly and appropriately in the event of an incident.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	– Traffic management measures will be put in place and consistently implemented to control on-site traffic, as well as the practices of construction drivers to and from the construction site. – There will be adequate 24-hour security to prevent unauthorized entry into restricted Project areas, through CCTV or equivalent monitoring systems. Additional provisions that will be made to enforce safety in and around construction areas include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meet the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways. • Measures to mitigate potential impacts to public health and safety include the following: – Adequate signage, fencing, guardrails, and/or warning tape will be installed so that members of the public, particularly children, cannot wander into restricted Project areas, and sufficient security will be in place to monitor and enforce these restrictions. – Safety warning signs will be strategically placed near construction works to inform the public of prohibited activities. These signs will include both printed words and international symbols and will meet the universal design environmental access requirements/standards for persons with disabilities. – Notices will be published in the media to alert the public of the proposed construction works at least two weeks prior to the start of activities. – 24-hour security measures will be used to prevent unauthorized entry of persons after working hours, through CCTV or equivalent monitoring systems. – Potentially hazardous areas within and adjacent to the site will be left in a safe condition (e.g., securing materials and equipment, fencing off or preventing entry into excavations or trenches). – If detours are planned, relevant local authorities will be notified of the alternative routes in advance. – Project drivers will be cautioned to obey the speed limit and other traffic laws, and should ideally be trained in defensive driving. – Unauthorized persons who enter the site will be escorted off the site as soon as they are discovered. – The area will be well-lit and the public advised on site restrictions. **Human Capital and Social Dynamics** • In addition to regular OHS training and the proposed capacity-building and skills development, contractors will be required to provide gender sensitization training to address critical on-the-job issues and facilitate positive interactions between workers and the surrounding residents. Topics to be included in the training include gender-responsive behaviour and interactions, avoiding sexual harassment, and conflict resolution skills. In addition, there will be transparent disclosure of the requirements for adequate work facilities and decent work, to allow employees to be apprised of their worker rights and benefits. **Economy** • To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being made available to unemployed residents of specifically neighbouring communities.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
	Cultural Values • Concerns about the potential change to the aesthetics of the area will be addressed through a carefully planned and implemented public awareness campaign to address the typical concerns raised about the construction of solar facilities on the scale of the Project. An important component of this campaign will be to clearly explain the design of the facility and the potential benefits that could accrue to Barbados. • Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the Project Property. In this event, the contractor will work with the Museum to develop and implement a plan to protect the artefacts. • Public service announcements will be provided so that commercial operators, residents, and the public are updated on and given appropriate advance notice of the construction activities, especially those, such as construction activities planned outside of typical work hours, such as late evening or night, that could be disruptive. • Construction will be based on approved construction management measures in the ESMP to reduce the impacts of noise, dust, vibration, wastes, and traffic (refer to Chapter 11 and Appendix I). **Infrastructure and Services** • As indicated above, traffic management measures will be put in place and consistently implemented to control on-site traffic, as well as the practices of construction drivers to and from the construction site. • Measures to mitigate potential impacts on the use of public roadways include: – Transport of material and equipment will be scheduled for off-peak hours, to the extent practical. – The use of long convoys or trucks during construction and operation will be avoided. – Transport of over-sized loads (such as hydrogen tanks) will be coordinated with local traffic management authorities and / or the police. Arrangements will be made for police outriders to accompany long or wide loads during construction. – Flag-persons will be used at intersections with existing roads, or where single lane traffic is created during construction. – Signs will be used to indicate construction zone and movement of trucks and equipment. – High occupancy vehicles like buses will be used to transport workers to and from the site to the extent practical. – Roads, culverts, and bridges which are located along the access routes to the construction site will be inspected prior to the start of construction to check the stated load capacity. This should determine whether they can withstand the expected traffic loads and necessary mitigation should be carried out such as strengthening works, signing, diversions of routes. – Roads, culverts, or bridges which may be damaged as a direct result of construction traffic will be repaired. The nature of repairs will be determined in consultation with the Ministry of Transport, Works, and Water Resources, with repairs done as soon as practical. – Utilities will be properly mapped and considered during construction, and especially prior to ground disturbance activities. – Appropriate consultation will be carried out with utility providers and operators and arrangements will be made for addressing conflicts. – Prior to work, the contractor will consult with the local police service, the local fire service, and the local health authority to discuss proposed activities and possible implications for community services.

Table 3.3 Environmental Protection Procedures and Mitigation Measures

Project Phase	Proposed Measures
Operation and Maintenance	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project operation and maintenance activities. When operational, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. In addition to addressing the impacts of noise, air quality, vibrations, worker health and safety, and public health and safety, the ESMP (Appendix I) includes a Social Management Plan that comprises both a stakeholder engagement plan and a grievance redress mechanism, which are designed to allow the best interests of relevant stakeholders to be considered during the Project. The ESMP also includes a Social Monitoring Plan.
Decommissioning	Relevant construction-related mitigation measures will be implemented where applicable and as necessary during Project decommissioning activities.

3.8 OCCUPATIONAL HEALTH AND SAFETY

Occupational health and safety (OHS) plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans. Personnel will be required to use protective gear to guard against on-the-job injuries. Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers. Only trained and/or certified persons will use specialised equipment and handle dangerous chemicals. There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site. Weekly OHS meetings will be held.

3.9 PROJECT ALTERNATIVES

3.9.1 Do-Nothing Scenario

To do nothing would result in the Project Property continuing to be used as it currently is – for farming sugarcane and rotational crops (e.g., cotton). Conversely, proceeding with the Project as proposed will enable dual land use of the Project Property to generate renewable electricity while also maintaining the availability of the land for agricultural activities (i.e., sheep farming).

Chapter 4 describes the Project's anticipated contribution to energy production as well as several environmental, social, and economic benefits of the Project, including advancement of Barbados' progress towards achieving its BNEP goals (Government of Barbados 2019a) of attaining 100% renewable energy usage and carbon neutrality by 2030. These Project benefits would not be realized in a do-nothing scenario.

3.9.2 Alternative Renewable Energy Project

The production of wind energy via the installation of wind turbines on the Project Property is an alternative renewable energy solution that could be considered to advance Barbados' progress towards achieving the transformational goals stated in the BNEP (Government of Barbados 2019a). It may be possible to erect several smaller turbines or possibly two or three larger turbines on the site, that is to say less than 10 MW of installable capacity. However, the feasibility of this alternative is unknown since no site-specific

wind study has been undertaken to determine whether the natural wind regime of the Project Property is even suitable for the development of a wind power project. In addition, a wind power project would be associated with several potential adverse impacts that are not anticipated for the Project, including visual impacts to surrounding communities, shadow flicker from the rotating turbine blades, nuisance impacts from turbine noise, and the risk of bird and bat kills.

3.9.3 Alternative Location for the Project

Harrow Plantation was selected as the preferred Project location for several reasons, including the following:

- The Project Property is large enough to accommodate Project components and activities while maintaining a substantial setback around the HyPCe area (i.e., with a radius of more than 200 m from the nearest permanent residence) as a safety zone.
- The immediate vicinity of the Project Property is not densely populated, and the Project Property is sufficiently separated from surrounding residences, businesses, and institutions to help reduce potential sensory disturbances or nuisance impacts to sensitive off-site receptors.
- The Project Property is located approximately 3.5 km away from BLPC's existing substation in Hampton, Saint Philip, Barbados, where the power plant will be connected to the national grid.
- The Project Property has relatively flat and uncomplicated topography.
- The Project property has good soil for growing high-protein grasses suitable for use by grazing sheep and as fodder.
- The Project Property is in close proximity to adaptable transmission infrastructure.

The initial site that was considered for the Project location was Orange Hill Plantation, in the Parish of Saint Peter, which is situated near the northern end of the island of Barbados. Although Orange Hill Plantation would have been a possible Project location due to its remoteness and proximity to existing high-capacity electricity transmission infrastructure, use of that site for the Project was ultimately determined to be not feasible due to complications during the land procurement process and presence of gullies and water runoffs.

3.9.4 Alternative Electrolyser Technology

Three different technologies of electrolyser exist on the market: alkaline, PEM, and solid oxide. The main difference between the technologies is the electrolyte used. Two technologies may be suitable for the Project: alkaline and PEM. Alkaline technology, which uses KOH as an electrolyte in a closed-loop process, was selected because it is more mature than PEM technology.

3.9.5 Alternative Solar Energy Storage Technology

Batteries have been selected as the preferred technology for the short-term storage of solar energy from the Project and hydrogen fuel cells have been selected as the preferred technology for the longer-term storage of solar energy from the Project.

Potential alternative solar energy storage technologies include pumped-storage hydropower, thermal energy storage, flywheel storage, and compressed air storage. However, these alternative technologies are not preferred for the following reasons:

- Implementation of pumped-storage hydrogen technologies would require quite specific topographical conditions, large quantities of water, and an extensive surface area. Pumped-storage hydropower projects are usually very large-scale (GigaWatts) and entail high capital expenditures because of the complexity of their engineering requirements.
- Thermal, flywheel, and compressed air energy storage alternatives are low-maturity technologies, with no relevant commercial solution on the market for a project of the size of the Renewstable® Barbados Project.

Batteries (especially Li-ion batteries) are a well-matured technology, while hydrogen technologies (i.e., electrolysis, fuel cells, storage) are well-known worldwide and scaling up for use in a variety of industries. The Proponent has deemed a combination of Li-ion battery and hydrogen technologies to be the best technically and economically feasible solution to achieve short-term and long-term energy storage.

3.9.6 Alternative Battery Storage Technology

There are many battery storage technologies available on the market, but the current leading technology – and the technology most suitable for the Project – employs Li-ion batteries. The Proponent stays informed regarding new technologies in development for potential BESS applications (e.g., Lithium-sulphur batteries or solid-state batteries) and has determined that those new technologies have not yet reached sufficient maturity to be relied on for the Project. Conversely, Li-ion BESS manufacturing is rapidly scaling up worldwide due to the growing demand for use in electric vehicles and for stationary storage for residential, commercial, and utility purposes.

3.9.7 Alternative Hydrogen Fuel Cell Technology

Three different hydrogen fuel cell technologies exist on the market: alkaline, PEM, and solid oxide. The main difference between the technologies is the electrolyte used. The only fuel cell technology that is suitable for the Project is PEM. Of the fuel cell systems that are currently available on the market, only those employing PEM technology have sufficient capacity to be used for multiple-megawatt applications. The fuel cells to be used for the Project will be supplied by HDF Energy.

4.0 ENERGY PRODUCTION AND BENEFITS OF THE PROJECT

The total annual electricity demand for Barbados is approximately 900 gigawatt-hours (GWh), with a maximum load of approximately 170 MW. Average daily power consumption ranges from approximately 155 MW during the day to approximately 100 MW at night, with end-of-day consumption peaking at approximately 130 MW around 19:30.

Barbados' current installed dispatchable thermal power capacity is approximately 239.5 MW (Table 4.1), which allows a reserve margin for unscheduled downtimes and scheduled equipment maintenance. As shown in Table 4.1, Barbados' existing large-scale power plants primarily rely on imported petroleum products, such as heavy fuel oil, diesel, and jet fuel (kerosene). The steam turbines associated with these power plants are aging assets that need to be decommissioned.

Table 4.1 Large-Scale Power Plants in Barbados

Type of Power Plant	Power Installed	Type of Fuel	Specific Consumption	Carbon Dioxide (CO_2) Emissions
Steam Turbine	40 MW	Heavy Fuel Oil	3.78 kilowatt-hours (kWh) per litre (L)	1.39 tonnes (t) of CO_2 per MWh
Low-Speed Diesel Engine	113.5 MW	Heavy Fuel Oil	4.93 kWh/L	0.69 tCO_2/MWh
Gas Turbine	86 MW	Diesel and Jet Fuel	2.82 kWh/L to 2.94 kWh/L	0.95 tCO_2/MWh
Solar	10 MW	Solar	–	–
Source: Compiled by HDF Energy, based on publicly available data from the Fair Trading Commission (FTC).				

As noted in Section 1.1, the BNEP outlines the Government of Barbados' goals of achieving 100% renewable energy usage and carbon neutrality by 2030 (Government of Barbados 2019a), and BLPC and BREA have stressed the importance of implementing baseload renewable power generation to achieve these goals. The Project has been designed to deliver reliable baseload renewable power when it is most needed, including 13 MW of firm baseload power during periods of peak demand (i.e., typically between the hours of 8:00–17:00 and 19:00–21:00, as shown on Figure 4.1) when the price of conventional power generation is the highest due to the use of open cycle gas turbines running at a cost of between $250–$600 USD per megawatt. Thus, the Project will support Barbados' transition away from reliance on its existing fossil fuel burning power plants, whose components need to be decommissioned according to BLPC's retirement schedule (IADB 2016), and towards achieving the goals of the BNEP (Government of Barbados 2019a).

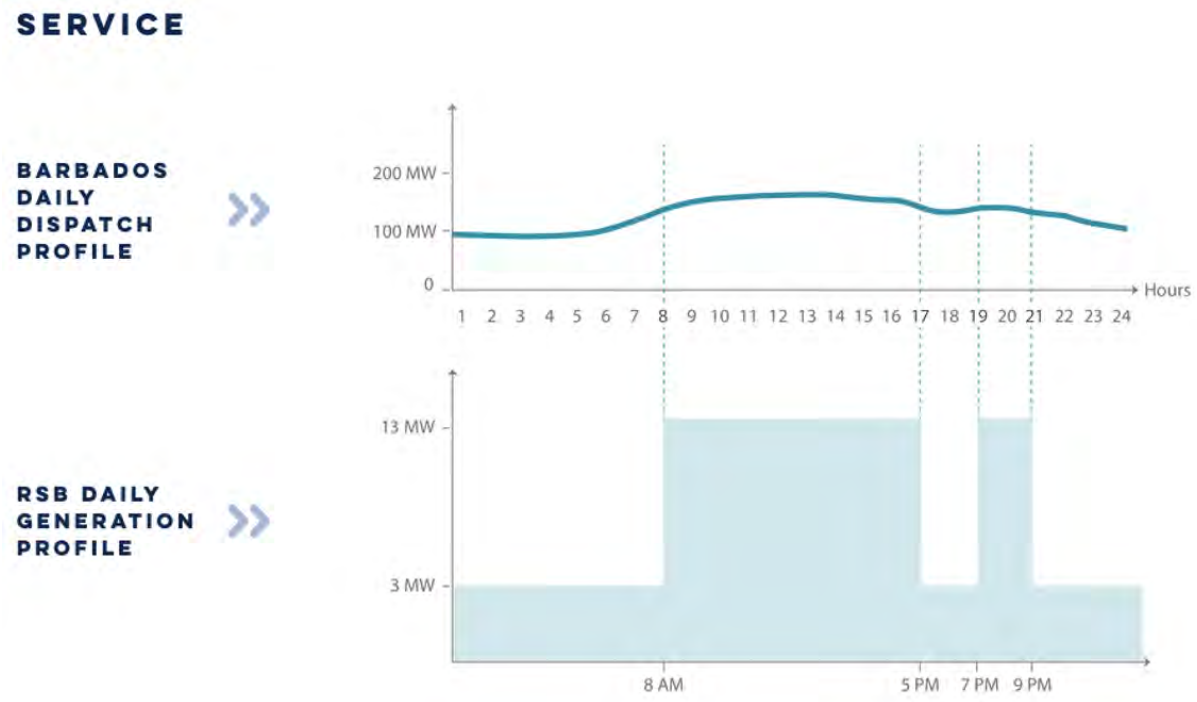


Figure 4.1 Barbados' Typical Daily Grid Dispatch Profile and Anticipated Project Generation Profile

Numerous small-scale to commercial-scale solar projects are expected to be developed in the upcoming years, and some large-scale solar projects (5–10 MW intermittent power plants) are in development as well. The existing small-scale solar PV systems on the island were installed under the Renewable Energy Rider (RER) Program with a feed-in tariff. In September 2019, the Barbados Fair Trading Commission (FTC) released new feed-in tariffs for renewable energy projects with generating capacities under 1 MW, thereby providing a regulatory framework for such size solar projects. It is anticipated that the future solar PV systems developed under these new feed-in tariffs will provide non-dispatchable electricity only during daytime hours and will be subject to intermittency, and that BLPC will therefore need to restrict power usage by its customers and/or invest in storage to dispatch this intermittent power without compromising energy security. A stand-alone storage investment by BLPC would likely be recovered through the FTC process and eventually transferred to the customer through the price of electricity.

The Project differs substantially from solar PV systems that provide intermittent power with minimal or no storage and will therefore help increase the penetration of renewable energy without causing intermittency issues. By combining hydrogen and lithium storage technologies, the Project offers a clean, carbon-free, viable, non-intermittent and renewable baseload solution that will help to sustain the stability of the grid at a competitive cost and with no hidden costs. It will deliver baseload power to the grid operator 24 hours per day, seven days a week, with an availability (i.e., capacity factor) higher than 85%. The Project EMS will enable RSB, based on the solar irradiance forecast and energy storage level data, to notify the grid operator 24 hours in advance regarding the availability of power so that storage can be optimized as necessary to deliver the maximum amount of power to the grid and reduce energy losses.

This predictable firm power will eliminate the additional operating costs and infrastructure upgrade requirements that BLPC would typically face when implementing traditional renewable energy projects (i.e., intermittent wind and solar).

In addition to offering substantial technical advantages over traditional renewable energy projects and advancing Barbados' progress towards achieving its BNEP goals of attaining 100% renewable energy usage and carbon neutrality by 2030, the Project is also anticipated to result in several other important environmental, social, and economic benefits, as outlined in the subsections below.

4.1 ENVIRONMENTAL BENEFITS OF THE PROJECT

4.1.1 Reduced Reliance on Non-Renewable Resources

Given the nature of the Project (i.e., a renewable power project), it will inherently reduce Barbados' reliance on finite fossil fuel resources for energy production, as well as the international and domestic environmental impacts associated with extracting, processing, transporting, and burning those fossil fuels.

4.1.2 Reduced Emissions

The Project energy facility will generate and deliver renewable power without emission of greenhouse gases or other air pollutants (however, limited GHG emissions will be associated with sheep farming and the operation of Project-related vehicles and equipment). By generating an average of approximately 56,000 MWh of carbon-free electricity per year, the Project is anticipated to reduce Barbados' total CO_2 emissions by approximately 48,000 tons annually[4].

Refer to Section 3.6 for a description of anticipated Project-related emissions, discharges, and wastes, which are generally anticipated to be minimal in comparison with those that would typically be associated with power generation from fossil fuels.

4.2 SOCIAL AND ECONOMIC BENEFITS OF THE PROJECT

4.2.1 Fixed and Competitive Pricing

RSB will derive its remuneration through a long-term power purchase agreement with BLPC that will be validated by the FTC. Compared to other firm renewable power solutions, the price is competitive and benefits from economies of scale. The cost of generation will be set and known for at least 25 years in the power purchase agreement, which will reduce the impacts of variable and unpredictable fuel cost adjustments on end-consumers.

[4] Calculation based on average specific CO_2 emissions of 0.87 tCO_2/MWh, as per BLPC figures.

4.2.2 Employment

Project construction will be managed by an international engineering, procurement, and construction contractor that will subcontract most of the local workforce. It is estimated that the construction phase of the Project will provide temporary employment for up to approximately 150 local people. Following construction, it is estimated that approximately 20 full-time-equivalent local jobs will be created to support Project operation, maintenance, and security requirements. The sheep farming aspect of the Project is expected to create 10 full-time-equivalent local jobs as farmers and farm staff. In addition to their pay, Project personnel will also gain valuable experience and training.

4.2.3 Optimized Land Use and Agricultural Benefits

As a dual land use project that accommodates commercial sheep farming within the grounds of the solar PV power plant, the Project will enable baseload renewable energy production while preserving local agricultural activities and saving foreign exchange (refer to Section 4.2.4 below). Since achieving the BNEP's 100% renewable energy target will likely require substantial changes to land use throughout Barbados, including impacts to the island's agricultural lands, it is a noteworthy benefit of the Project that it has been designed in such a way that allows agricultural activities to co-exist with solar energy production.

The Project Property is ideal for the location of a sheep farm due to the quality of its soils, which support high-quality grass for grazing and fodder. Although the Project Property does not have a working groundwater well suitable for irrigation available on-site, the Project will be designed to ease the impact of the dry season on sheep farming. The mineralized water by-product from the water treatment plant can be re-used for irrigation and washdown, while the fodder pasture area and feed silo will allow the harvesting, bailing, and storage of grass for use as livestock feed when needed.

The grounds of the power plant will also provide a secure, fenced environment for grazing sheep. This will reduce the risks of predation and livestock theft, which are major challenges faced by sheep farmers in Barbados.

4.2.4 Reduced Reliance on Imports and Provision of Products for Domestic and Export Markets

By generating an average of 56,000 MWh/year of renewable energy for delivery to the national grid over the life of the Project, it is anticipated that operation of the Project will enable Barbados to reduce consumption of imported heavy fuel oil by 13 million litres[5] annually, representing savings of approximately $13.6 million Barbadian dollars (BBD) per year[6].

[5] Calculation based on an average specific consumption of heavy fuel oil of 0.23 L/kWh, based on BLPC figures.
[6] Calculation based on a price of $25 BBD/MBTu, data from Barbados IRPP (Mott Macdonald). Average price projected between 2020 and 2030.

The agricultural component of the Project will raise sheep livestock for the purpose of producing lamb/mutton meat – and, if commercially viable, sheepskin and manure – for domestic and export markets. It will therefore enable Barbados to reduce lamb/mutton meat imports, which will save over $1 million BBD per year of foreign exchange.

4.2.5 Improved Energy Security and Resilience of National Grid

The existing power plants in Barbados that rely on imported fossil fuels are inherently vulnerable to potential fuel supply issues that could arise due to factors such as extreme weather, natural disasters, price volatility, and political and/or economic instability. In the event of such issues compromising the availability of fuel in Barbados, the Project would still be able to deliver stable electricity to the grid, thereby improving local energy security and the resilience of the national grid as well as reducing the risk of a general power outage and any associated social and economic repercussions.

4.2.6 Local Development and Transfer of Technological Knowledge

As the first large-scale industrial application of hydrogen technology in Barbados, the Project presents an opportunity for the country to develop local expertise in a highly promising industry and pave the way for other projects of this nature. For example, the Proponent's parent company, HDF Energy, has expressed an interest in developing other hydrogen-related projects in Barbados, including Renewstable® power plants, hydrogen mobility projects, desalination power plants running on solar power and hydrogen, and waste recovery through hydrogen.

The Project will enable the potential creation of a hydrogen skills program in Barbados, which could position Barbados as an expert in the field and allow Barbados to export its knowledge throughout the Caribbean region. HDF Energy intends to support a local education program or specific class related to renewable energy storage and hydrogen. In June 2021, HDF Energy secured a letter of intent from the University of the West Indies' (UWI) campus in Cave Hill, Barbados indicating a preliminary commitment to collaborate on research and knowledge transfer. The UWI is willing to conduct research focusing on carbon-free hydrogen power solutions in the Caribbean context. HDF Energy is willing to integrate knowledge transfer as part of the Project and is prepared to commit resources to help add value to existing UWI research programs in Barbados if and when Project development success is demonstrated at financial close. There are also additional strong potential synergies between the UWI and HDF Energy capabilities regionally. Further opportunities for collaboration will be explored in other countries in which HDF Energy develops projects and in which UWI has a local campus or other institutional presence.

If desired, HDF Energy is also open to participating with the Barbadian government on a national scientific research program focusing on Barbados' energy strategy objectives, working in collaboration with regulators as well as local and international industry leaders, scientists, and relevant stakeholders. This research should focus on emerging technologies such as "green hydrogen" and its various uses. Potentially relevant applications in the Caribbean region include the promotion of energy independence of territories and the development of clean regional ferries running on hydrogen.

5.0 PUBLIC AND STAKEHOLDER CONSULTATION AND ENGAGEMENT

Engagement with the individuals, communities, groups, and organizations interested in or potentially affected by a project is a key step in understanding potential issues and concerns, mitigating adverse effects and enhancing potential positive impacts. RSB is committed to building and maintaining positive relationships with the local community.

As part of the Social Impact Assessment (SIA) described in Chapter 9, a survey of 155 households was conducted. The objective of the survey was to establish baseline conditions, but respondents were also provided with a flyer that offered a brief description of the Project and questions were asked about the potential benefits and adverse effects of the Project. Table 5.1 is a list of the potential concerns that were raised and identifies where these are addressed in the ESIA.

Table 5.1 Potential Concerns about the Project Identified During Surveys

Project Concerns	Where Addressed in the ESIA
Noise pollution during construction	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for noise is outlined in Section 3.7.2
Dust pollution during the construction phase	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for dust is outlined in Section 3.7.2
Removal of trees and other vegetation during the during construction phase	• Section 8.4 – Flora and Fauna • As indicated in Section 8.5, a tree barrier will be established around the facility to reduce visual impacts on the community
Unsafe/hazardous work sites	• Section 9.2 – Social Impact Assessment • Mitigation measures to protect public and worker health and safety are provided in Section 3.8 and Section 9.2.3
Noise from livestock during the operational phase	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for noise is outlined in Section 3.7.2
Vibration damage to structures nearby during construction phase	• Section 8.2 – Acoustic and Atmospheric Environment • Mitigation for vibration is outlined in Section 3.7.2
Lower water pressure in area due to water usage by the power plant during the operational phase	• Section 3.2.3.5 – Water Supply, Treatment, and Storage • Section 9.2 – Social Impact Assessment
Odours from the animals during the operational phase	• Section 8.6 – Agriculture and Other Land Uses
Release of hazardous emissions and products from the power plant during the operational phase	• Sections 3.5 and 3.6 of the Project Description • Section 8.7 – Accidents, Malfunctions, Emergencies, and Disasters

In addition to the surveys described above, RSB has completed the following public and stakeholder consultation and engagement activities:

- Four (4) public announcements on the Project were published in the local media in 2021
- Two (2) live television interviews were conducted in 2022 introducing the Project and the expectations for its development
- A technical presentation was made to the Barbados Association of Professional Engineers (BAPE) in March 2022
- Preliminary engagement with potential local Project service providers has commenced (construction contractors, etc.)
- A personal engagement with a local community representative was carried out, in which questions were fielded regarding environmental concerns and potential investment opportunities for the Project
- Planning with respect to potential contributions to the Six Roads Village community development has commenced

In addition, RSB intends to conduct additional public and stakeholder consultation and engagement activities as described below:

- Engage third-party consultant and/or Project Liaison to implement and maintain the Social Management Plans (SMP), Grievance Redress Mechanism, and associated processes (refer to Section 11.1)
- Directly engage with interested individuals and corporate entities
- Continue preliminary engagement with potential local service providers
- Publish the endorsed ESIA on the Project website
- Plan and facilitate Community meetings (1 minimum)
- Provide regular Project updates via the Project website and / or local media
- Perform personal introductory visits by the Project Liaison to community members and businesses
- Generate regular social media communications on issues of public interest / concern (e.g., via Instagram, Community WhatsApp group, etc.)
- Seek feedback on the success / adequacy of social management initiatives from stakeholders and implement feasible recommendations
- Maintain key stakeholder engagement records

6.0 ESIA SCOPING CONSIDERATIONS AND IMPACT ASSESSMENT APPROACH

6.1 SCOPE OF THE PROJECT TO BE ASSESSED

The scope of the Project to be assessed generally includes the components and activities described in Chapter 3, but excludes the following components and activities that will be entirely under the care and control of independent third parties (Table 6.1).

Table 6.1 Activities and Components Excluded from the Scope of the Project to be Assessed

Components and Activities Excluded from Assessment	Rationale for Exclusion from Assessment
Construction and operation of a new transmission line extending off-site from the Project Property to the Hampton substation	As indicated in Section 3.2.3.4, the Project will power the national grid via a new transmission line connecting the proposed power plant to BLPC's existing Hampton substation, which is located approximately 3.5 km away from the Project Property. It is anticipated that BLPC will independently undertake any necessary upgrades to off-site grid infrastructure beyond the boundaries of the Project Property. It is also assumed that the new transmission line extending off-site from the Project Property to the Hampton substation will be assessed, owned, and operated by BLPC; as a component of Barbados' national power distribution system, this transmission line will be entirely under the care and control of BLPC.
Potential upgrades to off-site telecommunications infrastructure beyond the boundaries of the Project Property (if applicable)	As indicated in Section 3.2.3.4, the Project will require connection to the local telecommunications network and will be hooked up to the existing fibre optic cable system that services the area. It is anticipated that the service provider will independently undertake any necessary upgrades to off-site telecommunications infrastructure beyond the boundaries of the Project Property (if applicable). Any upgrades that may be required beyond the Project Property will be assessed, owned, and operated entirely under the care and control of the service provider and are therefore excluded from the scope of the Project to be assessed.
Potential upgrades to off-site water utility infrastructure beyond the boundaries of the Project Property (if applicable)	As indicated in Section 3.2.3.5, the Project water supply will primarily be sourced from existing public water main pipelines that are owned and operated by BWA. It is anticipated that BWA will independently undertake any necessary upgrades to off-site water utility infrastructure beyond the boundaries of the Project Property (if applicable). Any upgrades that may be required beyond the Project Property will be assessed, owned, and operated entirely under the care and control of BWA and are therefore excluded from the scope of the Project to be assessed.
Off-site butchering activities	As indicated in Section 3.3.2, butchering activities will take place off-site at an approved facility. These activities will be carried out entirely under the care and control of an independent third party (i.e., a qualified professional butcher) and are therefore excluded from the scope of the Project to be assessed.

Table 6.1 Activities and Components Excluded from the Scope of the Project to be Assessed

Components and Activities Excluded from Assessment	Rationale for Exclusion from Assessment
Off-site waste management activities	As indicated in Section 3.6, Project-related wastes will be temporarily stored on-site in rubbish bins, containers, or water-tight barrels for off-site disposal, recycling, and/or treatment at approved waste management facilities in accordance with applicable regulatory requirements. The on-site collection, storage, handling, and transportation of waste materials is included within the scope of the Project to be assessed. However, any subsequent waste management activities that take place after the waste materials leave the Project Property (i.e., for off-site disposal, recycling, and/or treatment) will be carried out entirely under the care and control of an independent third party (e.g., a qualified and accredited professional waste hauler, an accredited waste management facility, and/or the manufacturer) and are therefore excluded from the scope of the Project to be assessed.

Refer to the first column of Table 8.1 (in Section 8.1.1 below) for an overview of the scope of the Project activities to be assessed.

6.2 SELECTION AND SCOPING OF VALUED COMPONENTS

This ESIA focuses on the identification and assessment of potential adverse impacts of the Project on VCs. VCs are components of the biophysical/ecological environment, the anthropogenic (i.e., built/developed) environment, and the social environment (including economic and cultural aspects) that have potential to be impacted by the Project and that are of value or interest because they have been identified to be of concern by regulatory agencies, the Proponent, resource managers, scientists, key stakeholders, and/or the general public.

Table 6.2 identifies the VCs that have been selected for the ESIA, defines their scopes, and explains the rationales for their selection.

Table 6.2 Valued Components Selected for the Assessment

Valued Component	Scope and Rationale for Selection
Biophysical/Ecological VCs	
Atmospheric and Acoustic Environment	The Atmospheric and Acoustic Environment VC includes air quality, GHGs, noise (i.e., unwanted sound), and vibration. These components constitute a VC in consideration of the following: • In general, the atmospheric and acoustic environment is a pathway for the potential transport of air contaminants, GHGs, noise, and vibration to terrestrial, freshwater, marine, and human environments. • Air quality has intrinsic importance to the health and wellbeing of humans, wildlife, vegetation, and other biota. Some Project activities will result in the release of substances to the atmosphere that are classed as air contaminants. The release of these substances during Project-related activities may change air quality, and exposure to air contaminants is a potential health hazard.

Table 6.2 Valued Components Selected for the Assessment

Valued Component	Scope and Rationale for Selection
	• GHGs contribute to human-induced climate change (IPCC 2021). Emissions of GHGs and their accumulation in the atmosphere are therefore issues of scientific and regulatory concern, and GHGs are the subject of domestic and international reduction targets. • Noise and vibration from the Project have potential to cause sensory disturbance affecting human health and wellbeing, land and resource use, and wildlife and wildlife habitat. Noise from potential pile driving (if required) could also cause auditory injury to humans or wildlife in proximity to the source, while vibration from potential pile driving (if required) could also cause damage to nearby buildings and infrastructure.
Surface Water and Groundwater Resources	Surface water includes freshwater waterbodies and watercourses, as well as storm water drainage. Groundwater includes domestic, commercial, and industrial groundwater-source water supplies, and the groundwater component of freshwater ecosystems. Surface Water and Groundwater Resources was selected as a VC for assessment in consideration of the following: • Potential Project-related changes in surface water quantity and surface water quality warrant assessment due to the importance of surface water as a source of potable water for humans; its importance to wildlife and freshwater aquatic biota as habitat; its importance for supporting commercial, recreational, and industrial activities; and the potential impacts of storm water drainage on surrounding habitats. • Potential Project-related changes in groundwater quantity and groundwater quality warrant assessment because groundwater resources have potential to be a source of potable water and are important in maintaining ecological habitats by supporting stream flow, vegetation, and wetlands.
Flora and Fauna	The Flora and Fauna VC comprises terrestrial plant and wildlife (i.e., mammal, herptile, and bird) species and their habitats. It also includes marine bird, shore bird, and waterfowl species that make use of terrestrial habitat during their life history and have potential to interact with the Project while doing so. The scope of this VC includes both secure species and species at risk. Project activities (e.g., vegetation clearing; use of vehicles, heavy equipment, and machinery; and solar grazing), and Project-related emissions, discharges, and wastes, will directly and indirectly impact flora, fauna, and terrestrial habitat by causing changes in risk of injury or mortality and changes in habitat use. In addition to its ecological importance, the Flora and Fauna VC is also important to humans, who value plants, wildlife, and the terrestrial environment for recreational, aesthetic, and traditional/cultural purposes.
Anthropogenic VCs	
Visual Environment	The Visual Environment VC includes consideration of visual aesthetics, reflection (i.e., glint and glare), and lighting. This VC warrants assessment because the Project will alter the visual landscape and aesthetics of the Project Property and may result in glint and glare and lighting impacts that could cause sensory (visual) disturbance to adjacent and nearby land users.

Table 6.2 Valued Components Selected for the Assessment

Valued Component	Scope and Rationale for Selection
Agriculture and Other Land Uses	The Project will alter the existing agricultural land within the Project Property and repurpose it for the following dual industrial and agricultural uses, which will supersede and replace the current cultivation of existing sugarcane and rotational crops on the Project Property. The new industrial use to be introduced at the Project Property is the operation of a solar PV power plant and associated energy storage and management systems. The new agricultural use to be introduced at the Project Property is the operation of a commercial Blackbelly sheep farm. Other existing surrounding land uses that could be affected by the Project include residential and commercial developments as well as tourism/recreation and historical/cultural facilities (e.g., Bushy Park Raceway, Sunbury Greathouse, and Bushy Park Cemetery).
Social VCs	
Health and Safety	The development of the site and the operation of the Project could directly or indirectly affect human health.
Human Capital	Construction and operation of the facility can provide opportunities for human capital development.
Economy	The Project may provide new economic and employment opportunities.
Cultural Values	The Project will alter the aesthetic of the area.
Infrastructure and Services	The Project could affect the integrity, quality or capacity of local infrastructure and services.
Social Dynamics	In-migration of temporary workers could affect social networks and dynamics in nearby communities.

6.3 ASSESSMENT BOUNDARIES

Spatial boundaries set the geographic areas over which the assessment will be conducted. Temporal boundaries set the timeframe to be considered. These boundaries provide a meaningful and manageable focus for the assessment, as they define the areas within which and the periods during which the VCs are likely to interact with or be influenced by the Project.

6.3.1 Spatial Boundaries

Spatial boundaries for the assessment have been selected based on the geographic extent over which Project activities and their effects are likely to occur, as well as other ecological, technical, and social considerations. The following three geographic areas are defined for VC assessment purposes:

- The **Project Development Area (PDA)** encompasses the immediate area in which Project components and activities will occur and is the anticipated area of direct physical disturbance associated with the construction, operation and maintenance, and decommissioning of the Project (i.e., the Project footprint). For the purposes of this ESIA, the boundaries of the Project Property also constitute – and are identical to – the boundaries of the PDA.

- The **Area of Influence (AOI)** encompasses the area in which Project-related impacts (direct or indirect) will be experienced and can be predicted or measured with a level of confidence that allows for assessment, and in which there is a reasonable expectation that those potential impacts may be a concern. It is also the area in which potential cumulative impacts may occur. The AOI for the ESIA is limited to a 1-km buffer centered on the PDA.
- The **Regional Study Area (RSA)** is a broader area used to describe existing (baseline) conditions and to provide context for the assessment of potential impacts. The RSA encompasses both the PDA and the AOI, as well as the surrounding Parish of Saint Philip, Barbados.

6.3.2 Temporal Boundaries

Temporal boundaries for the assessment address the potential effects during the Project's construction, operation and maintenance, and decommissioning phases over relevant timescales. These temporal boundaries are used in the assessment of residual impacts and are also considered applicable for the assessment of cumulative impacts. The overall Project schedule is presented in Section 3.4. The temporal boundaries for the assessment consist of the Project phases indicated in Table 6.3.

Table 6.3 Temporal Boundaries for the Assessment

Project Phase	Anticipated Timing (Approximate)	Anticipated Duration (Approximate)
Construction	June 2023 to June 2025	24 months
Operation and Maintenance	July 2025 to July 2050, with the possibility of extension	25+ years
Decommissioning	Following the conclusion of Project operations	12 months

6.4 OVERVIEW OF IMPACT ASSESSMENT APPROACH

The impact assessment approach for this ESIA incorporates the following main steps:

- Identify key Project components and activities (Chapter 3) and define the scope of the Project to be assessed (Section 6.1).
- Identify VCs that have potential to be impacted by the Project and that are of value or interest because they have been identified to be of concern by regulatory agencies, the Proponent, resource managers, scientists, key stakeholders, and/or the general public (Section 6.2).
- Define the spatial and temporal boundaries of the assessment (Section 6.3).
- Describe the existing conditions of the biophysical/ecological environment, anthropogenic environment, and social environment within the spatial boundaries of the assessment (Chapter 7 and Section 9.1).
- Describe and evaluate potential Project-related changes to the biophysical/ecological, anthropogenic, and/or social environment (as applicable) and the likely impacts on the identified VCs (Section 8.2.1 to Section 8.6.1 and Section 9.2).
- Identify measures to mitigate potential adverse environmental and social impacts on the identified VCs (Section 8.2.2 to Section 8.6.2 and Section 9.2.3).

- Characterize the residual environmental and social impacts of the Project (i.e., the Project-related impacts that are anticipated to remain following the implementation of mitigation measures) in consideration of the residual impact characterization criteria that are defined for the EIA in Section 8.1.2.3 (Section 8.2.3 to Section 8.6.3) and the evaluation criteria that are defined for the SIA in Section 9.2 (Section 9.2.1 and Section 9.2.2).
- Determine whether the residual environmental and social impacts are predicted to be significant or not significant, in consideration of the VC-specific significance criteria that are defined for the EIA in Section 8.1.2.4 (Section 8.2.4 to Section 8.6.4) and the general significance criteria that are defined for the SIA in Section 9.2 (Section 9.2.1 and Section 9.2.2).
- Summarize the results of the impact assessment (Section 8.2.4 to Section 8.6.4 of the EIA, Section 9.2.1 and Section 9.2.2 of the SIA, and Chapter 12).
- Identify deficiencies and challenges related to the assessment, where applicable (Section 8.2.5 to Section 8.6.5 and Section 9.2).
- Develop follow-up and monitoring programs to verify both the accuracy of the impact assessment and the effectiveness of mitigation measures (Section 8.2.6 to Section 8.6.6 and Chapter 11).
- Assess the potential environmental and social impacts that could be associated with the Project in the event of an accident, malfunction, emergency, or disaster (Section 8.7 and Section 9.2).
- Assess the Project's contribution to potential cumulative impacts on the identified VCs, if applicable (i.e., if there is potential for the residual impacts of the Project to overlap spatially and temporally with, and to therefore interact cumulatively with, the residual impacts of other projects or activities) (Chapter 10).

7.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

7.1 BIOPHYSICAL AND ECOLOGICAL ENVIRONMENT

7.1.1 Climatic Conditions

The following overview of climatic conditions in Barbados is based on climatological data for the period of 1991–2020, which was collected at the Grantley Adams International Airport, in Seawell, Christ Church, Barbados, and reported by Barbados Meteorological Services (2021):

- There is little variation in diurnal or seasonal temperatures. The temperature is moderate with monthly mean temperatures ranging from 25.9 to 27.9°C. The monthly minimum and maximum mean temperatures range from 23 to 31 °C. There is day to night variations of approximately 8°C.
- The climate is humid with a mean monthly relative humidity ranging from 75 to 82%. There are few cloudy days. Monthly mean sunshine ranges from 7.5 to 8.8 hours/day.
- The northeast trade winds are persistent over much of the year. Mean wind speed is 4.6 to 7.2 m/s, creating a gentle to moderate breeze; maximum monthly wind speeds ranges from 11.3 to 13.4 m/s. Winds usually increase in velocity during the dry season and have a desiccating effect. Many parts of the windward coast are severely affected by salt spray carried on the wind.

- Rainfall varies throughout the island due to elevations, ranging from >2,000 mm per year in the central highland regions, to 1,100–1,250 mm/year along the coastlines (Rouse 1962, in Humphrey 1997). Barbados has a wet and a dry season with monthly mean rainfall ranging from 38.9 mm (March) to 179.6 mm (October); maximum monthly rainfall ranges from 87.2 mm (March) to 513.9 mm (November). The amount and distribution of rainfall is the major climatic factor limiting crop growth and there is considerable variation in rainfall from year to year. Generally, the dry season extends from January to May and the wet season from June to December, but the inception of seasons is not the same every year and "transitional" months occur. The amount of rainfall for the island is also influenced by El Niño Southern Oscillation (ENSO) trends. ENSO is the interaction between the ocean and atmosphere in the equatorial pacific which results in periodic departures from the expected sea surface temperatures. Barbados experiences both phases: La Niña, the cold phase of sea surface temperatures which results in higher rainfall and El Niño, the warm phase which results in lower rainfall.

7.1.2 Acoustic Environment

A baseline noise assessment was completed to measure noise levels originating from current site conditions in the vicinity of the PDA. The complete Baseline Noise Assessment report, including detailed methods and results, is provided in Appendix E (i.e., is appended to the Acoustic Assessment therein).

Baseline noise measurements were recorded at seven points (i.e., monitoring stations) over three separate weekdays between the hours of 7:00 AM and 5:00 PM (Table 7.1). Six of the seven monitoring stations were situated along the PDA boundary – to the north, west, and south of the PDA – and one monitoring station was situated more centrally within the PDA (Figure 7.1). Each station was monitored for one hour during the morning period and for one hour during the afternoon period. The monitoring stations were selected based on proximity to the PDA as well as the potential impact that receptors at those locations may experience.

Table 7.1 Baseline Noise Monitoring Stations and Sampling Schedule

Monitoring Station	Description	Remarks	Sampling Date and Time
M1	Open agricultural field within the PDA	The approximate location proposed for much of the power production infrastructure for the Project (i.e., the HyPCe area)	• September 1, 2021 (7:17 to 8:17) • September 2, 2021 (12:05 to 13:05)
M2	Private residence	Located on the southeastern border of the PDA, adjacent to two houses	• September 1, 2021 (10:52 to 11:52) • September 2, 2021 (15:35 to 16:35)
M3	Residential community	Located on the southern border of the PDA, adjacent to a residential community	• September 1, 2021 (8:29 to 9:29) • September 2, 2021 (13:13 to 14:13)
M4	Residential community	Located on the southwestern border of the PDA, adjacent to a residential community	• September 1, 2021 (9:41 to 10:41) • September 2, 2021 (13:27 to 14:27)

Table 7.1 Baseline Noise Monitoring Stations and Sampling Schedule

Monitoring Station	Description	Remarks	Sampling Date and Time
M5	Private business, residence	Located 400 m to the west of the PDA, adjacent to a veterinary clinic and private residence	• August 31, 2021 (11:07 to 12:07) • September 1, 2021 (14:44 to 15:44)
M6	Private residence	Located on the northern border of the PDA, adjacent to two private residences	• August 31, 2021 (8:53 to 9:53) • September 1, 2021 (13:36 to 14:36)
M7	Residential community	Located on the northeastern border of the PDA, adjacent to a major road and a residential community	• August 31, 2021 (7:45 to 8:45) • September 1, 2021 (12:29 to 13:29)

Figure 7.1 Locations of Baseline Noise Monitoring Stations

Baseline noise monitoring results were compared against the World Health Organization (WHO) *Guidelines for Community Noise* (WHO Guidelines; WHO 1999). The WHO Guidelines are summarized in Section 2.1.6 of the Baseline Noise Assessment, which is appended to the Acoustic Assessment in Appendix E. Existing ambient noise levels at five of the seven monitoring stations were found to be below the WHO Guideline threshold for outdoor residential areas. The only exceptions occurred at monitoring stations M5 and M7, both of which exhibited ambient sound levels that slightly exceeded WHO Guidelines. Maximum noise levels (i.e., during sporadic and momentary instances of increased sound pressure levels [SPLs]) at all seven monitoring stations were consistently above WHO Guidelines. Table 7.2 presents an overview of the baseline noise monitoring results. Detailed results are included in the Baseline Noise Assessment (Appendix E).

Generally, noise sources observed at each monitoring station were limited to the wind interacting with vegetation and various noises originating from nearby communities (e.g., power tools, animals, and vehicles). Much of the PDA and surrounding area consists of open agricultural fields with nothing to obstruct wind flow, and a strong, steady breeze persisted throughout the collection of baseline noise measurements. The two monitoring stations with the lowest recorded ambient sound levels – M2 and M6 – were the two stations located the furthest away from a major residential community or public road.

Table 7.2 Overview of Baseline Noise Monitoring Results

Monitoring Station	Results	Analysis
M1	• The average ambient equivalent continuous SPL value (L_{eq}) over the two hours of monitoring was 46.3 A-weighted decibels (dBA). • The average maximum SPL value (L_{max}) (i.e., the highest sound level measured during a single noise event) was 68.2 dBA. • The highest peak SPL value (L_{peak}) (i.e., the absolute highest sound pressure of the noise signal of either the positive or negative part of the sound wave) was 98.1 dBA. • The average time-weighted average (TWA) SPL value was 37.4 dBA. • SPLs exceeded 48.3 dBA 10% of the time and 46 dBA 90% of the time.	• Monitoring station M1 was located in the center of the open field slated for Project development. There was very little ambient noise other than the wind through the grass. On one occasion, a truck transporting field workers passed within 5 m of the sound meter, resulting in the 98.1 dBA peak value recorded. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.
M2	• The average ambient L_{eq} SPL value over the two hours of monitoring was 46 dBA. • The average L_{max} SPL value was 63.3 dBA. • The highest L_{peak} SPL value was 88.0 dBA. • The average TWA SPL value was 36.9 dBA. • SPLs exceeded 47.5 dBA 10% of the time and 46.3 dBA 90% of the time.	• Monitoring station M2 was located immediately south of the PDA, on the edge of an open field and adjacent to two private residences. The occasional dog bark and other noises were heard from the nearby residence. Cars could be heard in the distance driving along the main road to the Southeast. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.

Table 7.2 Overview of Baseline Noise Monitoring Results

Monitoring Station	Results	Analysis
M3	• The average ambient L_{eq} SPL level over the two hours of monitoring was 47.4 dBA. • The average L_{max} SPL value was 66.8 dBA. • The highest L_{peak} SPL value was 86.7 dBA. • The average TWA SPL value was 38.4 dBA. • Noise levels exceeded 49.4 dBA 10% of the time and 46.6 dBA 90% of the time.	• Monitoring station M3 was located immediately south of the PDA (east of monitoring station M2), on the edge of an open field and adjacent to a cane field and a private community. Occasional noise could be heard from the nearby residences. There was also noise resulting from the wind passing through the sugarcane. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.
M4	• The average ambient L_{eq} SPL over the two hours of monitoring was 49.7 dBA. • The average L_{max} value was 66.1 dBA. • The highest L_{peak} SPL value was 92.1 dBA. • The average TWA SPL value was 40.7 dBA. • SPLs exceeded 52.1 dBA 10% of the time and 47.7 dBA 90% of the time.	• Monitoring station M4 was located immediately southwest of the PDA, on the edge of an open field and adjacent to a residential community. Consistent noise could be heard from the community, including a powered garden tool, power tools, dog barks, and vehicles. The highest peak value of 92.1 dBA resulted from a loud vehicle exiting a nearby driveway. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.
M5	• The average ambient L_{eq} SPL over the two hours of monitoring was 53.2 dBA. • The average L_{max} SPL value was 70.2 dBA. • The highest L_{peak} SPL value was 88.9 dBA. • The average TWA SPL value was 44.1 dBA. • SPLs exceeded 56 dBA 10% of the time and 48.3 dBA 90% of the time.	• Monitoring station M5 was located immediately west of the PDA, on a cart road connected to Sunbury Road. Tall sugarcane flanks the cart road on either side. Most of the ambient noise could be attributed to cars constantly passing on the main road nearby and to the wind passing through the cane. • Ambient sound levels at this location exceeded the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.

Table 7.2 Overview of Baseline Noise Monitoring Results

Monitoring Station	Results	Analysis
M6	• The average ambient L_{eq} noise level over the two hours of monitoring was 45.9 dBA. • The average L_{max} value was 63.9 dBA. • The highest L_{peak} SPL value was 84 dBA. • The average TWA SPL value was 36.8 dBA. • SPLs exceeded 47.3 dBA 10% of the time and 46.1 dBA 90% of the time.	• Monitoring station M6 was located immediately north of the PDA, on the edge of an open field and adjacent to a residence. Thick vegetation sheltered the monitoring point to the east. Some noise could be attributed to wind passing through the vegetation. • Ambient sound levels at this location are below the WHO residential guidance threshold for outdoor living areas. • L_{max} values at this location exceeded the WHO residential guidance threshold.

7.1.3 Topography

The following information on the topography of the PDA was obtained by conducting field reconnaissance in support of a site-specific drainage assessment for the Project (Appendix B), as well as by reviewing 1:10,000 and 1:5,000 topographical mapping available from the Lands and Surveys Department of the Government of Barbados and a higher resolution topographical survey of the site made available by RSB:

- Along the northern boundary of the PDA, adjacent to the Old Train Line Road, ground elevations range from 52 m above mean sea level (AMSL) in the west to 56 m AMSL in the east.
- Along the southern boundary of the PDA, land elevations range from 46.0 m AMSL in the west to 43 m, 47.0 m, and 48 m AMSL going eastwards. Land elevations are in the region of 50 m AMSL at the eastern end of the southern PDA boundary.
- In between the northern and southern PDA boundaries, the land is relatively flat with site slopes from north to south in the region of 1.5%.
- There are several relatively small (compared to the overall PDA) natural depressions – possibly past collapsed caves. Natural drainage watercourses lead to these depressed areas.

7.1.4 Geology and Surficial Soils

Barbados is a coral-capped sea mount emerging from a broad and ill-defined submarine ridge which separates the ocean depths of the Tobago Trough to the west from the Atlantic depths to the east. Barbados owes its origin to geanticlinal folding beginning in the Late Cretaceous. Coral now covers approximately 85% of the island (Stantec 2013). Periodic erosion of the coral has created subterranean caves and holes in the subsurface. As a result, the island is pervasively karstified, as demonstrated by the occurrence of more than 100 caves, hundreds of gullies, and over 2,800 sinkholes (Kambesis and Machel 2013).

On the remainder of the Barbados cap, coral has been removed by erosion and the older sedimentary rocks of the sea mount outcrop at the surface. The oldest rocks of Barbados, the Scotland formations, are very thick sediments deposited into a rapidly and continuously subsiding geosynclinals foredeep. They frequently show evidence of large-scale slumping and sliding features. The Scotland formations are strongly folded, and the limbs of the folds are often overturned and thrusted.

The greater part of Barbados is characterized by kandoid clay and smectoid clay soils overlying coral limestone. Each group of soils consists of two associations with a gradual transition in properties between the two associations that is difficult to discern in the field. The PDA is located in the Coral Region of Barbados, which is characterised by shallow topsoil followed by limestone rock of significant depth. The surficial geology of the PDA predominantly consists of a Saint Philip Plain Association soil cover layer that is over 900 mm in thickness (Vernon and Carrol 1966). Southwestern sections of the PDA consist of a Grey-Brown Association soil that is less than 450 mm in thickness. A Coral Limestone rock layer that is approximately 30–55 m in depth underlies the site, with the deeper depths occurring towards the southern extent of the PDA. The limestone layer is underlain by the impermeable Oceanics layer, which is known to have a westerly dip towards the sea and to be several hundred metres in depth (Poole and Barker 1983). Figure 7.2 shows the locations of the different soil types within the PDA.

The Grey Brown Association soil layer is composed of approximately 65% clay, 10% sand, and 18% silt, with calcium carbonate and moisture accounting for the balance of the composition. The Saint Philip Plain Association generally resembles the Grey-Brown Association but has a different parent material. Both soil covers are slated to have slow to moderate permeability.

The limestone rock layer has a very high effective porosity. This porosity, coupled with the extensively cracked and fissured nature of the rock, makes it an extremely permeable stratum. The permeable coral limestone rock and impermeable Oceanics geological structure described above collectively form an unconfined aquifer through which groundwater flows.

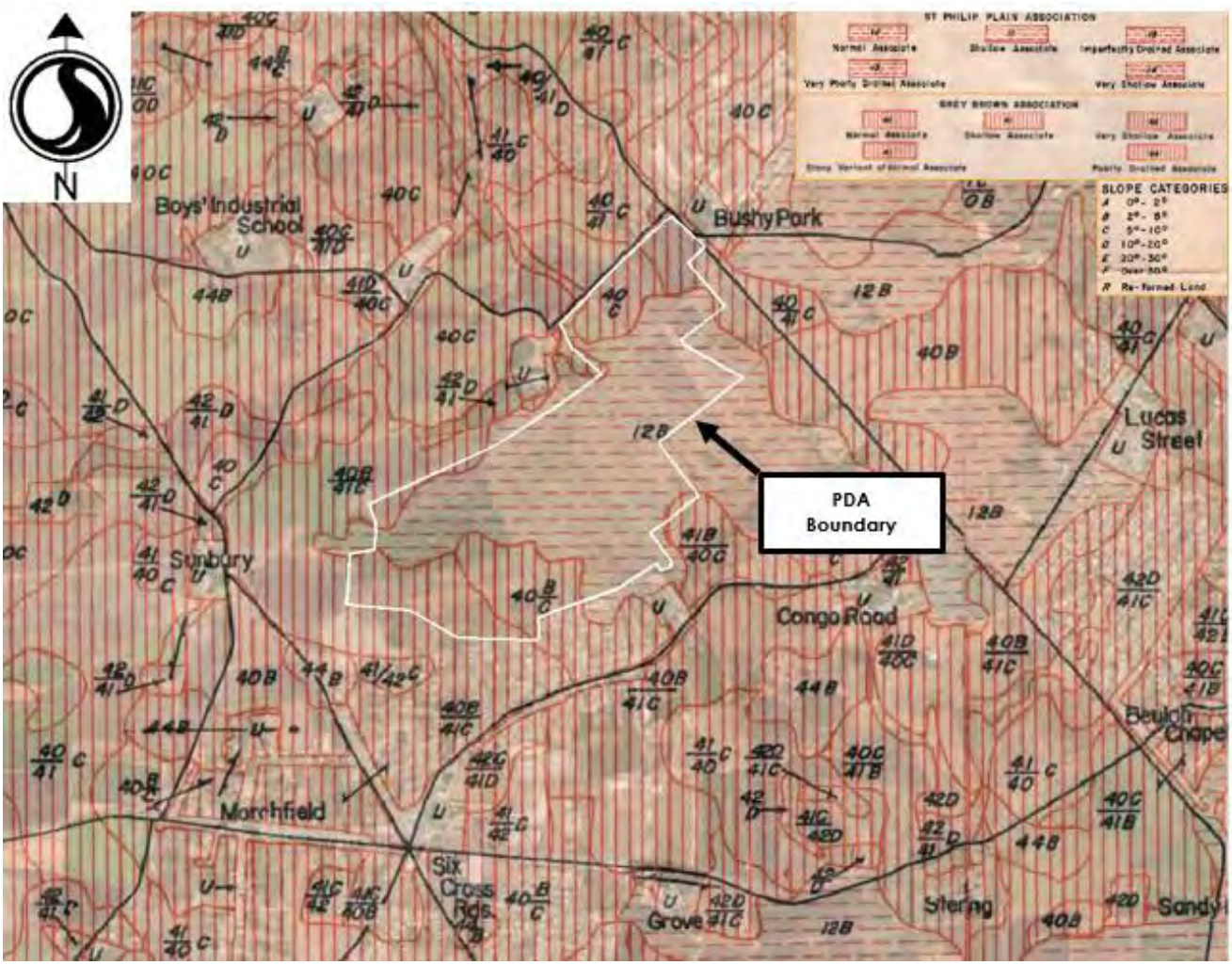


Figure 7.2 Project Development Area Overlaid on Soils Map (Vernon and Carrol 1966)

7.1.5 Surface Water and Drainage

The lands to the north of the PDA have higher elevations than lands within the PDA, while the lands to the south of the PDA have lower elevations than those within the PDA. The net result is that runoff from rainfall flows from lands to the north of the PDA (hereafter referred to as the “North Watershed”) onto lands within the PDA. This runoff combines with runoff generated from rainfall directly on the PDA, thereby resulting in cumulative runoff that discharges south of the PDA to the adjacent community and towards the town of Six Roads. Given the highly vegetated nature of both the North Watershed and the PDA catchment area (hereafter referred to as the “South Watershed”), considerable interception and depression storage are expected to occur, with infiltration and percolation of captured runoff to groundwater zones. The North Watershed and South Watershed are depicted on Figure 7.3, and the hydrological characteristics of each of these watersheds are presented in Table 7.3.

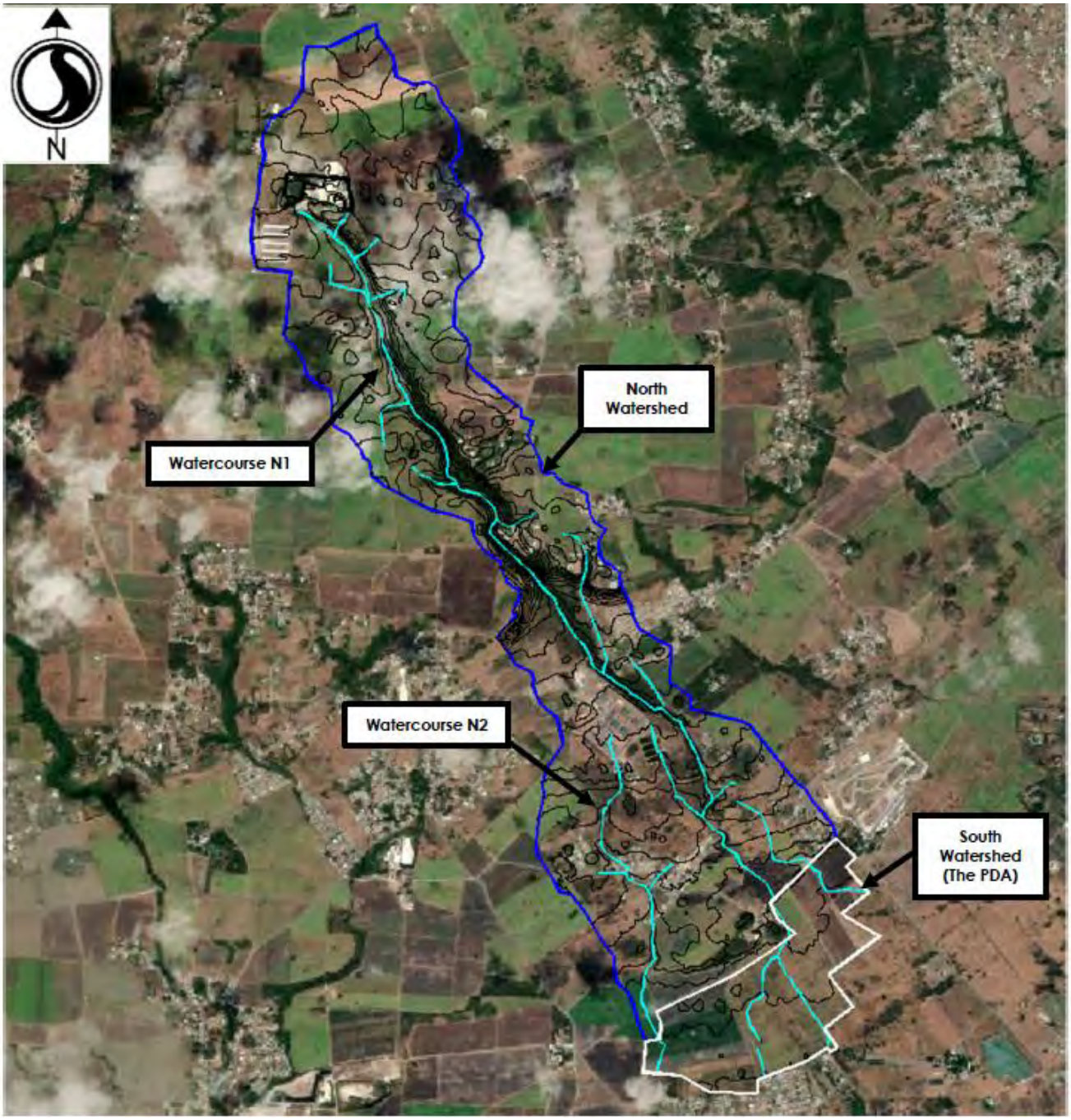


Figure 7.3 Watersheds and Prominent Watercourses in the Vicinity of the PDA

Table 7.3 Hydrological Characteristics of the North and South Watersheds

Description	Parameter	
	North Watershed	South Watershed
Watershed Area	474.22 ha	73.00 ha
Vegetation Area (grass)	457.62 ha	69.44 ha
Impermeable Area (e.g., roads, pavement, and buildings)	16.6 ha	3.64 ha
Longest drainage path	4.74 km	1.1 km
Average slope of longest watercourse	2.53%	1.37%
Average Annual Rainfall	1,300 mm	

7.1.5.1 Existing Conditions to the North of the PDA

The North Watershed resulting in runoff towards the PDA is quite large, extending from the northern boundary of the PDA in a northwesterly direction to the general vicinity of Guinea, Victoria, and Colleton plantations. The North Watershed contains several catchments and drainage watercourses that lead in some instances to natural depressions, which are commonplace throughout the watershed. These depressions help to promote depression storage and the percolation of captured water to groundwater zones attenuating or lessening the amount of runoff that is conveyed to the site. Based on the 1:10,000 topographical map of the area, the North Watershed has 29 infiltration wells (suckwells) within its boundary.

Though there are several sub-catchments with associated watercourses within the North Watershed, there are two prominent watercourses that traverse substantial distances within the watershed in northern to southern directions; the locations of these watercourses – referred to as “Watercourse N1” and “Watercourse N2” – are indicated in Figure 7.3. Both watercourses result in runoff entering the PDA.

The Old Train Line Road (i.e., an unpaved “cart” road) effectively represents the southern boundary of the North Watershed; this road generally slopes with reducing elevation in a westerly direction implying that any captured runoff could be conveyed in westerly directions away from the PDA. However, there are several points where sags in the road direct runoff captured from the North Watershed onto the PDA.

7.1.5.2 Existing Conditions Within the PDA

The PDA is relatively flat and totally vegetated, including with agricultural crops. In addition to runoff from the North Watershed, the PDA itself also forms a rainwater catchment (i.e., the South Watershed) onto which runoff is generated when rain falls. There are 23 infiltration wells within the PDA to augment surface water drainage.

Drainage of runoff from the PDA is predominantly via overland flows in a southward direction with infiltration and percolation of runoff to groundwater zones. The furrows and rows of cultivated lands aid in retarding runoff and promoting infiltration. The several infiltration wells on-site also promote the drainage of captured runoff to groundwater zones.

There are five well-defined drainage paths/watercourses (WCs) within the PDA, which are labelled as “WC-A”, “WC-B”, “WC-C”, “WC-D”, and “WC-E” on Figure 7.4 below. Four watercourses are connected to upstream watercourses within the North Watershed introduced above. WC-C originates within the PDA and possibly connects to WC-B during heavy rainfall events. WC-B, WC-D, and WC-E terminate within existing natural depressions within the PDA, while WC-A and WC-C extend past the southern PDA boundary. The existing watercourses that channel runoff to natural depressions promote the storage and percolation of runoff to groundwater zones; those watercourses that pass through the PDA convey captured runoff downstream of the site.

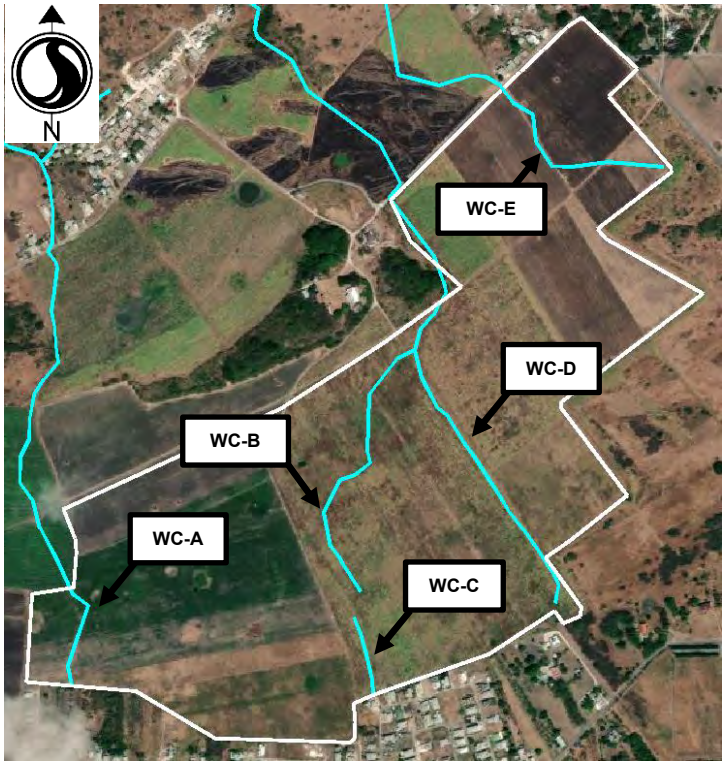


Figure 7.4 Existing Watercourse Flow Paths Within the PDA

During prolonged rainfall events, runoff enters the PDA from the North Watershed predominately following the natural watercourses within the watershed and those introduced above within the PDA. Rainfall onto the lands of the PDA also adds to the volume of runoff on-site. Some watercourses within the PDA direct runoff to natural depressions. The 23 infiltration wells/suckwells (i.e., artificial shafts excavated in soft carbonates to relieve surface flooding) within the PDA assist with draining surface runoff. When depressions are filled, runoff overflows the banks of the depressions and flows southwards predominantly via overland flow. As the PDA becomes flooded, the roadways/cart paths within the PDA become watercourses conveying runoff in southwards directions towards the PDA site boundary. Once the PDA is flooded and suckwells are at their drainage capacity, runoff effectively passes through the site to downstream areas.

7.1.5.3 Existing Conditions to the South of the PDA

South of the PDA are the densely populated residential/commercial areas of Farm Garden and Marchfield Village. An examination of contour information in that area – further confirmed by field reconnaissance carried out in support of a site-specific drainage assessment for the Project (Appendix D) – reveals that there is a drainage watercourse that follows a north to south roadway through the village and which further traverses in a southward direction through the Six Roads Industrial Park and the Six Roads town centre. There have been instances in the past where prolonged and intense rainfall has resulted in runoff from the North and South Watersheds flowing to the mentioned areas to the South of the PDA causing flooding. Several years ago, a cannery within the industrial park was completely flooded causing equipment damage during a prolonged rainfall event. Field reconnaissance of this area revealed the construction of culverts and several infiltration wells as means to improve drainage within this southern zone. Appendix D provides further information regarding the existing drainage systems to the south of the PDA, including photographs.

7.1.6 Groundwater Resources

The level of the surface of the Oceanics layer with respect to mean sea level (MSL) defines whether groundwater in the unconfined aquifer (refer to Section 7.1.3) exists as streamwater or as sheetwater. Oceanic levels below mean sea level (BMSL) indicate that groundwater may exist as sheetwater, whilst levels above MSL indicate the possible existence of streamwater. Streamwater, found in the higher land elevations of Barbados, is defined as groundwater flowing at the interface of coral rock and the Oceanic clay layer towards the sea, after having percolated through overlying coral rock and its fissures. Sheetwater, found at lower elevations, is a thin layered reservoir of freshwater resting above saline water, in the coral rock medium, at the interface with the sea level.

Based on the map series entitled *The Geology of Barbados* (Poole and Barker 1983), the elevation of the Oceanics layer beneath the site ranges from approximately 35 m AMSL in the northeast to -15 m AMSL in the south. Consequently, groundwater beneath the PDA exists predominantly as streamwater, with some sheetwater present in southern sections of the PDA. An examination of the Oceanic contours implies that groundwater flows are in a southerly direction.

To validate the interpolated limestone-oceanic contouring included in the mapping by Poole and Barker (1983), a review of nearby water wells surveyed by Alfred Senn was conducted. Senn's (1946) geological investigations of the groundwater resources of Barbados included physical surveys of water wells in the environs of the PDA. This historical well data confirms depths to Oceanics as previously described and indicates that the depth of groundwater within the PDA is likely approximately 1.8 m (Table 7.4).

Table 7.4 Results of Historical Well Survey Completed by Senn (1946) in the Vicinity of the PDA

Location (as shown on Figure 7.5)	Surface Elevation	Well Depth	Elevation of Base	Water Depth	Water Elevation	Approx. Interface Elevation	Aquifer Type
	(m AMSL)	(m)	(m AMSL)	(m)	(m AMSL)	(m AMSL)	
Sunbury	46.9	48.2	-1.2	1.2	0.0	< 0	*Sheetwater*
Harrow	**62.2**	**37.5**	**24.7**	**1.8**	**26.5**	**27**	**Streamwater**
Chapel	77.1	60.7	16.5	1.8	18.3	18	*Streamwater*
Marchfield	40.4	41.5	-1.1	1.1	0.0	< 0	*Sheetwater*
Summervale	102.4	68.9	33.5	0.6	34.1	34	*Streamwater*
Farm #1	43.6	41.8	1.8	0.0	–	–	–
Farm #2	37.2	34.1	3.1	0.0	–	–	–
Bushy Park	61.0	22.3	38.7	0.9	39.6	40	*Streamwater*
Fairfield	78.9	29.0	50.0	2.4	52.4	52	*Streamwater*
Source: Senn 1946.							

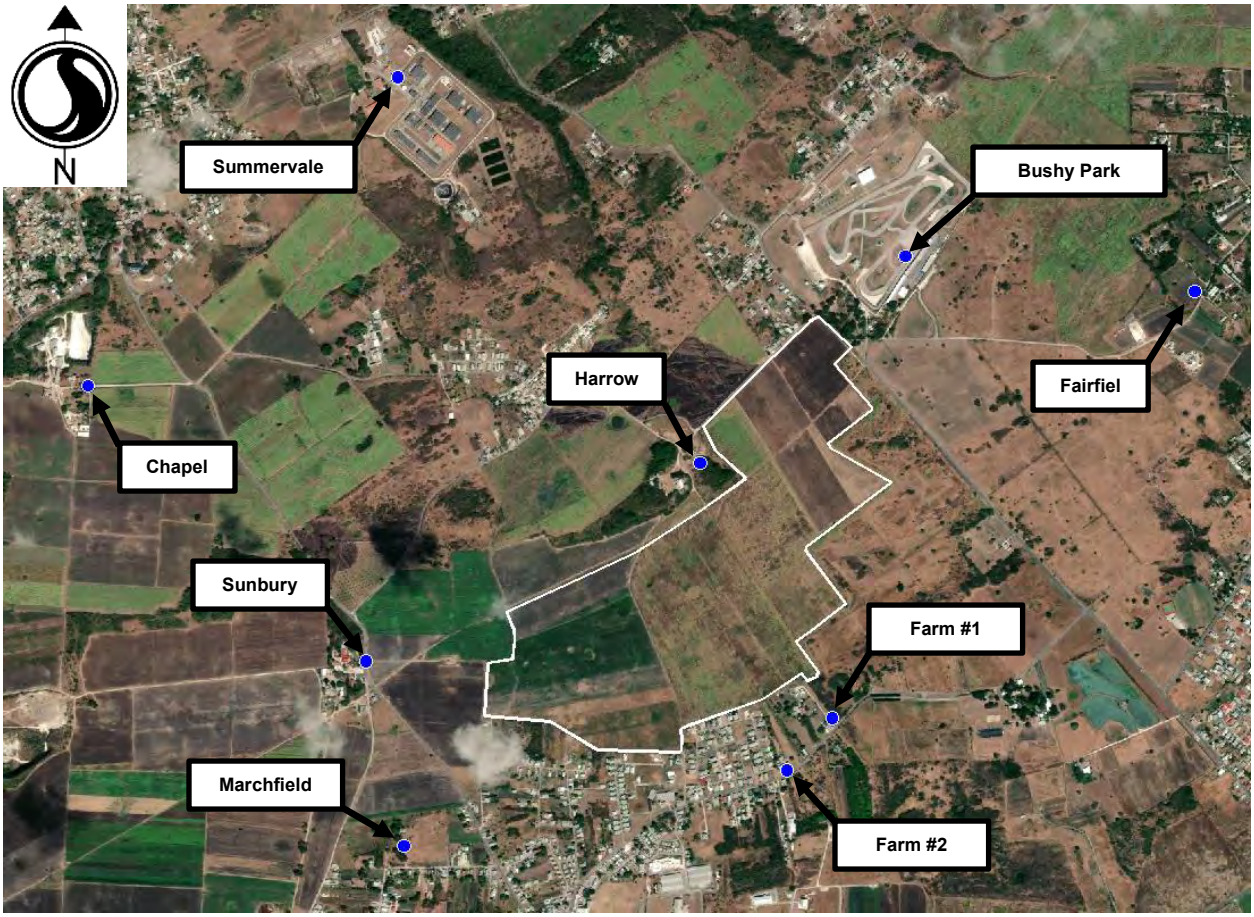


Figure 7.5 Locations of Wells Surveyed by Senn (1946)

7.1.7 Flora and Fauna

A baseline ecological assessment was completed to gather information on the availability and distribution of habitat for various species of flora and fauna, including for rare or protected species, in the vicinity of the PDA. Baseline information was collected through a field reconnaissance survey combined with a review of existing literature and databases related to rare species. The field survey, which was undertaken in mid-September 2021, consisted of walking along a series of transect lines within the PDA and recording observations (e.g., flora, evidence of fauna, landscape features). Forested areas adjacent to the PDA and dark spots (i.e., potential waterbodies) were identified via Google Earth and surveyed, where accessible. The roads/tracks used to access the Project Property and the residential area to the south of the PDA were also travelled/surveyed. Figure 7.6 shows the transects and adjacent habitats that were surveyed in mid-September 2021.

Transect lines where similar habitat features were observed were grouped together, resulting in three main habitat types within the PDA: cleared agricultural land, grassy areas, and sugarcane fields. The species of flora found in the PDA are common in Barbados and are not considered rare or endangered. The fauna recorded in the PDA and surrounding area included secure species of mammals, birds, and arthropods that are not considered rare or endangered. The diversity of species encountered during the survey was limited, which was expected given that the surveyed area primarily consists of agricultural land.

The complete Baseline Ecological Assessment report, including detailed methods and results, is provided in Appendix F. Appendix F also includes photographs of representative habitat types, wildlife and evidence of wildlife (e.g., paw prints and burrows), and potential habitat features (e.g., settled water and forested areas) encountered during the survey. The subsections below summarize the main findings of the Ecological Baseline Assessment.

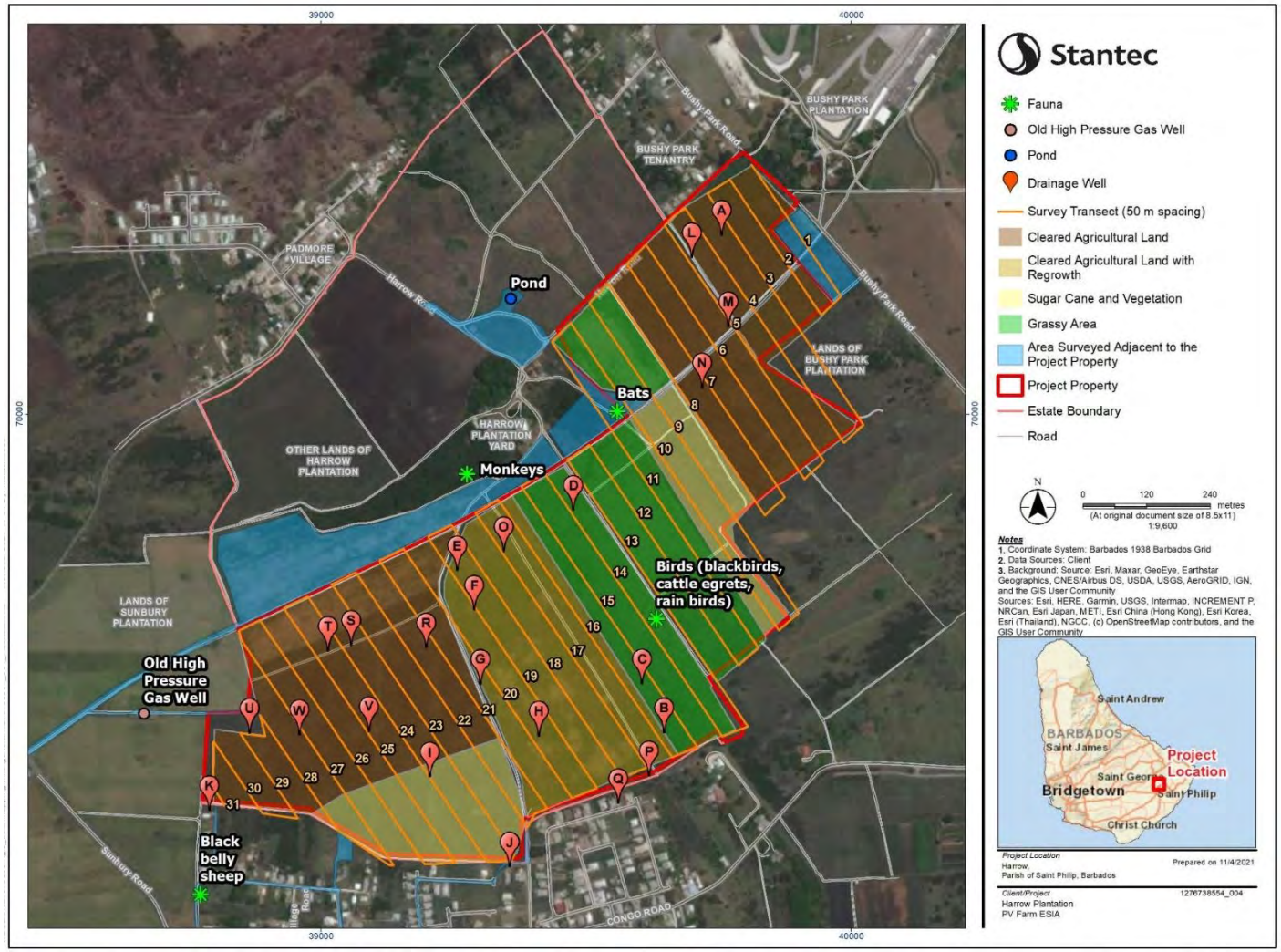


Figure 7.6 Transects and Adjacent Habitats Surveyed in Support of the Ecological Baseline Assessment, Observations Recorded, and General Layout of Habitats in the PDA

7.1.7.1 Habitat Types

The PDA generally consists of areas of cleared agricultural land, grassy areas, and sugarcane fields. Throughout the PDA, there was little wildlife beyond a few species of birds which were seen more frequently and more abundantly in areas with greater vegetation. Another notable feature was the number of wells found. In general, habitat features were common among groups of transects.

Transect lines 1 to 8 was cleared agricultural land with very little habitat change noted (Figure 7.6). This area was divided by paths/tracks and showed little signs of wildlife. There were ant nests scattered throughout this section and occasionally wood doves (*Zenaida aurita*) and blackbirds (*Quiscalus lugubris*) were seen. The vine known locally as wild cucumber (*Cucumis melo var. dudaim (L.) Naudin*) was found sporadically in this area. Four drainage wells were observed (Figure 7.6).

The upper area of transect lines 8 to 11 was a grassy area (Figure 7.6) with ant nests scattered throughout. An isolated rain tree (*Albizia sp.*) exists near the center of the area and three coconut trees (*Cocos nucifera*) border the northern property boundary by the roadside. Between transect lines 10 and 11, a small ditch was observed outside of the Project Property boundary. The ditch, overgrown with vegetation, appears to follow the outline of the Project boundary in that area. South of the main track that runs perpendicular to transect lines 8 to 11 is one of two cane fields found on the property (Figure 7.6).

Transect lines 10 to 15 were on land that was mostly grassy (Figure 7.6), with grass and elephant grass (*Pennisetum purpureum*) growing freely. Birds were seen more frequently and in bigger groups in this section. Toward the end of transect line 7, there was settled water where water beetles, dragon flies, flies, and an unidentified paw print (possibly canine) were found. Three drainage wells were identified (Figure 7.6).

The flora in the PDA consisted mostly of grass and shrub regrowth after the land had been left unattended, and there were sugarcane (*Saccharum officinarum*) rows in some areas. The “forested” areas identified on the outside of the PDA were mostly observed to consist of river tamarind trees (*Leucaena leucocephala*) and rain trees. There was limited wildlife and evidence of wildlife found in the area. Most of the animals seen were birds.

Flora

There are roughly 700 species of flowering plants found in Barbados, two which are endemic to the island, a gully shrub *(Phyllanthus andersonii)* and slender climber (*Metastelma barbadense*). These endemic species are neither rare or endangered and are found in wooded areas (Government of Barbados 2021b), making it unlikely they would be found on the predominantly agricultural lands of the PDA.

Twenty-three species plants on the island have been identified as needing protection, fifteen of which are found in one location, Turner’s Hall Woods (S. Carrington, personal communication, 2020) in northern Barbados, with eight of them being considered rare or endangered. These species were not observed on the Project Property and are not likely to be in the vicinity as they are found mostly in moist more sheltered regions.

The cleared agricultural land mostly consisted of plants, such as grasses, vines, and the occasional tree. The vine known locally as wild cucumber could be found sporadically throughout the cleared land and along the edges of the PDA. Grasses could also be found along the paths/tracks cut through the cleared agricultural land. A lightning rod plant (*Leonotis nepetifolia*) was found along one of these paths. Elephant grass was found on the southern borders of the transect lines 1 to 9. Amongst them were castor oil plants (*Ricinus communis*). Sugarcane also occurs on the lands of the PDA. Shrubby false buttonweed (*Spermacoce verticillata*) and cupid's shaving brush (*Emilia fosbergii*) were found in the area of cleared agricultural land with more substantial regrowth.

Butterfly pea vines (*Clitoria ternatea*) and other vines from the sweet potato family (e.g., *Merremia dissecta (Jacquin) Hallier f.*) were found in the bushy areas outside of the PDA. The areas that could be identified as possibly forested from satellite images were predominantly rain trees and river tamarind trees. On the ground around them were coarse grass and plants from the daisy family, which are normally considered weeds.

Other flora encountered during the field survey included clammy cherry tree (*Cordia obliqua*), khus khus grass (*Chrysopogon zizanioides*), and *tridax procumbens*. None of the flora recorded during the field reconnaissance survey are considered rare or endangered, and the habitats in the area are considered unlikely to support such species.

7.1.7.2 Fauna

The mammalian fauna of Barbados is dominated by introduced species including rats, green monkeys, and mongooses. Barbados has only six extant indigenous mammals, which are all species of bats. None of the mammals found in Barbados are considered rare or endangered and the population of all six bat species are "in good condition" (Genoways et al. 2012).

The only mammals observed within the PDA were bats, which were observed flying overhead around the trees found north of transect line 10 in the evening; however, the species could not be identified. In the residential area to the south of the PDA, three Blackbelly sheep (*Ovies aries*) were observed grazing and green monkeys (*Chlorocebus sabaeus*) were heard in the forested areas north of transect lines 14 to 17. The introduced green monkey is known to be adaptable and thrives in the human-disturbed environments of Barbados (Government of Barbados 2002) and are considered an agricultural pest (Government of Barbados 2021b). In addition, a paw print was found in an area of settled water located at southern end of transect lines 6 and 7.

The island's bird fauna is much more diverse compared to the mammalian fauna. Much of this diversity is a result of migratory species travelling to South America towards the end of the year. These birds are attracted to swamp areas in Barbados, such Graeme Hall swamp, Chancery Lane swamp, Green Pond, and Long Pond. There is an Important Bird Area (IBA) (i.e., IBA #BB006 – St. Philip Shooting Swamps) located approximately 1.2 km to the south of the PDA. The IBA aims to attract the neotropical migratory species that head south between the months of July and October. It also provides a habitat for other wetland birds, including populations of three (of the four) Lesser Antilles Endemic Bird Area (EBA) restricted-range birds (Burke 2008). Due to the proximity of one IBA and ponds in the area, there is potential to see more species of birds in the vicinity of the PDA, including restricted-range birds. However,

these restricted-range species would be expected to preferentially use wetlands/swamps rather than agricultural habitats and are therefore unlikely to use the Project Property.

They are approximately 36 resident species of birds nesting on the island, the majority of which have adapted well to human-altered habitats and are considered common. Birds made up a large proportion of the fauna observed within the PDA. Rain bird (*Tyrannus dominicensis*), blackbirds, and cattle egrets (*Bubulcus ibis*) were observed primarily in the parts of the PDA with higher vegetation, such as the grassy areas between transect lines 10 to 15 (Figure 7.6). A green heron (*Butorides virescens*) was observed standing in settled water which collected in a tractor tire mark left on the ground just south of the Project Property border between transect lines 9 and 10. In addition, a group of approximately six grassland yellow finches *(Sicalis luteola*) was observed west of the PDA in mostly cleared agricultural land with a green patch of grass in the center. A hummingbird (*Orthorhyncus cristatus*) was also observed at the flowers of a rain tree at the top of transect line 13. None of the birds observed during the field survey are considered rare or at risk, however they are all protected under the *Wild Birds Protection Act*.

The terrestrial reptile population of Barbados is comprised of snakes, lizards, and tortoise species. In 2011, the gecko, which was previously considered extinct, was found on Barbados' Culpepper Island. Colonies of geckos were found in the Parish of Saint Philip in 2013 (CBD 2019). However, no geckos or other reptiles were observed during the field survey.

Approximately 1,300 species of insects and allied arthropods have been recorded in Barbados, the most common being odonates (dragonflies), hemipterans (bugs), coleopterans (beetles), and dipterans (flies) (Government of Barbados 2021b). Arthropods, such as arachnids, myriapods, and insects, were found within the PDA and the adjacent forested areas. Ants were the most abundant type of insect observed during field reconnaissance, with numerous nests found throughout the surveyed area. Millipedes were also observed above-ground around the PDA, and a centipede was found under a rock. Small spiderwebs were documented in areas with elephant grass, and the silver argiope spider (*Argiope argentata*) was found outside of the PDA in bushy areas among the river tamarind and rain trees. In addition, numerous insects, such as flies, dragonflies, butterflies, water beetles, grasshoppers, and mosquitoes were found within the PDA, mostly close to settled water or bushy areas. A termite nest was found among fallen cane and black worms were also found in the same area of the PDA. Honeybee (*Apis mellifera*) was also recorded during the field survey. All of the insects and allied arthropods encountered during the field survey are common in Barbados.

Giant African snail (*Lissachatina fulica*), which is an invasive species that was formally recognized in Barbados in 2002 (Paliwal et al. 2011), was also recorded during the field survey.

7.2 ANTHROPOGENIC ENVIRONMENT

7.2.1 Land Use

The PDA is located at Harrow Plantation, Saint Philip, in an area that has traditionally been rural in character and dominated by agricultural land use. Harrow Plantation is bounded by Padmore Village to the north, Bushy Park Tenantry and Bushy Park Road (Highway M) to the east, the agricultural lands of Bushy Park Plantation and the Six Cross Roads settlement to the south, and the lands of Sunbury Plantation to the west (Figure 7.7).

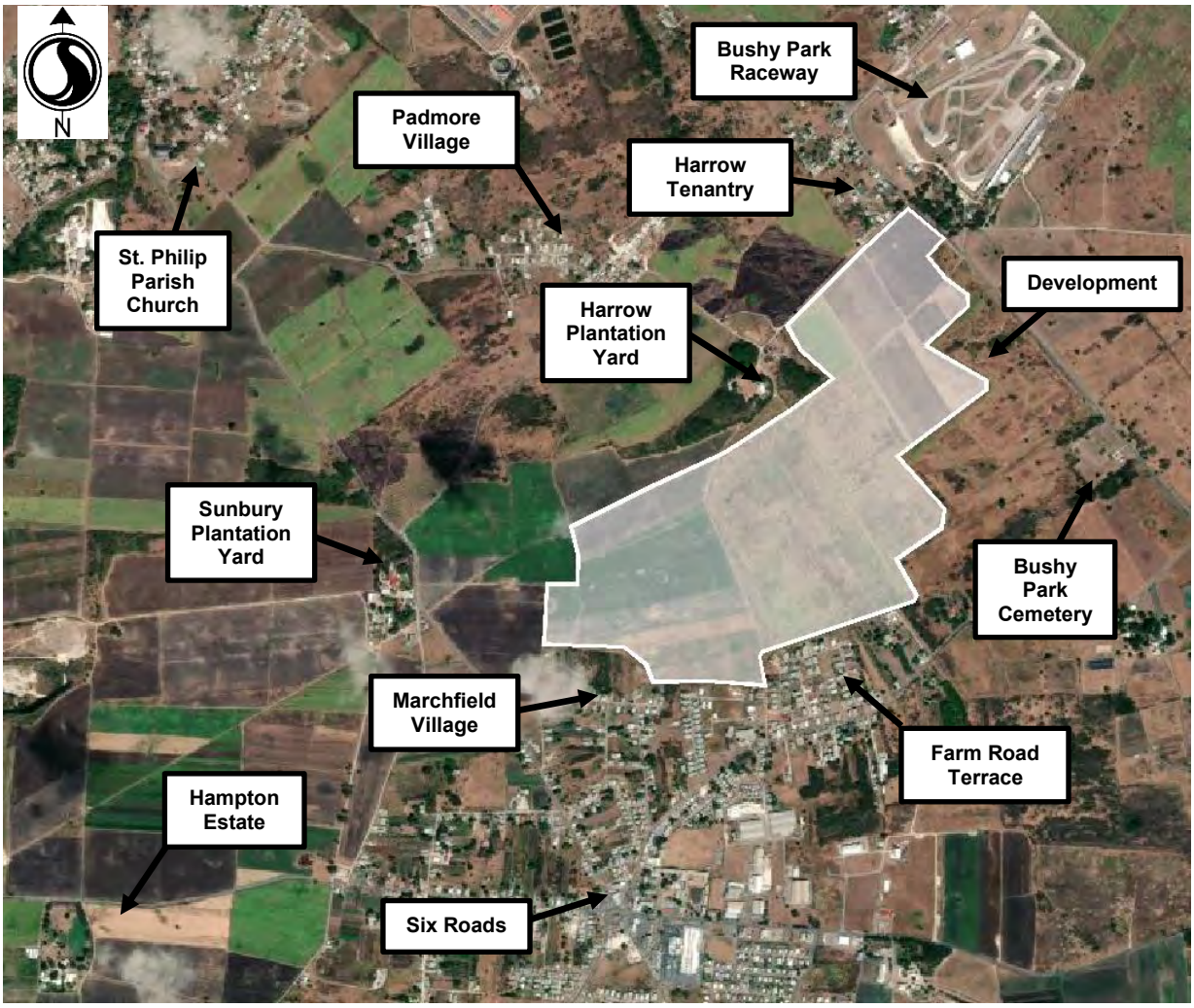


Figure 7.7 Land Uses Surrounding the PDA

The PDA itself is situated on agricultural land that is currently used for sugarcane farming augmented by rotational crops (e.g., cotton), with the immediate and expanded surroundings predominantly consisting of residential and agricultural land. Residential communities exist adjacent to the northern and southern PDA boundaries. Harrow Plantation Yard is located immediately adjacent and north of the portion of the

PDA in which the solar PV power plant is proposed to be located (i.e., west of the proposed sheep grazing area). A small community is located adjacent and north of the sheep grazing area, and a larger community – Marchfield Village – is situated along much of the southern PDA boundary (Figure 7.7). A veterinary clinic is located at Sunbury Plantation, approximately 400 m west of the PDA. Bushy Park Raceway is located approximately 250 m northeast of the PDA, and Bush Park Cemetery is located approximately 300 m to the southeast of the PDA (Figure 7.7).

The following description of existing agricultural land use within the PDA is based on information on baseline conditions that was collected in support of a Project-specific Agricultural Impact Assessment (Appendix C).

Harrow Plantation has an area of approximately 123.0 ha, with most of the productive lands having been traditionally in sugarcane. Agricultural production at Harrow Plantation is managed and operated by the Barbados Agricultural Management Company (BAMC). There are currently approximately 102.2 ha in arable production, of which the PDA will occupy approximately 73.2 ha.

Harrow Plantation falls within Agro-ecological Group C. Agro-ecological Group is defined by soil type, land capability (i.e., slope, fertility, drainage), and effective rainfall (i.e., annual total and distribution within the growing season that meets the need for a specific crop during its growth cycle). Group C is regarded as a less productive zone because of the above factors, with effective rainfall ranked highest as the most binding constraint to crop development within the area.

Traditionally, mono-cropping of sugarcane with rotation of secondary crops has been the production pattern at Harrow Plantation. At present, sugarcane accounts for approximately 78.4 ha under various rotations, with approximately 7.1 ha of cotton grown as a rotation enterprise, while approximately 36.1 ha are fallowed/rested.

The irrigation well at Harrow Plantation requires extensive refurbishment and this can facilitate year-round growth of cash crops once it is renovated.

Within the recent past, farms managed by the BAMC have underperformed given cash-flow constraints of the parent company. Actual productivity indicators suggest underperformance within crop production at Harrow Plantation.

Given good management practices (e.g., effective weed control, high plant population, varieties suitable for the area) within the present crops, an estimate of potential output can be made for the area. Table 7.5 below shows BAMC’s estimated output to be harvested at Harrow Plantation for the 2022 harvest. The productivity indicator ranges between 25–30 imperial tons per acre (i.e., approximately 56–67 metric tonnes of cane per hectare) for the farm using the methodology for establishing productivity potential for sugarcane in Barbados performance index developed by Thelma McCatty and Ranjit Singh (Barbados Cane Industry Corporation). Given the low rainfall of approximately 74.3 cm in 2020, the achievement of output of 22 imperial tons per acre (i.e., approximately 49 metric tonnes per hectare) during the 2022 harvest within the conventional plant cane (CPC) would indicate that other factors described under good management practices above are critically important to raising field productivity on a per hectare basis.

Table 7.5 Estimated Output at Harvest 2022

Sub Farm Unit	Harrow Plantation					
	Imperial Units of Measurement			Metric Units of Measurement*		
	Acres	Tons/Acre	Total Tons	Hectares	Tonnes / Hectare	Total Tonnes
Sugarcane Production						
CPC 2020/22	77.00	22.00	1,694.00	31.16	49.31	1,536.50
HWT CPC 2020/22	9.00	20.00	180.00	3.64	44.83	163.18
HWT 2020/22 R1	2.5			1.01		
HWT 2019/21 R2						
Force Back						
Ratoon 1	15.75	18.00	283.50	6.37	40.35	257.03
Ratoon 2						
Ratoon 3						
Ratoon 4						
Ratoon 5						
Sub Total	**104.25**		**2,157.50**			
TOTAL			**2,157.50**			**1,956.71**

Note:

* Original data was provided using imperial units of measurement (refer to the Agricultural Impact Assessment in Appendix C). Approximate conversions to metric units of measurement were calculated using the online Google Unit Converter.

7.2.2 Visual Environment

A Project-specific Visual Impact Assessment (VIA) was conducted by way of field reconnaissance to select vantage points to assess the future visibility of the solar PV power plant when constructed. Photographs from vantage points of concern were taken as part of the VIA. The vantage points of concern (i.e., the locations around PDA where photographs were taken for the VIA) are shown on Figure 7.8, and the photographs that were taken at each of these vantage points are provided in Appendix G. The results of the VIA are described below.

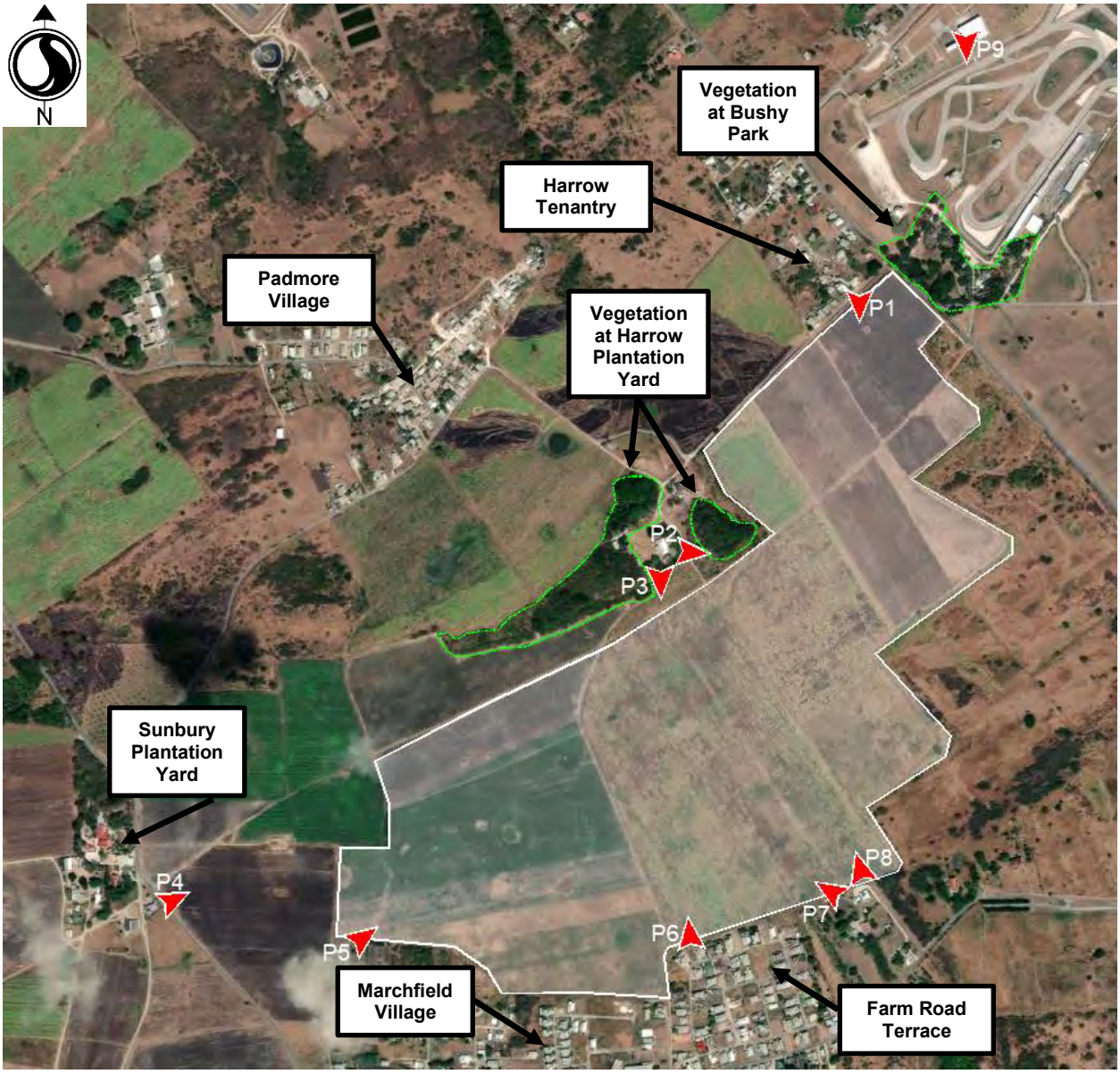


Figure 7.8 Locations Around PDA Where Photographs Were Taken for Visual Impact Assessment

The PDA is currently used for agricultural operations. The majority of the PDA consists of open land; however, portions of the PDA are currently used for sugarcane and other crop cultivation. The PDA slopes gently in a southern direction, with minor undulations throughout. Consequently, observers along the PDA boundaries generally have wide views of the areas that is unobstructed by terrain.

Six key locations were identified at or close to the PDA boundary that are most likely to experience visual impacts due to the proposed Project. These locations, and their current views of the site, are described below. Each of the following locations is shown in the satellite imagery on Figure 7.8, and photographs showing their respective views of the PDA are provided in Appendix G.

- **Harrow Tenantry –** Located to the northeast of the PDA. Views of the PDA are largely unobstructed to the south and south-southwest. Portions of the public road adjacent to the tenantry also provide a view of the PDA. Sections of the PDA to the far west are obstructed by a densely vegetated depression and other trees at Harrow Plantation Yard. Marchfield Village and Farm Road Terrace are clearly visible on the far side of the PDA.
- **Harrow Plantation Yard –** Located to the north of the PDA. Views of the PDA are largely unobstructed to the south. Vegetation to the east and west of the Yard prevents clear view of the PDA in those directions. Marchfield Village and Farm Road Terrace are clearly visible on the far side of the PDA.
- **Sunbury Plantation / Eastern Veterinary Clinic –** Located to the west of the PDA. Views of the PDA are obstructed by tall sugarcane growing between Sunbury and the PDA. Western sections of the PDA may become visible following crop harvest, or in the event that shorter root crops are grown on this land. The tall vegetation surrounding Harrow Plantation Yard can be seen in the distance.
- **Marchfield Village –** Located to the southwest of the PDA. Views of the PDA are largely unobstructed to the northeast. Other portions of the southern PDA border are visible. The tall vegetation surrounding Harrow Plantation can be seen across the PDA.
- **Farm Road Terrace –** Located to the south of the PDA. Views of the PDA are largely unobstructed to the northwest, north, and northeast. Harrow Plantation Yard and Harrow Tenantry are clearly visible on the far side of the PDA.
- **Bushy Park Raceway –** Located to the northeast of the site. The spectator stands – a tall structure situated on a small rise – faces the PDA. Views of the PDA are currently obstructed by mahogany trees and other vegetation. Portions of the PDA may become visible in the future if some or all of this vegetation is removed.

7.3 SOCIAL ENVIRONMENT

A baseline study of the existing social environment (including economic and cultural aspects) in which the Project is proposed to be carried out was conducted in support of the Social Impact Assessment (SIA) portion of the ESIA. Representatives from 155 households within a 1-km radius of the PDA were interviewed to collect data pertaining to local demographics, housing and community conditions, public perceptions of solar PV energy in general, public perceptions of the Project in particular, and local commercial enterprises. Section 9.1 provides further information regarding the survey methods that were employed, as well as detailed results of the baseline study.

8.0 ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION

This chapter is the Environmental Impact Assessment (EIA) portion of the ESIA, which focuses on the potential interactions between the Project and the biophysical/ecological and anthropogenic VCs identified in Section 6.2. The following types of impacts are assessed with respect to the biophysical/ecological and anthropogenic VCs:

- the residual environmental impacts of the Project on its own (refer to Section 8.2 to Section 8.6)
- the residual environmental impacts that have potential to occur in the event of an accident, malfunction, emergency, or disaster (refer to Section 8.7)

Chapter 10 assesses the residual environmental and social impacts of the Project in combination with the residual impacts of other past, present, or reasonably foreseeable future projects and activities.

8.1 ENVIRONMENTAL IMPACT ASSESSMENT METHODS

The following subsections describe the approach and methods used to conduct the assessment of potential Project-related impacts on the biophysical/ecological and anthropogenic VCs. Potential cumulative environmental impacts are assessed separately as described in Chapter 10, and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

8.1.1 Identification of Project Interactions with Valued Components

Table 8.1 identifies the potential for interaction between routine Project activities and components and the biophysical/ecological and anthropogenic VCs identified for the assessment (Section 6.2). Further discussion of the potential environmental changes and impacts associated with each of these identified interactions is provided in the assessment subsections for each VC (i.e., Section 8.2 to Section 8.6).

Table 8.1 Project-VC Interaction Matrix

Routine Project Activities and Components, by Project Phase	Valued Components				
	Atmospheric and Acoustic Environment	Surface Water and Groundwater Resources	Flora and Fauna	Visual Environment	Agriculture and Other Land Uses
Construction					
Site preparation, including vegetation clearing, levelling of soils, establishment of temporary construction laydown areas, and excavation of ditches and ponds	✓	✓	✓	✓	✓
Physical construction and equipment installation of the following Project components: • Solar PV power plant • HyPCe area facilities (i.e., BESS, HESS, and EMS) • Buildings associated with the agricultural facilities • Supporting infrastructure, facilities, and utilities (including other buildings and yards, access road and internal site roads, parking areas, security facilities, site lighting, on-site transmission lines and cables and associated on-site hook-ups, connection to existing public water main, package water treatment plant, water storage tanks, and drainage works)	✓	✓	–	✓	✓
Project-related vehicle traffic within the Parish of Saint Philip	✓	–	✓	✓	–
Presence and operation of Project vehicles, heavy equipment, and machinery on-site	✓	–	✓	✓	✓
On-site management (i.e., collection, storage, handling, and transportation) of Project-related wastes	✓	✓	✓	✓	–
Employment and presence of Project personnel	–	–	✓	✓	–
Finalization and commissioning	✓	–	–	–	–
Operation and Maintenance					
Presence and operation of the following Project components: • Solar PV power plant • HyPCe area facilities (i.e., BESS, HESS, and EMS) • Supporting infrastructure, facilities, and utilities (including related buildings and yards, access road and internal site roads, parking areas, security facilities, site lighting, on-site transmission lines and cables and associated on-site hook-ups, connection to existing public water main, package water treatment plant, water storage tanks, and drainage works)	✓	✓	✓	✓	✓

Table 8.1 Project-VC Interaction Matrix

Routine Project Activities and Components, by Project Phase	Valued Components				
	Atmospheric and Acoustic Environment	Surface Water and Groundwater Resources	Flora and Fauna	Visual Environment	Agriculture and Other Land Uses
Solar grazing of sheep between the solar panels of the power plant; vegetation management; and harvesting, bailing, and storage of grass from the fodder pasture	✓	✓	✓	✓	✓
Sheep husbandry and the provision of associated feeding, watering, and veterinary care	✓	–	✓	–	–
Re-use of mineralized by-product water from the water treatment plant for irrigation of the fodder pasture, washdown, and sanitation purposes	–	✓	–	–	✓
Project-related vehicle traffic within the Parish of Saint Philip	✓	–	✓	✓	–
Presence and operation of Project vehicles, heavy equipment, and machinery on-site	✓	–	✓	✓	✓
On-site management (i.e., collection, storage, handling, and transportation) of Project-related wastes	✓	✓	✓	✓	–
Employment and presence of Project personnel	–	–	✓	✓	–
Decommissioning					
Dismantling and removal of the following Project components: • Solar PV power plant • HyPCe area facilities (i.e., BESS, HESS, and EMS) • Buildings associated with the agricultural facilities • Supporting infrastructure, facilities, and utilities (including other buildings and yards, access road and internal site roads, parking areas, security facilities, site lighting, on-site transmission lines and cables and associated on-site hook-ups, connection to existing public water main, package water treatment plant, water storage tanks, and drainage works)	✓	✓	✓	✓	✓
Backfilling of ponds and ditches and re-establishment of natural drainage patterns	✓	✓	✓	✓	✓
Recontouring and revegetation of disturbed areas	✓	✓	✓	✓	✓
Project-related vehicle traffic within the Parish of Saint Philip	✓	–	✓	✓	✓
Presence and operation of Project vehicles, heavy equipment, and machinery on-site	✓	–	✓	–	✓
On-site management (i.e., collection, storage, handling, and transportation) of Project-related wastes	✓	✓	✓	✓	–

Table 8.1 Project-VC Interaction Matrix

Routine Project Activities and Components, by Project Phase	Valued Components				
	Atmospheric and Acoustic Environment	Surface Water and Groundwater Resources	Flora and Fauna	Visual Environment	Agriculture and Other Land Uses
Employment and presence of Project personnel	–	–	✓	✓	–
Notes: ✓ = Potential interaction – = No interaction					

8.1.2 Impact Analysis, Mitigation, and Environmental Impact Predictions

Project-related environmental impacts are assessed for each biophysical/ecological and anthropogenic VC during every phase of the Project (i.e., construction, operation and maintenance, and decommissioning). The focus of the assessment is on residual environmental impacts (i.e., the environmental impacts that remain after planned mitigation has been applied).

8.1.2.1 Potential Project-Related Impacts

Specific Project activities that may interact with the VC to result in an environmental impact (i.e., a measurable change that may affect the VC) are identified and the associated impact pathway(s) are described for each potential impact. Project components and activities that do not interact with the VC are also identified and the reason for the lack of interaction is explained. Each identified environmental impact is then analysed based on scientific knowledge, assessment tools such as quantitative modelling (where needed), and professional judgement.

8.1.2.2 Mitigation

Technically and economically feasible mitigation measures are proposed to eliminate, reduce, or control adverse environmental impacts, to address public concerns, and to optimize beneficial effects. Types of mitigation measures include:

- Project design mitigation measures, such as those identified in Section 3.7.1;
- Standard environmental protection procedures, such as those identified in Section 3.7.2;
- VC-specific mitigation measures to address the potential impacts on a particular VC, such as those identified in the assessment subsections for each VC (Section 8.2.2 to Section 8.6.2) and summarized in Section 3.7.2;

- Mitigation and contingency measures to address the possibility of accidents, malfunctions, emergencies, or disasters that could affect the environment, such as those identified in Section 8.7; and
- Measures proposed in monitoring and management plans as part of a process of adaptive management, such as those referred to in Chapter 11 and identified in the ESMP for the Project (Appendix I).

8.1.2.3 Residual Environmental Impact Characterization Criteria

Direct and indirect residual impacts are described and rated based on the characterization criteria defined in Table 8.2, which are standard across all VCs.

Table 8.2 Residual Environmental Impact Characterization Criteria

Criteria	Description	Definition of Possible Ratings
Direction	This rating denotes the long-term trend of the residual impact.	**P** **Positive:** A residual impact that moves the measurable parameter(s) in a direction beneficial to the VC relative to baseline conditions. **A** **Adverse:** A residual impact that moves the measurable parameter(s) in a direction detrimental to the VC relative to baseline conditions. **N** **Neutral:** No net change in the measurable parameter(s) for the VC relative to baseline conditions.
Magnitude	This rating denotes the expected degree or severity of the residual impact, in consideration of the proportion of the VC affected.	**N** **Negligible:** No measurable change from existing/baseline conditions. **L** **Low:** Measurable change from existing/baseline conditions that is within the range of natural variability and does not exceed applicable objectives, guidelines, or standards, nor does it pose a risk to the short-term viability of human health or wellbeing; surface water or groundwater resources; terrestrial habitats, populations, or biodiversity; the activities of agricultural or other land users; or the visual landscape. **M** **Moderate:** Measurable change from existing/baseline conditions that may exceed natural variability but does not exceed applicable objectives, guidelines, or standards, nor does it pose a risk to the long-term viability of human health or wellbeing; surface water or groundwater resources; terrestrial habitats, populations, or biodiversity; the activities of agricultural or other land users; or the visual landscape. **H** **High:** Measurable change from existing/baseline conditions that exceeds the limits of natural variability; may exceed applicable objectives, guidelines, or standards; and may affect the long-term viability of human health or wellbeing; surface water or groundwater resources; terrestrial habitats, populations, or biodiversity; the activities of agricultural or other land users; or the visual landscape.
Geographic Extent	This rating denotes the geographic area in which a residual environmental impact occurs.	**S** **Site:** Residual impact is spatially limited to within the PDA. **L** **Local:** Residual impact is spatially limited to within the AOI. **R** **Regional:** Residual impact is spatially limited to within the RSA. **R+** **Extra-Regional:** Residual impact extends beyond the RSA.

Table 8.2 Residual Environmental Impact Characterization Criteria

Criteria	Description	Definition of Possible Ratings
Duration	This rating denotes the length of time the residual impact is expected to persist, which may be longer than the duration of the Project activity or component that gave rise to the residual impact.	Quantitative measure; or **ST** **Short-term:** Residual impact occurs for a portion of the duration of the applicable phase(s) of the Project. **MT** **Medium-term:** Residual impact occurs for the entire duration of the applicable phase(s) of the Project. **LT** **Long-term:** Residual impact extends beyond the life of the Project.
Frequency	This rating denotes how often the residual environmental impact might occur within a specified time period.	Quantitative measure; or **O** **Occasional:** Residual impact occurs once per month or less. **S** **Sporadic:** Residual impact occurs sporadically at irregular intervals. **R** **Regular:** Residual impact occurs on a regular basis and at regular intervals. **C** **Continuous:** Residual impact occurs continuously.
Reversibility	This rating denotes whether or not the VC can recover to existing/baseline conditions once the activity causing the residual impact ceases.	**R** **Reversible:** Residual impact is likely to be reversed (i.e., VC will likely recover to existing/baseline conditions) before or after the completion of Project activities. **I** **Irreversible:** Residual impact is unlikely to be reversed, even after the completion of Project activities, and is likely permanent.
Probability	This rating denotes the likelihood of the residual impact occurring.	**L** **Likely:** Residual impact is considered likely to occur based on available information and professional judgement. **U** **Unlikely:** Residual Impact is considered unlikely to occur based on available information and professional judgement.

8.1.2.4 Significance Criteria

The predicted significance of residual Project-related environmental impacts is determined for each VC based on the VC-specific significance criteria (or thresholds) defined below.

- For the **Atmospheric and Acoustic Environment VC** (Section 8.2), a significant residual adverse impact is defined as a residual Project-related change to the atmospheric and/or acoustic environment that results in any of the following:
  - A reduction in air quality beyond the PDA such that the maximum ground-level air contaminant concentration associated with the Project, in combination with the conservative background concentration, frequently exceeds the applicable ambient air quality standard presented in Table 8.3. “Frequently” is defined as once per week for 1-hour and 8-hour objectives, and once per month for 24-hour objectives. Barbados’ ambient air quality standards (Table 8.3) are based on international standards such as the United States Environmental Protection Agency’s *National Ambient Air Quality Standards* for the following air contaminants: particulate matter, sulphur dioxide, nitrogen dioxide, ozone, carbon monoxide, and lead.

Table 8.3 Barbados' Ambient Air Quality Standards

Air Contaminant	Standard µg - micrograms (one-millionth of a gram)			
Particulate Matter ($PM_{2.5}$)	25 µg/m^3 24-hour mean		10 µg/m^3 annual mean	
Particulate Matter (PM_{10})	50 µg/m^3 24-hour mean		20 µg/m^3 annual mean	
Ozone (O_3)	100 µg/m^3 8-hour mean			
Nitrogen Dioxide (NO_2)	200 µg/m^3 1-hour mean		40 µg/m^3 annual mean	
Sulphur Dioxide (SO_2)	500 µg/m^3 10-minute mean	200 µg/m^3 1-hour mean	20 µg/m^3 24-hour mean	
Carbon Monoxide (CO)	100 µg/m^3 15-minute mean	60 µg/m^3 30-minute mean	30 µg/m^3 1-hour mean	10 µg/m^3 8-hour mean
Lead (Pb)	0.5 µg/m^3 annual mean			
Source: Government of Barbados 2019f.				

  - The release of more than 500,000 t CO_2e/year of GHG emissions to the atmosphere.
  - Noise emissions from routine activities that exceed background sound pressure levels by more than 5 dBA beyond the PDA.
- For the **Surface Water and Groundwater Resources VC** (Section 8.3), a significant residual adverse impact is defined as a residual Project-related change to surface water and/or groundwater resources that results in any of the following:
  - Alteration of the hydrological regime and/or sediment transport regime beyond the PDA such that it no longer meets established instream flow needs.
  - A reduction in surface water quality beyond the PDA that causes acute or chronic toxicity to aquatic life at the community or population level.
  - A reduction in groundwater quantity and/or quality to the point where the yield from an established groundwater supply aquifer or well is no longer suitable or adequate for its intended use.
  - Physical or chemical alteration of an aquifer to the extent that interaction with local surface water results in streamflow or chemistry changes that adversely affect aquatic life at the community or population level or surface water supply.
  - Contravention of an applicable watershed management target.

- For the **Flora and Fauna VC** (Section 8.4), a significant residual adverse impact is defined as a residual Project-related change to the environment that results in any of the following:
  - A decline in abundance and/or change in distribution of a species such that the integrity (i.e., long-term persistence or viability) of the species in the RSA is threatened to the extent that natural recruitment (i.e., reproduction and immigration from unaffected areas) is insufficient to return the population to its former level within several growing seasons (for flora) or generations (for fauna).
  - A change in terrestrial habitat that alters its status or integrity within the RSA.
  - A disruption in the achievement of self-sustaining population objectives or recovery goals for special status species.
  - An impact that is contrary to or inconsistent with the goals, objectives, or activities of an applicable plan, policy, or legislation.
- For the **Visual Environment VC** (Section 8.5), a significant residual adverse impact is defined as a residual Project-related change to the environment that results in high-intensity glare with the potential to cause permanent eye damage if observed by receptors beyond the PDA, or glint and glare impacts that otherwise represent a public health and safety hazard.
- For the **Agriculture and Other Land Uses VC** (Section 8.6), a significant residual adverse impact is defined as a residual Project-related change to the environment that results in either of the following:
  - A change or disruption that widely restricts or degrades present land use capability to a point where agricultural or other land use activities cannot continue at or near current levels in the RSA.
  - Non-compliance with established land use plans, policies, or by-laws, or incompatibility with adjacent or historical land use activities as designated through a regulatory land use process.

8.1.2.5 Prediction Confidence

Level of confidence is assigned to the residual impact predictions for each VC. A lower level of confidence may be indicative of deficiencies in available information (e.g., data gaps in baseline information or limitations in the availability of existing knowledge related to potential Project-environment interactions) or other challenges. VC-specific deficiencies or challenges associated with the EIA process are identified, where applicable.

8.1.2.6 Follow-up and Monitoring

Follow-up and monitoring programs are identified for each VC, where applicable, to verify the accuracy of key EIA predictions and the effectiveness of prescribed mitigation measures. Although not described in the EIA, compliance monitoring will also be undertaken as necessary to verify compliance with applicable regulatory requirements, potentially including the terms and conditions of any environmental permits, approvals, or authorizations that may be issued in support of the Project.

8.2 ATMOSPHERIC AND ACOUSTIC ENVIRONMENT

As described in Section 7.1.2 and Appendix E, baseline noise monitoring was conducted to quantify the existing acoustic environment in the vicinity of the PDA. An acoustic assessment was subsequently carried out (Appendix E) in which commercially available CADNA/A acoustic modelling software was used to predict Project-related sound emissions and estimate the Project-related change in baseline sound levels at nearby receptor locations (i.e., within 100 m of the PDA) during the operation and maintenance phase of the Project. The complete Acoustic Assessment report is provided in Appendix E, including detailed modelling methods and results. Key findings and proposed mitigation measures from the Acoustic Assessment report are considered where applicable in this assessment of potential Project-related environmental impacts on the atmospheric and acoustic environment.

8.2.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with the atmospheric and acoustic environment to adversely affect air quality and result in increased levels of GHG emissions, noise, and vibration. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on the atmospheric and acoustic environment is focused on the following potential changes to the environment:

- Change in air quality
- Change in GHG emissions
- Change in the acoustic environment (including noise and vibration)

During the **construction phase** of the Project, the atmospheric and acoustic environment could be impacted by the following:

- An adverse Project-related change in air quality due to
  - atmospheric emissions of combustion by-products and other air contaminants resulting from the operation of gasoline and diesel-powered Project construction vehicles heavy equipment, and machinery.
  - atmospheric emissions of particulate matter and fugitive dust emissions associated with site preparation (including the levelling of soils, establishment of temporary construction laydown areas, and excavation of ditches and ponds) and other ground-disturbing activities, the construction of site roads and parking areas, the handling of aggregate materials used in construction, the on-site management of Project-related construction wastes, and the movement of Project construction vehicles, heavy equipment, and machinery.
- An adverse Project-related change in GHG emissions due to atmospheric emissions of GHGs in combustion by-products resulting from the operation of gasoline and diesel-powered Project construction vehicles, heavy equipment, and machinery.

- An adverse Project-related change in the acoustic environment due to acoustic emissions resulting from the physical construction and installation of Project components and the operation of Project construction vehicles, heavy equipment, and machinery, including potential noise and vibration emissions associated with pile driving (if required).

  In addition to the Project vehicles, heavy equipment, and machinery that will be used on-site to carry out Project construction activities, it is estimated that approximately 450 trucks will be required to transport key Project components to the PDA to enable construction and equipment installation (refer to Section 3.3.1.2).

During the **operation and maintenance phase** of the Project, the atmospheric and acoustic environment could be impacted by the following:

- An adverse Project-related change in air quality due to
  - atmospheric emissions of combustion by-products and other air contaminants resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance.
  - atmospheric emissions of particulate matter and fugitive dust emissions associated with the movement of Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance; the presence and operation of the feed silo; the use of gravel site roads and parking areas; and the on-site management of Project-related wastes.
- An adverse Project-related change in GHG emissions due to
  - atmospheric emissions of GHGs in combustion by-products resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance.
  - atmospheric emissions of GHGs from various sources associated with operation of the sheep farm (e.g., the presence of sheep manure, the potential application of fertilizers).
- A positive (i.e., beneficial) Project-related change in air quality and GHG emissions due to the generation and delivery of renewable power from a non-polluting and carbon-free source, which will reduce the potential air contaminant and GHG emissions that would have otherwise been associated with the generation and delivery of non-renewable power from Barbados' existing large-scale power plants that primarily rely on imported petroleum products.
- An adverse Project-related change in the acoustic environment due to noise emissions resulting from the operation of electrical and electronic components associated with the Project energy facility, the presence of approximately 1,830 Blackbelly sheep, and the operation of Project vehicles, heavy equipment, and machinery, including for farming and general facilities maintenance.

As described in Section 3.6.2, small amounts of pure oxygen, hydrogen gas, and water vapour will be emitted from the HESS during routine operation of the Project. However, these gaseous emissions are anticipated to be non-polluting and are therefore not considered further in the assessment of Project-related environmental impacts on the atmospheric and acoustic environment. Section 8.7 considers potential atmospheric and acoustic impacts that could occur in the event of accident or malfunction.

During the **decommissioning phase** of the Project, the atmospheric and acoustic environment could be impacted by the following:

- An adverse Project-related change in air quality due to
  - atmospheric emissions of combustion by-products and other air contaminants resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery.
  - atmospheric emissions of particulate matter and fugitive dust emissions associated with activities such as backfilling, recontouring, and other ground-disturbing site reclamation activities; the dismantling and removal of Project components; the on-site management of Project-related demolition wastes; and the movement of Project vehicles, heavy equipment, and machinery.
- An adverse Project-related change in GHG emissions due to atmospheric emissions of GHGs in combustion by-products resulting from the operation of gasoline and diesel-powered Project vehicles, heavy equipment, and machinery.
- An adverse Project-related change in the acoustic environment due to noise emissions resulting from the dismantling and removal of Project components and the operation of Project vehicles, heavy equipment, and machinery.

8.2.2 Mitigation

Potential Project-related adverse environmental impacts on the atmospheric and acoustic environment will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable.

The following VC-specific mitigation measures will also be implemented to reduce potential adverse impacts to the atmospheric and acoustic environment:

- Only areas required for construction will be cleared.
- Where practical, Project vehicles, heavy equipment, and machinery will be sized to the smallest needed to perform the work.
- Air and acoustic emissions from Project vehicles, heavy equipment, and machinery will be managed by conducting regular inspection, repair, and maintenance activities as required for operation in accordance with manufacturer's recommendations and to reduce instances of visible sooty emissions or abnormally high sound levels. Defective vehicles or equipment will be taken out of service and not permitted to resume operations until they are repaired.
- Project vehicles, heavy equipment, and machinery will be outfitted with mufflers (and/or other appropriate sound attenuation devices) that meet international design standards.
- Project vehicles, heavy equipment, machinery, and associated exhaust systems and mufflers (and/or other appropriate sound attenuation devices) will be regularly inspected and maintained so that they remain operating in accordance with manufacturer's recommendations.Project vehicles, heavy equipment, and machinery will be shut down when stationary for long periods of time. The idling of vehicles and equipment will be avoided whenever practical.
- Dust from Project activities will be controlled where required by using applications of water. Waste oil will not be used for dust control, but other agents, such as wood chips, calcium chloride, matting, and revegetation may be considered on a site-specific or as needed basis.

- Project-related fugitive road dust will be controlled through measures such as:
  - Establishing speed limits of less than 20 km/hour on Project-controlled gravel roads
  - Conducting road watering on an as-needed basis
  - Washing truck tires before leaving the construction area onto existing paved roads
  - Requiring trucks hauling material to have tarps to cover the load
- Dust emissions during Project activities will be further reduced by covers, screens, enclosures, or other similar methods, where necessary.
- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors, which will help to prevent the movement of dust onto surrounding areas.
- Cleared areas will be paved or revegetated, where possible.
- A cover of native grass will be planted and maintained under and between rows of solar PV panels and routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could produce dust emissions during dry conditions.
- Stockpiles of topsoil, overburden, and other potentially dust-generating materials will be kept covered and used as soon as practical.
- Waste materials will not be burned on-site.
- Haul distances to disposal sites will be reduced as much as possible.
- A construction fence will be retained along the perimeter of the site where feasible; this will act as a barrier to prevent the movement of dust onto surrounding areas.
- Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).
- Blasting will be avoided, where possible, during construction.
- If required and if feasible, augering will be conducted rather than pile driving. If pile driving cannot be avoided, it will be scheduled during daytime hours only and a vibratory hammer will be used since it is quieter and generates less vibration than an impact hammer.
- Nearby residents will be notified prior to potential pile driving (if required).
- Project vehicles will drive within the speed limit to reduce engine noises as vehicles travel on roadways within adjacent communities and horns will be used only as necessary for safety purposes.
- Acoustical barriers (e.g., engineered materials or stockpiled overburden) will be used near loud sources during construction, if feasible.
- Walled enclosures may be constructed around especially noisy activities, or clusters of noisy equipment or machinery.
- Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential impacts to various receptors, including flora and fauna, surface water resources, and surrounding agricultural and other land users, residents, and businesses.

The Acoustic Assessment report (Appendix E) recommends the following additional mitigation measures that will be implemented to further reduce Project-related sound pressure levels: the establishment of physical noise controls (e.g., an enclosure for the BESS and physical barriers for transformers and inverters) and the preferential selection of Project components with noise reduction capabilities, in cases where it is technically and economically feasible to do so.

8.2.3 Characterization of Residual Project-Related Impacts

Most of the potential emissions of air contaminants, GHGs, noise, and vibration associated with Project activities will be temporary and intermittent (i.e., occurring only during the course of transient activities such as the operation and movement of Project vehicles, heavy equipment, and machinery; the carrying out of ground-disturbing activities; the handling of aggregate materials; and the on-site management of Project-related wastes). The magnitude of Project-related atmospheric and acoustic emissions is predicted to be highest during the construction phase (which is anticipated to last approximately 24 months), followed by the decommissioning phase (which is anticipated to last approximately 12 months), due to the nature of the activities associated with those phases of the Project.

During the operation and maintenance phase of the Project (which is anticipated to last approximately 25 years or more), the potential use of heavy equipment and machinery will be limited to that required to support occasional to regular general facilities maintenance activities and sporadic to regular sheep farming activities. Other potential sources of atmospheric and acoustic emissions associated with operation of the sheep farm (e.g., emissions of particulate matter from the feed silo, GHG emissions from sheep manure and the potential application of fertilizers, and acoustic emissions from the bleating of sheep) may occur relatively more frequently. However, the residual impacts of Project farming-related emissions are not anticipated to differ substantially from the potential residual atmospheric and acoustic impacts that could conceivably occur at the site in the absence of the Project, since the PDA is currently designated for agricultural land use.

8.2.3.1 Characterization Residual Project-Related Changes in Air Quality and GHG Emissions

With the application of proposed mitigation, residual Project-related changes in air quality and GHG emissions during construction are predicted to be adverse in direction, low in magnitude, ranging in geographic extent from being spatially limited to the PDA or AOI (e.g., for emissions of particulate matter and fugitive dust) to extending beyond the RSA (i.e., due to the potential for certain types of air emissions, including GHG emissions, to disperse in the atmosphere), medium-term in duration, occurring sporadically at irregular intervals, and reversible. During the operation and maintenance phase and the decommissioning phase, residual Project-related changes in air quality and GHG emissions (i.e., from the operation of Project agricultural facilities, general facilities maintenance activities, the use of gravel site roads and parking areas, and the on-site management of Project-related wastes) are similarly predicted to be adverse in direction, low in magnitude, ranging in geographic extent from the PDA or AOI to beyond the RSA, medium-term in duration, and reversible. However, the residual impacts associated with the operation phase are predicted to occur occasionally to regularly, whereas the residual impacts associated with the decommissioning phase are predicted to occur sporadically at irregular intervals.

The Project energy facility (i.e., the solar PV power plant, BESS, HESS, and EMS) are not anticipated to produce any measurable emissions of air contaminants or GHGs during the operation phase. Furthermore, as indicated in Section 4.1.2, the Project is anticipated to reduce Barbados' total CO_2 emissions by approximately 48,000 tons annually through the generation of approximately 56,000 MWh of carbon-free electricity per year[7]. Generating that amount of electricity from a non-polluting source, rather than from Barbados' existing large-scale power plants that primarily rely on imported petroleum products, will also reduce Barbados' total annual emissions of air contaminants. Thus, the operation of the Project energy facility is predicted to result in a residual change in air quality and GHG emissions that is positive in direction (i.e., a beneficial reduction in air contaminant and GHG emissions), moderate in magnitude, medium-term in duration, continuous, and reversible.

8.2.3.2 Characterization of the Residual Project-Related Change in the Acoustic Environment

With the application of proposed mitigation, the residual Project-related change in the acoustic environment during construction is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible. If pile driving is required during construction, it would be expected to temporarily raise the magnitude of the residual impact to moderate. However, any potential pile driving activities (if required) will be short-term in duration (i.e., occurring for approximately 16 weeks out of the 24-month construction period). The characteristics of this residual impact are expected to be similar during the decommissioning phase, but exclusively low in magnitude (since no pile driving is anticipated) and likely relatively lower in frequency and duration than during construction.

The Project energy facility is anticipated to emit noise continuously during the operation and maintenance phase. As indicated earlier, an acoustic assessment was subsequently carried out (Appendix E) in which commercially available CADNA/A acoustic modelling software was used to predict sound emissions from the Project energy facility and estimate the change in baseline sound levels at nearby receptor locations. The noise sources that were included in the acoustic model were the electrolysers and fuel cells associated with the HESS, as well as their cooling fans; the inverters and transformers associated with operation of the solar PV panels, BESS, and HESS; the fan noise from the battery packs associated with the BESS; and the sheep pens. Noise levels at the nearest points of reception were estimated and then assessed for compliance using World Health Organization (WHO) and World Bank noise exposure guidelines (i.e., WHO 1999 and World Bank Group 2007b).

The results of the Acoustic Assessment (Appendix E) indicate that the noise contribution from the Project is not anticipated to exceed WHO criteria at the points of reception identified near the PDA during the daytime. During the nighttime, slight exceedances of the WHO guideline criteria of 45 dBA are predicted at the nearest receptors to the south of the PDA. However, the nighttime predictions are likely overly conservative, as they include noise from the operation of the inverters, which will likely not operate overnight when the solar PV plant is not generating power. Furthermore, these predictions are based on a modelling scenario that excludes the application of mitigation measures, and the model also did not

[7] Calculation based on average specific CO_2 emissions of 0.87 tCO_2/MWh, as per BLPC figures.

consider the potential barrier effect that may result from the proposed positioning of ten rows of solar panels between Project-related noise generating sources and the receptors south of the PDA.

With the application of proposed mitigation, the residual Project-related change in the acoustic environment during the operation and maintenance phase is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, and reversible. The frequency of the residual impact is predicted to be continuous with respect to operation of the Project energy facility but is anticipated to range from occasional to regular for residual noise emissions associated with general facilities maintenance, and from sporadic to regular for residual noise emissions associated with sheep farming.

8.2.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of the Project on the atmospheric and acoustic environment (i.e., residual Project-related adverse changes in air quality, GHG emissions, and the acoustic environment, as well as residual Project-related positive changes in air quality and GHG emissions) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.4 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on the atmospheric and acoustic environment. These predictions have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities, the effectiveness of standard mitigation measures, and the use of BLPC figures to calculate the anticipated Project-related reduction in Barbados' total CO_2 emissions.

Table 8.4 Summary of Project Residual Environmental Impacts on the Atmospheric and Acoustic Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in Air Quality									
Construction	A	L	L–R+	MT	S	R	L	N	H
Operation and Maintenance	A	L	L–R+	MT	O–R	R	L	N	H
Operation and Maintenance	P	M	L	MT	C	R	L	N	H
Decommissioning	A	L	L–R+	MT	S	R	L	N	H

Table 8.4 Summary of Project Residual Environmental Impacts on the Atmospheric and Acoustic Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in GHG Emissions									
Construction	A	L	L–R+	MT	S	R	L	N	H
Operation and Maintenance	A	L	L–R+	MT	O–R	R	L	N	H
Operation and Maintenance	P	M	L	MT	C	R	L	N	H
Decommissioning	A	L	L–R+	MT	S	R	L	N	H
Residual Change in the Acoustic Environment									
Construction	A	L–M	L	ST–MT	S	R	L	N	H
Operation and Maintenance	A	L	L	MT	O–C	R	L	N	H
Decommissioning	A	L	L	MT	S	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.2.5 Deficiencies, Challenges, and Prediction Confidence

Due to the completion of a Project-specific baseline noise study (appended to the Acoustic Assessment report in Appendix E) and Project-specific acoustic modelling (Appendix E), the level of confidence regarding the predicted residual Project-related change in the atmospheric environment is relatively slightly higher than it is for the predictions that are based on qualitative assessment of Project-related changes in air quality and GHGs emissions. Project-specific air contaminant and GHG emissions were not estimated or modelled due to the lack of information at this stage in Project planning regarding the anticipated types and numbers of vehicles, heavy equipment, and machinery that will be employed to carry out Project activities. However, the level of confidence regarding predicted residual Project-related changes in air quality and GHG emissions remains high in consideration of the results of air quality and GHG assessments that have been previously conducted by the Study Team for other projects of a similar nature and/or scale. Follow-up monitoring for Project-related emissions of air contaminants and GHGs will be undertaken to confirm residual atmospheric impact predictions or identify the potential need for adaptive management, if applicable.

8.2.6 Follow-up and Monitoring

No VC-specific follow-up and monitoring plans are proposed.

8.3 SURFACE WATER AND GROUNDWATER RESOURCES

A Project-specific Drainage Assessment (Appendix B) was completed in support of the ESIA. As part of the Drainage Assessment, a stormwater runoff modelling exercise was carried out for the PDA to analyze drainage patterns and potential changes to drainage patterns following construction of the Project. The complete Drainage Assessment report is provided in Appendix B, including detailed modelling methods and results. Key findings and proposed mitigation measures from the Drainage Assessment report are considered where applicable in this assessment of potential Project-related environmental impacts on surface water and groundwater resources.

8.3.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with surface and groundwater resources. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on surface and groundwater resources is focused on the following potential changes to the environment:

- Change in surface water quantity / quality
- Change in groundwater quantity / quality

During the **construction phase** of the Project, surface water and groundwater resources could be impacted by an adverse Project-related change in surface water quantity / quality due to

- potential erosion and loss of topsoil associated with the disturbance and/or removal of existing vegetation by heavy machinery, which could result in drainage impacts (e.g., sedimentation) affecting downstream farmlands and communities.
- the introduction of new impermeable surfaces to the PDA (e.g., through the construction of concrete pads, roads and other paved areas, and arrays of solar PV panels), which could increase runoff to downstream areas and potentially cause or worsen flooding during extreme or prolonged rainfall events.
- dust generated from Project vehicles, heavy equipment, and machinery, which could be introduced to and affect the quality of surface water.

During the **operation and maintenance phase** of the Project, surface water resources could be impacted by an adverse Project-related change in surface water quantity / quality due to

- surface runoff from rainwater/stormwater and Project sources (including potential excess water from the washdown and sanitation of Project facilities and the irrigation of grazing and fodder pasture areas) – in combination with the continued presence of Project-related impermeable surfaces (e.g., concrete pads, roofs, roadways, hard pavements, solar PV panels) within the PDA – could increase runoff to downstream areas and potentially cause or worsen flooding during extreme or prolonged rainfall events.
- the potential for grassed solar grazing areas to develop bare patches (especially in between panels where routine traffic and maintenance will occur), which could result in increased surface runoff and the formation of erosion channels and pathways.

The planned re-use of mineralized by-product water from the water treatment plant during the operation and maintenance phase of the Project is not anticipated to adversely affect surface water quality. As described in Section 3.6.2, the mineralized by-product water from the water treatment plant is not anticipated to contain potential contaminants other than the minerals that were removed during reverse osmosis (e.g., salt, manganese, iron, fluoride, lead, and calcium), and the concentration of minerals in the by-product water is anticipated to be suitable for irrigation and washdown purposes. As described in Section 3.2.1.2, the fuel cells in the HESS will essentially reverse the the electrolysis process by transforming hydrogen and oxygen back into electricity and pure water vapour (i.e., gaseous H_2O) that is anticipated to be free of contaminants.

During the **operation and maintenance phase** of the Project, groundwater resources could be impacted by a Project-related change in groundwater quantity / quality associated with the infiltration and percolation of captured runoff to groundwater zones from Project-related drainage systems, including existing and proposed on-site infiltration wells (suckwells) and a runoff interceptor drainage system that is proposed along the entire southern boundary of the PDA (as described in the Project-specific Drainage Assessment in Appendix B). The resultant Project-related change may be adverse if the captured runoff contains sediment or other contaminants.

During the **decommissioning phase** of the Project, surface water and groundwater resources could be impacted by an adverse Project-related change in groundwater quantity / quality and an adverse Project-related change in surface water quantity / quality due to the vehicle and heavy equipment use associated with the dismantling and removal of Project components, the backfilling of ponds and ditches, the re-establishment of natural drainage patterns, and the recontouring and revegetation of disturbed areas.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, surface water and groundwater resources could be impacted by an adverse Project-related change in surface water quantity / quality and/or an adverse Project-related change in groundwater quantity / quality due to potential interactions with the emissions, discharges, and wastes identified in Section 3.6.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, surface water and groundwater resources could also be impacted by an adverse Project-related change in surface water quality and/or an adverse Project-related change in groundwater quality due to potential spills/leaks of petroleum products, hydraulic fluids, lubricants, or coolants from Project construction vehicles, heavy equipment, and machinery, and the potential leaching of these substances into groundwater zones beneath the PDA. These potential impacts are considered separately in Section 8.7 – in the context of potential accidents, malfunctions, emergencies, and disasters – and are not considered further here in the assessment of Project-related environmental impacts on surface water and groundwater resources.

8.3.2 Mitigation

Potential Project-related adverse environmental impacts on surface and groundwater resources will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable.

The following VC-specific mitigation measures will also be implemented to reduce potential adverse impacts to surface water and groundwater resources:

- Existing drainage systems within the PDA – including land slopes, watercourses, depressions, suckwells, and dry ponds – will be retained and maintained where possible.
- A cover of native grass will be planted and maintained under and between rows of solar PV panels to help slow the rate of runoff, control erosion, and reduce the transport of sediment/topsoil off-site.
- Routine maintenance of grassed surfaces will be carried out to mitigate the potential development of bare patches or inconsistencies, which could result in a change of the runoff characteristics in those areas.
- Paved roadways within the PDA will consist of kerb and slipper drains, with sets of catchbasins including gully grates to drain captured runoff to culverts leading to suckwells.
- Paved areas within the HyPCe area and administration areas will be drained by a system of catchment basins, drainpipes, and suckwells. The use of suckwells is intended to promote on-site drainage of runoff to groundwater, rather than to natural drainage courses that convey runoff south and off-site.

- A 9-m wide drainage reserve has been proposed along the entire southern boundary of the Project Property. This would involve construction of a runoff interceptor drainage system within the aforementioned drainage reserve. This system may consist of an earthen swale with sloped embankments or an infiltration trench with vertical side faces. Suckwells/infiltration wells may be added to the interceptor drain to assist with the sub-surface drainage of captured rainwater. A hydrological study will be performed during detailed design which will seek to finalise drainage mitigation measures, including final selection of any interceptor drainage system(s) that would be required.
- A vegetated buffer strip will be established at the downstream site boundary to control excess runoff.
- Silt screens and/or bales of hay will be installed where necessary to contain and prevent the erosion and loss of topsoil from localized areas.
- Temporary boulder barriers will be installed at strategic points of surface runoff to retain sediment/topsoil and control the rate of runoff onto adjacent lands.
- Temporary stockpiles of topsoil that are not required for re-instatement will be removed from site as soon as possible to avoid migration of topsoil into the natural drainage system.
- Best practices for the proper handling, storage, and disposal of spilled hazardous chemicals and fuels will be included in the contractor's environmental management plan and implemented by the contractor.
- The drainage system for the site will be designed to limit stormflows from the site.
- The drainage system design for areas on-site where impermeable areas are to be added will focus on draining runoff to suckwells, and ultimately to groundwater, to reduce the amount of surface water runoff that could potentially impact communities downstream.
- During detailed design, the implementation of a dry pond will be studied. If needed, the dry pond will be constructed on land to the west of the area proposed for sheep grazing, north of the Old Train Line Road (i.e., at the location shown on Figure 17 in Appendix B), to capture a portion of runoff from the North Watershed, promote the infiltration and percolation of runoff to groundwater zones, and reduce to some extent the quantity of runoff that crosses the Old Train Line Road and enters the PDA. The dry pond shall have shallow slopes, be grassed to facilitate grazing by sheep, and include suckwells with top and side entry inlets along its perimeter.
- Septic tanks and soakaways will be routinely inspected at least once every six months and cleaned as necessary.
- The cleaning of PV panels will only be done with clean water. No detergents or cleaning chemicals will be used so that the water that runs off onto the ground does not have chemicals entrained.

8.3.3 Characterization of Residual Project-Related Impacts

8.3.3.1 Characterization Residual Project-Related Change in Surface Water Quantity / Quality

Construction

The topography of the PDA site is not proposed to be substantially modified by Project construction, and it is expected that the finished surface will be graded and planted with a native grass to control erosion of the surface soil. During construction, the use of Project vehicles, heavy equipment, and machinery may result in the disturbance and/or removal of existing vegetation, resulting in increased potential for erosion and washing of topsoil. Loss of topsoil could impact drainage and thus surface water on downstream farmlands and communities. However, the potential for this impact is temporary, as the PDA will be planted with native grass at the end of the construction phase. In addition, the implementation of proposed mitigation measures for erosion and sediment control (e.g., the installation of silt screens and/or bales of hay and temporary boulder barriers) will reduce potential residual impacts to surface water quality that could occur if sediment-laden runoff from the PDA results in the sedimentation/siltation of downstream surface water resources.

Based on the stormwater runoff model and associated assumptions in the Project-specific Drainage Assessment report (Appendix B), it is estimated that the addition of impermeable surfaces due to the development (excluding solar PV panel surfaces) will result in an approximately 9.5% increase in peak runoff from the South Watershed (versus the baseline scenario) for a 1:20-year 24-hour design storm criterion scenario and an approximately 8.4% peak runoff increase for a 1:50-year 24-hour design storm criterion scenario.

Taking into consideration runoff from the North Watershed and South Watershed (PDA), as well as the drainage provided by 29 infiltration wells in the North Watershed and 23 wells in the South Watershed (PDA), the runoff discharging along the southern boundary of the PDA towards the communities to the south of the site is estimated to increase (versus baseline flows) by 0.36% for the 1:20-year 24-hour design storm criterion and 0.3% for the 1:50-year 24-hour design storm criterion. Thus, the introduction of additional impermeable surfaces due to the development on site is not predicted to substantially increase runoff to downstream communities.

With the application of proposed mitigation, residual Project-related changes in surface water quantity / quality during construction are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, ranging in frequency from occurring sporadically at irregular intervals (for residual impacts associated with the disturbance and/or removal of existing vegetation) to continuous (for residual impacts associated with the introduction of impermeable surfaces to the PDA), and reversible.

Operation and Maintenance

As described in Section 7.1.5, runoff from the North Watershed to the PDA is predominantly via overland flow with shallow flow depths; there are a few watercourses where runoff occurs at deeper depth. Hydrological and hydraulic analyses conducted as part of the Project-specific Drainage Assessment (Appendix B) indicate shallow runoff depths predominantly throughout the site (post-development) and an increased percentage of impermeable areas in the catchment. As described above, this increase of impermeable surfaces within the PDA is expected to marginally increase runoff to downstream areas. Surface runoff from rainwater/stormwater and Project sources (including potential excess water from washdown and sanitation of Project facilities and irrigation of grazing and fodder pasture areas) will be managed through on-site drainage works (refer to Section 3.2.3.6). By way of analyses conducted in Appendix B, it was demonstrated that an infiltration trench along the southern boundary of the PDA could result in downstream runoff volumes from the PDA being slightly less than the baseline scenario. On-site rainwater harvesting, if implemented (Section 3.2.3.5), will also reduce runoff during precipitation events.

PV solar panels are impervious to rainfall; however, they are generally mounted on a steel support framework above the permeable land formation. A study by Cook and McCuen (2013) investigated the hydrologic effects of solar farms and examined whether or not stormwater management is needed to control runoff volumes and rates following the development of a farm. During the study, a model of a solar farm was created for simulating runoff conditions for pre- and post-PV panelled 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 the runoff.

Cook and McCuen (2013) concluded that the addition of solar PV panels 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 (e.g., 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% (Cook and McCuen 2013). The kinetic energy of water draining from a solar panel is 10 times greater than rainfall, resulting in the possibility that soil below panels could erode due to concentrated flow of water off the panel, and this scenario is heightened if there is bare earth and/or the panels are sloping in two directions (Cook and McCuen 2013).

Cook and McCuen (2013) ultimately recommend the use of consistent and well-maintained grass-covered soil beneath panels and in the pathway/space between panels. In situations where the use of gravel or hard pavements underneath and between panels is unavoidable, Cook and McCuen (2013) further recommend the use of a vegetated buffer strip at the downstream site boundary to control excess runoff.

With the application of proposed mitigation (Section 8.3.2), residual Project-related changes in surface water quantity / quality during operation and maintenance are predicted to be adverse, low in magnitude, spatially limited to the AOI, medium-term in duration, ranging in frequency from occurring sporadically at irregular intervals (for residual impacts associated with the development of bare patches in solar grazing areas) to continuous (for residual impacts associated with the continued presence of impermeable surfaces within the PDA), and reversible.

Decommissioning

Project decommissioning activities will ultimately serve to reduce and reverse the adverse Project-related impacts on surface water resources associated with Project construction and operation. The activities associated with decommissioning will, however, result in temporary adverse effects similar in nature to construction, although at a limited duration and scale. It will require the use of heavy machinery and equipment to dismantle and remove equipment and regrade and restore surfaces. Residual Project-related changes in surface water quantity / quality during decommissioning are therefore predicted to be adverse in direction, low in magnitude, spatially limited to the PDA, medium-term in duration, occurring continuously, and reversible.

8.3.3.2 Characterization Residual Project-Related Change in Groundwater Quantity / Quality

Construction

No pathways for potential Project-related changes in groundwater quantity / quality have been identified for the construction phase of the Project other than potential interactions with the emissions, discharges, and wastes identified in Section 3.6. With the application of proposed mitigation, residual Project-related changes in groundwater quantity / quality during construction are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible.

Operation and Maintenance

The runoff interceptor drainage system proposed in Section 8.3.2 above and in the Project-specific Drainage Assessment (Appendix B) will capture, attenuate, and promote the infiltration of runoff to groundwater zones. This increased infiltration could cause an adverse change in groundwater quality if the runoff contains sediment or other contaminants. During the operation and maintenance phase of the Project, groundwater resources could be impacted by a Project-related change in groundwater quality associated with the infiltration and percolation of captured runoff to groundwater zones from other Project-related drainage systems, including existing and proposed on-site infiltration wells (suckwells). However, standard mitigation measures and environmental protection procedures identified in Section 8.3.2 will be implemented to reduce potential adverse impacts on runoff quality and consequent adverse impacts on groundwater quality. Although an adverse Project-related change in groundwater quantity / quality could also conceivably occur due to the disposal of wastewater, if untreated wastewater is allowed to discharge directly to suckwells where it could impact groundwater quantity and quality beneath the site, such impacts are not anticipated for the Project since wastewater from sanitary uses within Project buildings will be discharged to the municipal sewage system.

With the application of proposed mitigation, the residual Project-related change in groundwater quantity / quality during the operation and maintenance phase is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible.

Decommissioning

Project decommissioning activities will ultimately serve to reduce and reverse the adverse Project-related impacts on groundwater resources associated with Project construction and operation. The activities associated with decommissioning will, however, result in temporary adverse effects similar in nature to construction, although at a limited duration and scale. It will require the use of heavy machinery and equipment to dismantle and remove equipment and regrade and restore surfaces. Residual Project-related changes in ground water quantity / quality during decommissioning are therefore predicted to be adverse in direction, low in magnitude, spatially limited to the PDA, medium-term in duration, occurring continuously, and reversible.

8.3.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual environmental impacts of the Project on surface water and groundwater resources are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Section 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.5 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on surface and groundwater resources.

Table 8.5 Summary of Project Residual Environmental Impacts on Surface Water and Groundwater Resources

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in Surface Water Quantity / Quality									
Construction	A	L	L	MT	S–C	R	L	N	H
Operation and Maintenance	A	L	L	MT	S–C	R	L	N	H
Decommissioning	A	L	S	MT	C	R	L	N	H
Residual Change in Groundwater Quantity / Quality									
Construction	A	L	L	MT	S	R	L	N	H
Operation and Maintenance	A	L	L	MT	S	R	L	N	H
Decommissioning	A	L	S	MT	C	R	L	N	H

Table 8.5 Summary of Project Residual Environmental Impacts on Surface Water and Groundwater Resources

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.3.5 Deficiencies, Challenges, and Prediction Confidence

Due to the completion of a Project-specific Drainage Assessment (Appendix B) that included stormwater runoff modelling, the level of confidence regarding the predicted residual Project-related change in surface water quantity / quality is slightly higher than it is for the predictions that are based on qualitative assessment of Project-related changes in groundwater quantity / quality. However, the predictions in Table 8.5 above have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

8.3.6 Follow-up and Monitoring

No VC-specific follow-up and monitoring plans are proposed.

8.4 FLORA AND FAUNA

8.4.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with flora and fauna species and their habitats. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on flora and fauna is focused on the following potential changes to the environment:

- Change in flora / flora habitat (as measured through the amount [m^2] of habitat directly or indirectly [qualitative] lost or altered)
- Change in flora health / survival (as measured through the change in species occurrence [i.e., number of species and/or number of individual plants])
- Change in fauna habitat quantity / quality / use (as measured through the amount [m^2] of habitat directly or indirectly [qualitative] lost or altered)
- Change in fauna mortality risk (as measured through interactions with Project infrastructure and equipment [number of incidents recorded])

During the **construction phase** of the Project, flora and fauna could be impacted by the following:

- An adverse Project-related change in flora / flora habitat due to the alteration or loss of flora habitat associated with site preparation activities (e.g., the clearing of vegetation and levelling of soils), which will also result in the direct mortality of flora; the planting of high-protein grasses for grazing; and the potential deposition of dust and emissions for vehicles and machinery.
- An adverse Project-related change in flora health / survival due to the potential deposition of dust and emissions from vehicles and machinery.
- An adverse Project-related change in fauna habitat quantity / quality / use due to the alteration or loss of fauna habitat associated with site preparation activities (e.g., the clearing of vegetation and levelling of soils), the planting of high-protein grasses for grazing, and potential sensory disturbances from dust, noise, light, and other emissions.
- An adverse Project-related change in fauna mortality risk due to site preparation and the risk of collisions with vehicles or other Project infrastructure.

During the construction phase, the physical construction and equipment installation for Project components and the finalization and commissioning of the Project are expected to have no interaction with flora or fauna and their habitats, as these activities would take place on sites already disturbed during site preparation.

During the **operation and maintenance phase** of the Project, flora and fauna could be impacted by the following:

- An adverse Project-related change in flora / flora habitat and an adverse Project-related change in flora health / survival due to
  - the alteration of flora habitat associated with activities such as the grazing of sheep between the solar panels of the power plant, vegetation management and harvesting, and the bailing and storage of grass from the fodder pasture.
  - the potential deposition of dust and emissions associated with vehicle traffic within the Parish, the presence and operation of vehicles and equipment on-site as well as the on-site management of wastes generated by Project operation activities.
- An adverse Project-related change in fauna habitat quantity / quality / use due to potential sensory disturbances that could repel or deter species. These sensory disturbances may be caused by Project-related emissions of dust and other air contaminants, noise, and light, as well as visual disturbances associated with the presence and operation of the solar PV power plant, HyPCe area facilities, and supporting infrastructure, facilities, and utilities; Project-related vehicle traffic within the Parish; the on-site management of Project-related wastes; and the presence and operation of Project vehicles, heavy equipment, and machinery on-site.
- An adverse Project-related change in fauna mortality risk due to the risk of collisions associated with the presence and operation of Project components such as the solar panel arrays and supporting infrastructure, facilities, and utilities; Project-related vehicle traffic; and the presence and operation of Project vehicles, heavy equipment, and machinery on-site.

During operation and maintenance, re-use of mineralized by-product water from the water treatment plant is not anticipated to affect the flora and fauna and their habitats, as this water will be conveyed as needed to the agricultural facilities.

During the **decommissioning phase** of the Project, flora and fauna could be impacted by the following:

- An adverse Project-related change in flora / flora habitat and an adverse Project-related change in flora health / survival due to the potential deposition of dust and emissions from vehicles and machinery as Project components are dismantled and removed, through the on-site management of wastes generated during decommissioning activities, and during the re-establishment of natural drainage patterns, the recontouring and revegetation of disturbed areas, and the backfilling of ponds and ditches.
- An adverse Project-related change in fauna habitat quantity / quality / use due to potential sensory disturbances that could repel or deter species. These sensory disturbances may be caused by the dismantling and removal of Project components, the backfilling of ponds and ditches and re-establishment of natural drainage patterns, the recontouring and revegetation of disturbed areas, the on-site management of wastes generated during decommissioning activities, and the presence of Project decommissioning personnel.
- An adverse Project-related change in fauna mortality risk is expected, as there will be a continued risk of collisions with vehicles or potentially other Project equipment. However, overall mortality risk will be reduced as Project components are dismantled and removed.

Following decommissioning, flora/flora habitats are expected to return to baseline conditions over time.

8.4.2 Mitigation

Potential Project-related adverse environmental impacts on flora and fauna will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable.

The following VC-specific measures will also be implemented to reduce adverse effects on flora and fauna and their habitats:

- The mitigation measures identified in Section 8.2.2 with respect to the Atmospheric and Acoustic Environment VC will be implemented to mitigate the potential impacts of air, noise, vibration, and dust emissions on flora and fauna. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna.
- Only areas required for construction will be cleared, and construction equipment and vehicles will only operate in previously disturbed areas, where possible. Sensitive areas and habitats (if identified) will be fenced off to prevent damage by Project vehicles, heavy equipment, and machinery.
- The vegetation/tree screens, which are proposed for reducing visual impacts (refer to Section 8.5.2), will also reduce sensory disturbance to fauna off-site.
- Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce the attraction of birds.
- To reduce solar glare, lightly textured solar panels with built-in anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels.
- Native plants will be used for landscaping.
- Cleared areas will be revegetated, where possible.
- To avoid attracting wildlife, wastes will be securely stored, frequently removed from site, and properly disposed of in an environmentally acceptable manner at an approved site.
- Erosion and sediment control measures will be established to reduce the potential for silty water runoff from construction areas to migrate off-site and/or into environmentally sensitive areas. Further details regarding proposed erosion and sediment control measures are provided in Section 8.3.2 in the context of the Surface Water and Groundwater Resources VC. These measures are also included in the ESMP (Appendix I) to reduce potential impacts to flora and fauna.
- Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations.

8.4.3 Characterization of Residual Project-Related Impacts

The Project is anticipated to result in some adverse residual effects on flora and fauna; however, the risk to flora and fauna is expected to be negligible to low in magnitude given the relatively low number of species using the site and the absence of any species at risk. Adverse changes to flora / flora habitat; flora health / survival; fauna habitat quantity / quality / use; and fauna mortality risk will occur primarily during the construction phase during site preparation activities, while some habitat changes will occur continuously throughout the life of the Project (e.g., sensory disturbance) and a low but increased risk of mortality over baseline conditions will continue for birds during Project operation (e.g., potential for birds to collide with Project infrastructure during migration). With the proposed mitigation, these effects are anticipated to be negligible to low in magnitude, have a low likelihood of occurrence, and reversible. Project effects will be medium-term (construction phase) to long-term (operation and maintenance and decommissioning phases) in duration and occur continuously. All of the flora and fauna identified during a field survey conducted in support of a Project-specific Baseline Ecological Assessment (Appendix F) are common in Barbados and, following decommissioning, previously occupied habitats are expected to return to baseline conditions.

8.4.3.1 Characterization Residual Project-Related Changes in Flora / Flora Habitat and Flora Health / Survival

Construction

The PV power plant will occupy land formerly used for agriculture. The flora / flora habitat found within the PDA will be directly affected through the clearing of vegetation and levelling of soils, resulting in the loss or alteration of habitats present. Indirect effects on plant health and survival from dust and other emissions (e.g., vehicle exhausts) during site preparation activities may also occur and may extend into the AOI. However, none of the flora in the PDA or surrounding areas recorded during the baseline survey (Appendix F) are considered rare or at risk. The majority of the area to be cleared and levelled during construction consists of already cleared agricultural land and sugarcane fields (approximately 0.5 km^2, based on visual assessment during the baseline survey), and the remainder consists of sparse grass and shrubs (approximately 0.2 km^2), which are largely considered weeds. In addition, mitigation measures will be applied (e.g., dust suppression and emissions reduction) to reduce potential effects on the surrounding vegetation.

With the application of proposed mitigation, residual Project-related changes in flora / flora habitat and flora health / survival during construction are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, long-term in duration, occurring continuously, and reversible.

Operation and Maintenance

Vegetation clearing will occur during the construction phase, and therefore no additional loss of flora and flora habitat is expected to occur during operation and maintenance. However, the flora / flora habitat in will be altered from the solar grazing of sheep between the solar panels of the power plant, vegetation management, and the harvesting, bailing, and storage of grass from the fodder pasture. Solar grazing is an important part of the PV power plant's design, and there will be a higher proportion of high-protein

grasses being grown, thus altering existing habitats in the PDA. The sheep may also graze on other grasses and shrubs that may be freely growing in the PDA. However, the growth of these other grasses and shrubs will occur in the area previously cleared during construction.

As during construction, Project-related vehicle traffic within the Parish, the presence and operation of vehicles and equipment on-site, on-site management of wastes generated by Project activities, and the presence of Project operation and maintenance personnel may have indirect effects on plant health and survival from dust and other emissions, that may extend into the AOI. Standard mitigation measures and environmental protection practices will be implemented to reduce potential effects on the flora in the AOI.

With the application of proposed mitigation, residual Project-related changes in flora / flora habitat and flora health / survival during operation and maintenance are predicted to be adverse in direction, negligible to low in magnitude, spatially limited to the AOI, long-term in duration, occurring continuously, and reversible.

Decommissioning

The decommissioning phase is anticipated to return previously occupied flora habitats to baseline conditions as Project components are dismantled and removed, ponds and ditches are backfilled, natural drainage patterns are re-established, and disturbed areas are recontoured and revegetated. Flora / flora habitats are expected to regrow over time. Potential effects on the flora in the AOI from dust or other emissions generated during decommissioning activities will be reduced using standard mitigation and environmental protection procedures. Overall, Project-related changes in flora / flora habitat and flora health / survival are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, long-term in duration, occurring continuously, and reversible.

8.4.3.2 Characterization of the Residual Project-Related Changes in Fauna Habitat Quantity / Quality / Use and Fauna Mortality Risk

Construction

Vegetation clearing, levelling of soils, and the establishment of temporary construction laydown areas will have a direct effect on habitat. As indicated, most of the area that will be cleared consists of already cleared agricultural land and sugarcane fields, with approximately 0.2 km^2 comprised of grass and shrubs. This latter area is the only location in the PDA where birds were found during the 2021 baseline survey (Appendix F). However, the bird species observed in the PDA during the baseline survey are considered common in Barbados and would be expected to move into similar adjacent available habitats. Further, prior to any clearing activities, the vegetation and ground will first be searched for bird nests or other evidence of nesting activity. One bird species, the cattle egret (*Bubulcus ibis*), may potentially benefit during site preparation, as this species is known to follow tractors and other machinery as they flush prey out by their movement while clearing vegetation and levelling soil.

Construction vehicle traffic to and from the site, the presence and operation of construction vehicles and equipment on-site, on-site management of wastes generated by Project construction activities, and the presence of Project construction personnel may result in sensory disturbance (e.g., visual, noise, light and dust) to birds and other fauna that may extend into the AOI. The AOI for the Project partly encompasses an Important Bird Area (IBA) used by migratory species. None of the IBA migratory bird species were observed in the PDA or adjacent sampled habitat during the baseline survey nor are they expected to occur, as they are attracted to swampy areas rather than cleared, dry land with minimal vegetation. Standard and VC-specific mitigation measures will be applied to reduce potential sensory disturbance effects on surrounding habitats that may be used by birds and other fauna. Therefore, Project activities during the construction phase are not anticipated to result in a measurable change in habitat or mortality risk of the birds in the neighboring IBA, which is located approximately 1.2 km to the south of the PDA.

Project-related traffic and other equipment may also have a residual effect on the mortality risk of fauna through an increased collision risk as vehicles move to and from the site and as infrastructure is installed. Standard and VC-specific mitigation measures, including speed limits, limiting the areal extent of activities and operating equipment in previously disturbed areas, and the use of deterrents, if necessary, will reduce the potential mortality risk to fauna.

With the application of proposed mitigation, the residual Project-related changes in fauna habitat quantity / quality / use and fauna mortality risk during construction are predicted to be adverse in direction, low in magnitude, occurring continuously, and reversible. The residual Project-related change in fauna habitat quantity / quality / use is anticipated to be spatially limited to the AOI and long-term in duration, whereas the residual change in fauna mortality risk is anticipated to be spatially limited to the PDA and short-term in duration.

Operation and Maintenance

Vegetation clearing will occur during the construction phase and therefore no additional loss of fauna habitat will occur during operation and maintenance. Project vehicle traffic (which will be limited during operation and maintenance of the Project), the presence and operation of Project equipment, on-site management of wastes generated by Project operation and maintenance activities, and the presence of Project operation and maintenance personnel may result in indirect sensory disturbances (i.e., visual, noise, light, and dust) that may extend into the AOI. These may indirectly affect the fauna and their habitat by repelling or deterring species throughout the life of the Project. Standard and VC-specific mitigation measures will be implemented to reduce potential sensory disturbances to fauna and their habitat.

The presence and operation of the Project components such as the PV arrays and supporting infrastructure may have a direct effect on fauna mortality risk. PV panels may attract migratory bird species through the “lake effect”, where some birds may perceive the reflective surfaces as bodies of water, which may lead to collisions as they try to land (ECO Consult 2020, Hathcock 2018, and Walston et al. 2016). There are nearby ponds that are already used as rest sites (within the Project AOI, as well as the IBA), and therefore this could be an issue for birds in the area. To date no empirical research has been identified that evaluates the attraction of PV facilities to migrating waterfowl or songbird species

(Hathcock 2018, Walston et al. 2016), though anecdotal events have been noted (Kagan et al. 2014). There may also be a collision risk for birds associated with certain Project infrastructure, potentially including power lines (depending on final Project design). Injuries or mortalities observed will be documented and additional mitigation considered (e.g., panel markings) should any high-risk areas be identified.

With the application of proposed mitigation, the residual Project-related changes in fauna habitat quantity / quality / use and fauna mortality risk during operation and maintenance are predicted to be adverse in direction, negligible to low in magnitude, long-term in duration, occurring continuously, and reversible. The residual Project-related changes in fauna habitat quantity / quality / use are predicted to be spatially limited to the AOI while the residual change in fauna mortality risk is predicted to be spatially limited to the PDA.

Decommissioning

The decommissioning phase is expected to return fauna habitats to their original baseline conditions as Project components are dismantled and removed, ponds and ditches are backfilled, natural drainage patterns are reestablished, and disturbed areas are recontoured and revegetated.

Sensory disturbances (e.g., noise, light, visual, dust) generated during decommissioning activities will be reduced using standard mitigation and environmental protection procedures.

An adverse Project-related change in fauna mortality risk is expected, as there will be a continued risk of collisions with vehicles. However, the overall mortality risk will be reduced as Project components (e.g., solar panels) are dismantled and removed.

With the application of proposed mitigation, the residual Project-related changes in fauna habitat quantity / quality / use and fauna mortality risk during decommissioning are predicted to be adverse in direction, low in magnitude, long-term in duration, occurring continuously, and reversible. The residual Project-related changes in fauna habitat quantity / quality / use are spatially limited to the AOI while the residual Project-related changes in fauna mortality risk are spatially limited to the PDA.

8.4.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of routine Project on flora and fauna (i.e., residual Project-related changes in flora / flora habitat; flora health / survival; fauna habitat quantity / quality / use; and fauna mortality risk) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.4 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on flora and fauna. These predictions have been made with a moderate level of confidence for change in fauna mortality risk during operation and maintenance based on a high level of confidence for all other changes based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

Table 8.6 Summary of Project Residual Environmental Impacts on Flora and Fauna

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in Flora / Flora Habitat									
Construction	A	L	L	LT	C	R	L	N	H
Operation and Maintenance	A	N–L	L	LT	C	R	L	N	H
Decommissioning	A	L	L	LT	C	R	L	N	H
Residual Change in Flora Health / Survival									
Construction	A	L	L	LT	C	R	L	N	H
Operation and Maintenance	A	N–L	L	LT	C	R	L	N	H
Decommissioning	A	L	L	LT	C	R	L	N	H
Residual Change in Fauna Habitat Quantity / Quality / Use									
Construction	A	L	L	LT	C	R	L	N	H
Operation and Maintenance	A	N–L	L	LT	C	R	L	N	H
Decommissioning	A	L	L	LT	C	R	L	N	H
Residual Change in Fauna Mortality Risk									
Construction	A	L	S	MT	C	R	L	N	H
Operation and Maintenance	A	N–L	S	LT	C	R	L	N	M
Decommissioning	A	L	S	LT	C	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

The Project is anticipated to result in adverse residual effects on the Flora and Fauna VC. Adverse changes to flora and flora habitat and flora health and survival and fauna and fauna habitat and their mortality risk will occur primarily during the construction phase during site preparation activities, while some habitat changes will occur continuously throughout the Project's lifetime (e.g., sensory disturbance). With the proposed mitigation, these effects are anticipated to be negligible to low in magnitude, have a low likelihood of occurrence, and reversible. Project effects will be medium-term (construction phase) to long-term (operation and maintenance and decommissioning phases) in duration and occur continuously. All of the flora and fauna identified during the field survey conducted in support of the Project-specific Baseline Ecological Assessment (Appendix F) are common in Barbados and, following decommissioning, previously occupied habitats are expected to return to baseline conditions.

Overall, the predicted residual environmental effects from the Project do not threaten the long-term persistence or viability of the flora or fauna within the AOI and are not contrary to or inconsistent with the goals, objectives and activities of action plans and management plans. As such, residual environmental effects from routine Project activities are predicted to be not significant.

8.4.5 Deficiencies, Challenges, and Prediction Confidence

The flora and fauna survey conducted in support of the Baseline Ecological Assessment (Appendix F) identified the different habitats and flora and fauna found in the PDA and adjacent areas surveyed. Although there is a lack of seasonal data since the baseline study was only conducted during the wet season, the timing of the study (in mid-September 2021) coincided with the annual period during which migratory birds stopover in Barbados on their way to South America. This is the annual period during which the greatest diversity of species has potential to occur in or around the PDA.

8.4.6 Follow-up and Monitoring

Follow-up and monitoring will include regular monitoring for evidence of avian mortalities/collisions with Project infrastructure during the operation and maintenance phase.

8.5 VISUAL ENVIRONMENT

A Project-specific Visual Impact Assessment (VIA) (Appendix G) and a Project-specific Glint and Glare Study (Appendix H) were conducted in support of the ESIA:

- The VIA was conducted by way of field reconnaissance to select vantage points to assess the future visibility of the solar PV power plant when constructed. Potential visual impacts and mitigation measures were also considered as part of the VIA. The complete VIA report is provided in Appendix E, including photographs that were taken at each of the six vantage points of concern identified in the VIA.

- For the Glint and Glare Study, glare modelling software – Solar Glare Hazard Analysis Tool (SGHAT) – was used to estimate glare at eleven observation points and four route receptors (i.e., public roadways). The selected observation points have the potential of being in direct line of sight of the solar PV power plant, depending on the state of the surrounding vegetation. Five different panel configurations were modelled, including smooth panels with/without anti-reflective coating, lightly textured panels with/without anti-reflective coating, and deeply textured panels without anti-reflective coating. Detailed methods and results for the Glint and Glare Study are provided in Appendix H.

  Key findings and proposed mitigation measures from the VIA and Glint and Glare Study are considered where applicable in this assessment of potential Project-related environmental impacts on the visual environment.

8.5.1 Potential Project-Related Impacts

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with the visual environment by altering the visual landscape and aesthetics of the PDA and causing reflection (i.e., glint and glare) and lighting impacts that could cause sensory (visual) disturbance to adjacent and nearby land users. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on the visual environment is focused on the following potential changes to the environment:

- Change in visual landscape / aesthetics
- Change in reflection conditions (i.e., glint and glare[8])
- Change in lighting conditions

During the **construction phase** of the Project, the visual environment could be impacted by the following:

- An adverse Project-related change in visual landscape / aesthetics due to physical alteration of the PDA – which currently consists primarily of sugarcane and rotational crops – through site preparation activities and the physical construction and installation of Project components. There will also be an adverse Project-related change in visual landscape / aesthetics associated with the presence of Project-related vehicle traffic within the Parish; the presence of Project vehicles, heavy equipment, and machinery on-site; the on-site management of Project-related wastes (e.g., overburden stockpiles); and the presence of Project personnel.
- An adverse Project-related change in lighting conditions due to the use of artificial night lighting to illuminate work areas as needed to carry out Project construction activities safely and effectively.

[8] "Glint" refers to a momentary flash of light from a reflective surface, which can cause discomfort to those impacted, while "glare" is generally described as direct sunlight or reflected sunlight from a surface for an extended duration.

During the **operation and maintenance phase** of the Project, the visual environment could be impacted by the following:

- An adverse Project-related change in visual landscape / aesthetics due to the new presence of the Project energy facility (including a ground-mounted solar PV power plant and associated energy storage and management systems); Project agricultural facilities (including a fodder pasture, sheep pens, barn, feed silo, and other buildings) and solar grazing sheep; and supporting Project infrastructure, facilities, and utilities; as well as the continued presence of Project vehicles, heavy equipment, machinery, and personnel.
- An adverse Project-related change in reflection conditions due to the potential glint and glare impacts associated with the presence of an array of 96,154 solar panels.
- An adverse Project-related change in lighting conditions due to the use of artificial night lighting to illuminate the site as needed for security purposes and to carry out operation and maintenance activities safely and effectively.

During the **decommissioning phase** of the Project, the visual environment could be impacted by the following:

- An adverse Project-related change in visual landscape / aesthetics due to physical alteration of the PDA to return it to conditions that are consistent with the desired land use of the Project Property by the landowner, which will include the dismantling and removal of Project components, the backfilling of ponds and ditches and re-establishment of natural drainage patterns, and the recontouring and revegetation of disturbed areas. There will also be an adverse Project-related change in visual landscape / aesthetics associated with the presence of Project-related vehicle traffic within the Parish; the presence of Project vehicles, heavy equipment, and machinery on-site; the on-site management of Project-related wastes (e.g., demolition wastes, topsoil and overburden stockpiles); and the presence of Project personnel.
- An adverse Project-related change in lighting conditions due to the use of artificial night lighting to illuminate work areas as needed to carry out Project decommissioning activities safely and effectively.

8.5.2 Mitigation

Potential Project-related adverse environmental impacts on the visual environment will be mitigated through implementation of the standard environmental protection procedures discussed in Section 3.7.2, as applicable.

The following VC-specific measures will also be implemented to reduce adverse effects on the visual environment:

- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted in areas where potential off-site visual impacts are of such a nature and magnitude that warrants the introduction of vegetation/tree screens. During the growing-in period of the vegetation/tree screens, the perimeter fencing around the PDA will be fitted with an opaque privacy screen.

- Artificial lighting will be limited to the amount required for safety and security purposes and will be directional or otherwise designed to reduce spill-over light (i.e., unwanted outdoor light shining further than anticipated) wherever feasible without compromising site safety or security. Full cut-off lighting will be used wherever possible. Where full cut-off lighting cannot be used, lights will be side-shielded and directed downward to reduce visual impacts.
- To reduce solar glare, lightly textured solar panels with anti-reflective coating, or adequate alternate technology, will be used to reduce the light reflecting from the panels.
- An adaptive management approach will be employed if complaints regarding glint and glare are received from local residents or other surrounding land users, potentially including implementation of some or all of the following mitigation measures:
  - the establishment of additional and/or taller vegetation/tree screens and/or additional opaque privacy screens to further shield or obscure offending panels so that they cannot be seen
  - replacement of the offending solar panels with those that have a deeply textured surface, to reduce glare intensity
  - removal or reorientation of the offending solar panels

    More generally, if complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

8.5.3 Characterization of Residual Project-Related Impacts

8.5.3.1 Characterization of Residual Project-Related Changes in Visual Landscape / Aesthetics

The results of the VIA (Appendix G) indicate that the PDA is at least partially visible from all directions. Although there are some existing screens (e.g., vegetation at Bushy Park and Harrow Plantation Road), screens are not present along the entire length of the PDA boundary. Proposed mitigation measures include the establishment of additional screens to hide the solar PV power plant from ground-level receptors in all directions from the PDA. However, even with the establishment of additional screens, the solar PV power plant will remain visible to vantage points of upper floors of buildings and from tall structures. There are several two storey houses along the southern PDA boundary that may retain partial views of the site. Since the PDA boundaries are unobstructed by terrain, observers can have wide views of the area.

With the application of proposed mitigation, residual Project-related changes in visual landscape / aesthetics during the construction phase and the decommissioning phase are predicted to be adverse in direction, moderate in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible. During the operation and maintenance phase, residual Project-related changes in visual landscape / aesthetics are predicted to be similar but low in magnitude. Following the completion of decommissioning activities, it is anticipated that the PDA will return to physical and visual conditions that are similar to baseline and/or are consistent with the desired land use of the Project Property by the landowner.

8.5.3.2 Characterization of Residual Project-Related Changes in Reflection Conditions (i.e., Glint and Glare)

When glare was modelled for smooth or lightly textured solar panels, the results of the Glint and Glare Study (Appendix H) predict potential glint and glare impacts at 9 out of 11 observation points and 4 out of 4 route receptors. The entirety of the glare that is predicted to result from smooth and lightly textured solar panels is classified as a “moderate potential hazard”, meaning that glare will be present and will have potential to leave a temporary after-image of the glare (i.e., a lingering image of the glare in the field of view) but will not be strong enough to cause permanent eye damage. Smooth panels are predicted to generate less glare than lightly textured panels, and anti-reflective coating is predicted to have a detrimental effect when applied to smooth panels and a beneficial effect when applied to lightly textured panels. Several trends were observed from the model results regarding smooth and lightly textured panels. Receptors to the west of the PDA are predicted to experience glare during the morning hours (just after sunrise) while receptors to the east of the PDA are predicted to experience glare during the evening hours (just before sunset). The low angle of the sun at these hours provides an opportunity for sunlight to reflect off panels at a shallow angle and possibly affect receptors. It should be noted that the thick vegetation/tree screen, recommended as a mitigation measure, was not included in the model.

Deeply textured panels are predicted to produce far more glare-minutes than any other configuration, although at a lesser intensity. When glare was modelled for deeply textured panels, the results of the Glint and Glare Study predict extended periods of glare at 10 out of 11 observation points and 4 out of 4 route receptors. However, the glare from deeply textured panels is classified as a “low potential hazard” (i.e., glare will be present with a low potential for a temporary after-image).

The Glint and Glare Study notes that impacts to the receptors identified, where glare is predicted, 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 the PDA which are not accounted for in the model. Several receptors had a clear line of sight to a portion of the proposed solar PV array and the rest were chosen based on their proximity to the PDA or due to the possibility of vegetation being cleared in the future.

The Glint and Glare Study further notes that, to attain maximum efficiency, solar panels are designed to absorb as much light/solar energy as possible (rather than reflect it); PV panels usually reflect 2% of incident sunlight. Thus, glint and glare effects of solar panels are generally minimal when compared to other reflective surfaces such as water, fresh snow, and steel (e.g., metal sheeted roofs).

With the application of proposed mitigation (i.e., use of thick vegetation/tree screens and additional adaptive management measures should complaints be received), residual Project-related changes in reflection conditions during the operation and maintenance phase are predicted to be adverse in direction, moderate in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible. No pathways for potential Project-related changes in reflection conditions have been identified for the construction or decommissioning phases of the Project. Project construction and decommissioning activities are therefore not anticipated to result in a residual change in reflection conditions.

8.5.3.3 Characterization of Residual Project-Related Changes in Lighting Conditions

It is anticipated that several of the mitigation measures that are proposed in Section 8.5.2 to reduce potential adverse Project-related changes in visual landscape / aesthetics will also serve to reduce adverse Project-related changes in lighting, as they will help obscure views of the PDA for off-site receptors.

With the application of proposed mitigation, residual Project-related changes in lighting conditions during the construction, operation and maintenance, and decommissioning phases are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible.

8.5.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual environmental impacts of the Project on the visual environment (i.e., residual Project-related adverse changes in visual landscape / aesthetics, reflection conditions (i.e., glint and glare), and lighting conditions) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.6 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on the visual environment. These predictions have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

Table 8.6 Summary of Project Residual Environmental Impacts on The Visual Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Change in Visual Landscape / Aesthetics									
Construction	A	M	L	MT	C	R	L	N	H
Operation and Maintenance	A	L	L	MT	C	R	L	N	H
Decommissioning	A	M	L	LT	C	R	L	N	H
Change in Reflection Conditions (i.e., Glint and Glare)									
Construction	No pathways for potential Project-related changes in reflection conditions have been identified for the construction phase of the Project (refer to Section 8.5.1). Project construction activities are therefore not anticipated to result in a residual change in reflection conditions.								

Table 8.6 Summary of Project Residual Environmental Impacts on The Visual Environment

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Operation and Maintenance	A	M	L	MT	C	R	L	N	H
Decommissioning	No pathways for potential Project-related changes in reflection conditions have been identified for the decommissioning phase of the Project (refer to Section 8.5.1). Project decommissioning activities are therefore not anticipated to result in a residual change in reflection conditions.								
Change in Lighting Conditions									
Construction	A	L	L	MT	C	R	L	N	H
Operation and Maintenance	A	L	L	MT	C	R	L	N	H
Decommissioning	A	L	L	MT	C	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.5.5 Deficiencies, Challenges, and Prediction Confidence

Due to the completion of a Project-specific Glint and Glare Study (Appendix H), which included glare modelling, the level of confidence regarding the predicted residual Project-related change in reflection conditions (i.e., glint and glare) is relatively higher than it is for the predictions that are based on qualitative assessment of Project-related changes in visual landscape / aesthetics and lighting conditions. However, an important limitation of the SGHAT software that was used for the glare modelling is that it

only applies to reflective surfaces on flat topography and does not account for the detailed geometry of a solar array system constructed on variable topography (e.g., gaps between modules, variable heights of PV arrays and support structures), which could impact glare results.

8.5.6 Follow-up and Monitoring

There are no follow-up and monitoring plans proposed.

8.6 AGRICULTURE AND OTHER LAND USES

A Project-specific Agricultural Impact Assessment (AIA) was completed in support of the ESIA, as an AIA is required for any development proposal that may result in alienation or fragmentation of food and agricultural land or when development is proposed adjacent to such lands. The AIA report, which evaluates the potential impacts of Project activities on existing agricultural operations and recommends ways to avoid or mitigate adverse impacts, is provided in Appendix C. Key findings and proposed VC-specific mitigation measures from the AIA report are considered where applicable in this assessment of potential Project-related environmental impacts on agriculture and other land uses. The AIA also outlines general (not VC-specific) measures for site management and the control of dust, noise, and sediment, as well as waste management; these measures have been incorporated where applicable in Section 3.7.2 and in the Project-specific ESMP (Appendix I).

8.6.1 Potential Project-Related Impacts

The Project will alter the existing agricultural land within the PDA, which is currently used for sugarcane farming, and introduce a new agricultural use (i.e., a commercial Blackbelly sheep farming operation). Other existing surrounding land uses that could be affected by the Project include residential and commercial developments as well as tourism/recreation and historical/cultural facilities (e.g., Bushy Park Raceway, Sunbury Greathouse, and Bushy Park Cemetery).

Activities and components associated with Project construction, operation and maintenance, and decommissioning could potentially interact with agriculture and other land uses. In consideration of the potential Project-VC interactions identified in Table 8.1, the assessment of Project-related environmental impacts on agriculture and other land uses is focused on the following potential changes to the environment:

- Change in the quantity / quality of agricultural land
- Change in other (non-agricultural) land use

During the **construction phase** of the Project, agricultural and other land uses could be impacted by the following:

- An adverse Project-related change in the quantity / quality of agricultural land due to
  - the loss of arable production within the PDA.
  - potential sensory disturbance and nuisance impacts from noise, vibration, and dust emissions associated with the operation of Project construction vehicles, heavy equipment, and machinery.

- An adverse Project-related change in other (non-agricultural) land use due to potential sensory disturbance and nuisance impacts from noise, vibration, and dust emissions associated with the operation of Project construction vehicles, heavy equipment, and machinery.

During the **operation and maintenance phase** of the Project, agricultural and other land uses could be impacted by the following:

- An adverse Project-related change in the quantity / quality of agricultural land due to the continued loss of arable production within the PDA.
- A positive (i.e., beneficial) Project-related change in the quantity / quality of agricultural land due to the introduction of a commercial Blackbelly sheep farming operation within the PDA.
- An adverse Project-related change in the quantity / quality of agricultural land and/or an adverse Project-related change in other (non-agricultural) land use due to potential sensory disturbance and nuisance impacts from Project-related noise, dust emissions, odours (e.g., from the operation of Project agricultural facilities), and visual impacts (e.g., from reflections [glint and glare] and site lighting).
- An adverse Project-related change in other (non-agricultural) land use due to the potential for the inverters associated with the solar PV power plant to produce radio frequency emissions, which is a form of electromagnetic interference that could impact radio receivers, communication devices, and navigational aids.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, agricultural and other land uses could be impacted by an adverse Project-related change in the quantity and quality of agricultural land and/or an adverse Project-related change in other (non-agricultural) land use due to potential interactions with the emissions, discharges, and wastes identified in Section 3.6.

During **all phases** of the Project **(i.e., construction, operation and maintenance, and decommissioning)**, agricultural and other land uses could also be impacted by potential drainage and runoff impacts and associated changes to the quantity / quality of surface water and/or groundwater resources. These potential impacts are assessed separately in Section 8.3, in the context of potential Project-related environmental impacts on surface water and groundwater resources.

8.6.2 Mitigation

Potential Project-related adverse environmental impacts on agriculture and other land uses will be mitigated through implementation of the standard environmental protection procedures outlined in Section 3.7.2, as applicable, as well as implementation of the VC-specific mitigation measures proposed in Section 8.2.2, Section 8.3.2, and Section 8.5.2, for the Atmospheric and Acoustic Environment VC, the Surface Water and Groundwater Resources VC, and the Visual Environment VC, respectively.

The following VC-specific mitigation measures will also be implemented to reduce Project-related adverse effects on agriculture and other land uses:

- Project-specific sediment, dust control, and noise management measures are included in the ESMP (Appendix I) to reduce potential sensory/nuisance impacts to nearby land users (e.g., agricultural workers on the site or on adjacent lands), residents, businesses, and other off-site receptors. The ESMP also includes details of how RSB will liaise with the local community before each phase of development.
- Project activities will be timed to avoid undue nuisance to off-site receptors (e.g., by limiting construction activities to between the hours of 7:00 and 17:00 on weekdays and between the hours of 8:00 and 14:00 on Saturdays, with no work on Sundays).
- Thick vegetation/tree screens with heights of at least 3 m (10 feet) will be planted along portions of the site boundary that are close to off-site receptors and will act as a buffer to adjoining lands. RSB will consult with neighboring landowners and request that the spraying of herbicides on adjoining fields be limited to days that are not windy in order to reduce dispersion onto the operational renewable energy facility and the sheep farm.
- If complaints are received from agricultural or other land users regarding perceived Project-related impacts, RSB will work with the affected land users to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

With respect to the mitigation of potential Project-related impacts associated with electromagnetic interference, the inverters will be sited at least 46 m away from the EMS, since electromagnetic fields typically reach background levels at a distance of approximately 46 m (150 feet) away from inverters (REPO 2017). The U.S. Department of the Navy's Renewable Energy Program Office also recommends establishing a minimum setback distance of approximately 76 m (250 feet) between an airfield radar system and the leading edge of a PV array or any of its ancillary support equipment (REPO 2017).

8.6.3 Characterization of Residual Project-Related Impacts

The Project is generally anticipated to result in adverse residual impacts on agriculture and other land uses. However, the proposed use of the PDA for sheep farming will result in a positive (i.e., beneficial) Project-related change in the quantity / quality of agriculture land that will partially offset the residual adverse Project-related change in the quantity / quality of agricultural land associated with the loss of arable production at Harrow Plantation. Residual Project-related adverse changes to the quality and quantity of agricultural land and to other (non-agricultural) land use will occur primarily during the construction and operation and maintenance phases. Following decommissioning, the PDA is expected to return to baseline conditions.

The shift from solely arable production to sheep farming and renewable energy production will result in the loss of approximately 36 ha (90 acres) of arable land within the PDA, which occupies a total of approximately 73.2 ha of agricultural land within the larger (approximately 123.0 ha) Harrow Plantation. The approximately 49.8 ha of remaining Harrow Plantation lands are expected to continue to be used for agricultural purposes, with all of Harrow Plantation's productive land to the north of the PDA anticipated to

remain in mainly sugarcane production, managed and operated by BAMC. There will be no fragmentation or alienation of the remaining plantation lands due to the simple manner in which the overall plantation is being divided to accommodate Project facilities. The viability of the continuation of sugarcane production at Harrow Plantation will depend on external factors unrelated to the Project, and there is also scope for other crops to potentially be introduced at Harrow Plantation in the future. While the lands of Harrow Plantation are flat and therefore suitable for mechanical sugarcane production, yields are affected by low rainfall and poorer quality soils.

Construction impacts on the PDA and surrounding area will occur over a relatively short period of time and can be managed. The most common impacts are dust and noise which can affect those employed on adjacent agricultural lands, and neighbouring residents. Adjoining agricultural lands of Harrow Plantation and other plantations could potentially experience dust and drainage impacts. The Project-specific AIA (Appendix C) that was carried out in support of the ESIA recommends mitigation measures aimed at reducing potential dust impacts and these are included in the ESMP (Appendix I). Noise impacts will be inevitable, and the contractor will implement mitigation measures to reduce this to the extent possible. Other construction mitigation measures will be implemented aimed at site management as outlined in Section 3.7.2.

The AIA (Appendix C) concludes that the Project will have a limited impact on the agricultural activities of the remaining lands of Harrow Plantation (i.e., outside of the PDA) by virtue of the benign nature of the proposed Project, together with the fact that agricultural activity (i.e., commercial sheep farming) will continue at the site.

With respect to the potential for electromagnetic interference to adversely impact other land users, the only Project components that are capable of producing radio frequency emissions are the inverters associated with the solar PV power plant. Although there is potential for radio frequency emissions from solar PV systems to block nearby radar emissions of the type that is typically used by airport control towers, ground-mounted solar PV systems (such as the Project) generally tend to have a low profile/height relative to radar surveillance equipment, which is typically located on elevated towers or platforms (NREL 2017). No airfields or airports are located within approximately 76 m of the PDA, which is the minimum recommended setback distance that should be established between an airfield radar system and the leading edge of a PV array or any of its ancillary support equipment (REPO 2017).

8.6.3.1 Characterization Residual Project-Related Changes in Quantity / Quality of Agricultural Lands

As discussed in Section 3.7.1, the introduction of the sheep farming operation as part of the Project is anticipated to partially offset the adverse change associated with the loss of arable production within the PDA.

With the application of proposed mitigation, residual Project-related changes in the quantity / quality of agricultural land during the construction phase and the operation and maintenance phase are generally predicted to be adverse in direction, moderate in magnitude, spatially limited to the AOI, medium-term in duration, ranging in frequency from occurring sporadically at irregular intervals (for sensory disturbance) to occurring continuously (for the loss of arable production within the PDA), and reversible.

Following decommissioning activities and the implementation of mitigation strategies, the PDA is expected to be viable for re-instatement to baseline conditions. For the decommissioning phase itself (i.e., the activities associated with removal of infrastructure and rehabilitation of the site), Project related changes in the quantity and/or quality of agricultural lands are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, continuous, and reversible.

8.6.3.2 Characterization of Residual Project-Related Changes in Other (Non-Agricultural) Land Use

With the application of proposed mitigation, residual Project-related changes in other (non-agricultural) land use during the construction phase are predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring sporadically at irregular intervals, and reversible. If pile driving is required during construction, it would be expected to temporarily raise the magnitude of residual sensory disturbance and nuisance impacts to moderate. However, potential pile driving activities (if required) will be short-term in duration (i.e., occurring for approximately 16 weeks out of the 24-month construction period).

With the application of proposed mitigation, the residual Project-related change in other (non-agricultural) land use during the operation and maintenance phase is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, and reversible. The frequency of the residual impact is predicted to be continuous with respect to noise associated with operation of the Project energy facility, odours from the operation of Project agricultural facilities, and visual impacts, but is anticipated to range from occasional to regular for residual sensory disturbance and nuisance impacts associated with general facilities maintenance, and from sporadic to regular for residual sensory disturbance and nuisance impacts associated with sheep farming.

Similar to construction, the residual Project-related change in other (non-agricultural land use) as a result of decommissioning activities is predicted to be adverse in direction, low in magnitude, spatially limited to the AOI, medium-term in duration, occurring continuously, and reversible.

8.6.4 Significance Determination and Summary of Impact Assessment

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of the Project on agriculture and other land uses (i.e., a residual Project-related adverse change in the quantity / quality of agricultural land, a residual Project-related positive change in the quantity / quality of agricultural land, and a residual Project-related changes in other [non-agricultural] land use) are predicted to be not significant. This significance determination applies to the residual impacts of routine Project activities; potential cumulative environmental impacts are assessed separately in Chapter 10 and the potential environmental impacts of accidents, malfunctions, emergencies, and disasters are assessed separately in Section 8.7.

Table 8.7 summarizes the residual impact characteristics and significance determinations for the assessment of Project-related environmental impacts on agricultural and other land uses. These predictions have been made with a high level of confidence based on a good understanding of the general environmental impacts of Project activities and the effectiveness of standard mitigation measures.

Table 8.7 Summary of Project Residual Environmental Impacts on Agricultural and Other Land Uses

Project Phase	Residual Environmental Impact Characteristics							Significance	Prediction Confidence
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability		
Residual Change in the Quantity / Quality of Agricultural Land									
Construction	A	M	L	MT	S–C	R	L	N	H
Operation and Maintenance	A	M	L	MT	S–C	R	L	N	H
Decommissioning	A	L	L	MT	C	R	L	N	H
Residual Change in Other (Non-Agricultural) Land Use									
Construction	A	L–M	L	ST–MT	S	R	L	N	H
Operation and Maintenance	A	L	L	MT	C	R	L	N	H
Decommissioning	A	L	L	MT	C	R	L	N	H

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

8.6.5 Deficiencies, Challenges, and Prediction Confidence

No deficiencies or challenges have been identified in relation to the environmental impact assessment for this VC.

8.6.6 Follow-up and Monitoring

No VC-specific follow-up and monitoring plans are proposed.

8.7 ACCIDENTS, MALFUNCTIONS, EMERGENCIES, AND DISASTERS

Subsection 8.7.1 below assesses the potential impacts of accidental events on the biophysical/ecological and anthropogenic environment (i.e., atmospheric and acoustic environment, surface water and groundwater resources, flora and fauna, visual environment, and agriculture and other land use). The potential impacts of accidental events on the social environment are considered separately in Section 9.2.

Subsection 8.7.2 below focuses on the potential impacts of climate change and natural disasters on the Project.

8.7.1 Accidents, Malfunctions, Emergencies, and Disasters

Table 8.8 identifies potential accidents, malfunctions, and emergencies that could occur during the construction, operation and maintenance, and decommissioning phases of the Project.

Table 8.8 Potential Project-Related Accidents, Malfunctions, Emergencies, and Disasters

Potential Accidents, Malfunctions, Emergencies, and Disasters	Potential Causes of Incident
Spills or leaks of petroleum products, hydraulic fluids, lubricants, or coolants during Project construction, operation and maintenance, or decommissioning	• Improper transportation, storage, handling, or use of petroleum products, hydraulic fluids, or lubricants • A malfunction or mechanical failure due to improper operation or maintenance of Project vehicles, heavy equipment, or machinery • A collision, roll-over, other accidental event, or natural disaster resulting in physical damage to Project vehicles, heavy equipment, or machinery
Spills or leaks of the KOH solution used as an electrolyte in the process of alkaline electrolysis during Project operation and maintenance	• Improper transportation, storage, handling, or use of KOH solution • A malfunction due to improper operation or maintenance of electrolyser equipment • A vehicle collision, other accidental event, or natural disaster resulting in physical damage to electrolyser equipment • Improper removal, handling or transportation of used KOH solution at the end of its useful life
Spills or leaks of oil from electrical transformers during Project operation and maintenance	• Improper transportation, storage, handling, or use of transformer oil • A malfunction due to improper operation or maintenance of electrical transformer equipment • A vehicle collision, other accidental event, or natural disaster resulting in physical damage to electrical transformer equipment • Improper handling of transformer oil during operational sampling and testing activities • Improper removal, handling or transportation of used transformer oil at the end of its useful life

Table 8.8 Potential Project-Related Accidents, Malfunctions, Emergencies, and Disasters

Potential Accidents, Malfunctions, Emergencies, and Disasters	Potential Causes of Incident
Loss of containment (LOC) of flammable vapours from battery modules within the BESS during Project operation and maintenance	• Ruptures or leaks from battery modules within the BESS, which could occur as a result of the following: – A malfunction due to improper operation or maintenance of battery modules – A vehicle collision, other accidental event, or natural disaster causing physical damage to battery modules • Upset conditions such as fires within the BESS, runaway chemical reactions, or other accidents or malfunctions
LOC of hydrogen gas (H_2) from the HESS during Project operation and maintenance	• Ruptures or leaks from H_2 storage tanks, process piping, electrolysers, or fuel cells, which could occur as a result of: – A malfunction due to improper operation or maintenance of these components – A vehicle collision, other accidental event, or natural disaster causing physical damage to these components • Upset conditions such as fires within the HESS, runaway chemical reactions, or other accidents or malfunctions

8.7.1.1 Potential Impacts of Accidents, Malfunctions, Emergencies, and Disasters on the Environment

An accident, malfunction, emergency, or disaster resulting in the release of hazardous materials (e.g., petroleum products, hydraulic fluids, lubricants, or coolants associated with Project vehicles, heavy equipment, or machinery; the KOH solution used as an electrolyte in the process of alkaline electrolysis; or the oil in electrical transformers) to the environment could result in the contamination of soil and/or water resources. Such an incident could potentially cause adverse changes to the quality and use of terrestrial habitat within the PDA, the quality and use of downstream aquatic habitat beyond the PDA, and the health and survival of affected terrestrial and aquatic biota. Birds are particularly vulnerable to potential injury or mortality when exposed to hydrocarbon contamination. The accidental release of hazardous materials could also conceivably adversely affect drinking water resources if contamination reaches the groundwater table, due to the presence of drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6) as well as several existing and proposed drainage systems within the PDA.

A Project-specific Quantitative Risk Assessment (QRA) was conducted to examine the potential consequences in the event of an accidental LOC of flammable vapours from the BESS or an accidental LOC of hydrogen gas from the HESS during the operation and maintenance phase of the Project. The full QRA report, including detailed methods and results, is provided in Appendix D. Completion of the QRA involved the following tasks:

- Source characterization of several LOC, including the following:
  - Estimated time-varying H_2 release rates in the event of storage, piping, electrolyser, or fuel cell ruptures or leaks
  - Flammable or toxic gas releases due to upset conditions associated with the BESS

- Consequence modelling to determine the extents of hazard zones for various combinations of release types, hazards, and meteorological conditions
- Risk modelling, which combines the results of the consequence modelling with the probability of a release occurring, to provide an estimate of the likelihood of harm on individual or societal bases

As described in Section 3.2.1.2, the Project energy facility will include a BESS and a HESS in the HyCPe area. The BESS will employ Li-ion batteries for the short-term storage of electricity. The HESS will produce gaseous hydrogen via water electrolysis and then store it in pressurized storage cylinders until it is eventually converted into electricity and water via fuel cells.

In the event of an accident, malfunction, emergency, or disaster that causes a rupture, leak, or other upset conditions, flammable vapours could potentially be released from the battery modules in the BESS or hydrogen gas could potentially be released from the H_2 storage cylinders, associated piping, electrolysers, or fuel cells in the HESS. The main hazards associated with the energy facility components in the HyCPe area are the potential fires or explosions that could result from ignition of the flammable vapours from the BESS or the hydrogen gas from the HESS, respectively.

Accidental releases of flammable vapours from the BESS or hydrogen gas from the HESS could result in the following hazardous events, which are assessed in the QRA (Appendix D):

- Flash fires
- Vapour cloud explosions
- Jet fires/fireballs
- Explosions from storage vessels or process containers

During an uncontrolled release within an enclosure (e.g., the electrolysers or battery storage enclosure), it is possible that combustible material could be vented from the enclosure and ignite outdoors, or that a fire could be initiated within the enclosure and potentially lead to thermal radiation exposure. However, based on the current design of the enclosed processes and the facility, the potential hazard extents from jet fires or explosions are anticipated to be much larger than the potential hazard extents from thermal radiation due to fires related to enclosure releases. Therefore, enclosure fires were not considered further in the QRA.

Hydrogen gas is not known to have toxic effects and the only expected hazard from H_2 inhalation is asphyxiation. Simple asphyxiation can occur if the concentration of a substance is sufficiently high enough that it displaces oxygen in the air. Based on NFPA 59a guidance (i.e., the National Fire Protection Association's S*tandard for the Production, Storage, and Handling of Liquefied Natural Gas*), the lethality limit is a 40% concentration of the contaminant (hydrogen), while irreversible harm occurs at a 23% concentration of the contaminant (NFPA 2019). Based on the current design of the HESS, concentrations that exceed these thresholds for asphyxiation are not expected to occur beyond the PDA boundary. The asphyxiation hazard was therefore not considered further in the QRA.

As part of the QRA, consequence modelling was completed for potential hazardous events – including consideration of a range of weather conditions, release scenarios, and configurations – to identify the maximum predicted distances to selected endpoints. The information obtained through this modelling exercise is included in Appendix D and can be used to inform emergency responders and assist in the development of emergency response plans.

The consequence modelling results were used as inputs to the subsequent risk modelling, which was conducted to evaluate the potential for harm at locations in the vicinity of the PDA. Risk modelling was completed with consideration of both the potential consequences and their likelihood of occurrence. The results of this risk modelling are included in Appendix D and considered in Section 8.7.1.3 below.

8.7.1.2 Mitigation

Mitigation measures related to the storage, handling, use, and end-of-life disposal/recycling of hazardous materials are described in Section 3.5 and Table 3.3 (in Section 3.7.2) of this ESIA. Table 3.3 also outlines relevant environmental protection procedures for spill prevention, control, and response in relation to these substances.

The BESS and HESS, as well as related utilities and auxiliary systems, will be centralized and contained within a secured and fenced HyPCe area that will be approximately 1.6 ha in size and located near the middle of the PDA (refer to Figure 3.2 and Figure 3.7). As described in Section 3.2.1.2, the HyPCe area will be specifically designed to mitigate the risks associated with the energy storage equipment (e.g., fire or explosion due to a battery malfunction or hydrogen leak), for the protection of Project personnel and the surrounding community:

- The BESS will be designed in accordance with applicable international standards, including NFPA 855 (NFPA's *Standard for the Installation of Stationary Energy Storage Systems*). Each unit will be individually sealed and separated to avoid fire propagation, with fusing and electrical protection adapted to shut-down each module individually if necessary. The units will have at least a 2-hour rating in accordance with ANSI/CAN/UL 9540A: 2019 (*Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*). The battery cells will be designed to withstand temperatures of up to 50°C. At the system level, HVAC and building management control systems will be able to shut the units down and put them in safe mode in the event that the range of safe operating conditions is exceeded. The ventilation system will also enable the safe evacuation of gases and flames through the top of the unit and passive deflagration venting to control the risk of fire and explosion. Fire detection systems will include integrated sensors and multi-spectrum infrared systems capable of detecting fire-related thermal or gas emissions.
- The HESS will similarly be designed in accordance with applicable international standards, including NFPA 2 (Hydrogen Technologies). The electrolysers and hydrogen fuel cells in the HESS will be housed in prefabricated and containerised enclosures that are actively ventilated to maintain a non-explosive atmosphere. The containers will be equipped with H_2 detectors (set to 20% of the lower explosive limit) and ventilation switch detectors.

The Project has been designed with a setback radius of more than 200 m between the HyPCe area fenceline and the PDA site boundary.

An Emergency and Disaster Management Plan has been prepared as part of the ESMP (Appendix I) to describe the recommended procedures and protocols to be carried out in the event of a natural, accidental, or human-induced emergency or disaster (e.g., explosion, fire, spill, or hurricane) at the Project facility. This Plan has been developed in consideration of the QRA (Appendix D), which identifies the maximum predicted distances to selected emergency planning endpoints based on the results of consequence modelling.

8.7.1.3 Characterization of Residual Impacts and Significance Determination

With the application of proposed mitigation, the residual Project-related environmental impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, coolants, KOH solution, or transformer oil are predicted to be adverse in direction and reversible. Depending on the volume and type of hazardous material that is spilled/leaked, residual impacts could range from low to high in magnitude, from the PDA to the AOI in geographic extent, and from short-term to medium-term in duration. The probability of occurrence is generally considered low for all volumes and types of potential hazardous material spills/leaks, but is relatively higher for smaller spills/leaks during activities such as refueling. Refueling will be conducted at designated sites furnished with spill containment equipment and will be sited away from watercourses and drainage works where possible. An accidental spill of a large volume of bulk hazardous materials (i.e., fuel, lubricant, or KOH solution) is considered unlikely due to the planned storage of these substances in secure areas equipped with bund walls and impervious flooring for additional spill containment. Other hazardous materials will not be stored in large quantities on-site, and secondary containment (e.g., drip trays) will be used in areas of storage and transfer. Spill response kits will also be available on-site.

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil could be significant for the Surface Water and Groundwater Resources VC and the Agriculture and Other Land Uses VC but are predicted to be not significant for the remaining biophysical/ecological and anthropogenic VCs. These significance determinations are based on the considerations outlined in Table 8.9.

Table 8.9 Potential Significance of the Residual Impacts of an Accidental Spill or Leak of Hazardous Materials on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Atmospheric and Acoustic Environment	• A residual Project-related reduction in air quality beyond the PDA such that the maximum ground-level air contaminant concentration associated with the Project, in combination with the conservative background concentration, frequently exceeds the applicable ambient air quality standard.	Although an accidental spill of a large volume of hazardous material could conceivably cause a one-time residual reduction in air quality (e.g., due to the volatilization of hydrocarbons), the associated air emissions would not be anticipated to frequently exceed the applicable ambient air quality standard(s).	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on the atmospheric and acoustic environment are predicted to be **not significant**.
Surface Water and Groundwater Resources	• A residual Project-related reduction in groundwater quality to the point where the yield from an established groundwater supply aquifer or well is no longer suitable or adequate for its intended use • A residual Project-related contravention of an applicable watershed management target	One or both of the identified significance criteria/thresholds could be exceeded in the event that an accidental spill of a large volume of hazardous materials infiltrates and percolates to groundwater zones via existing and proposed on-site infiltration wells (suckwells) and the runoff interceptor drainage system that is proposed along the entire southern boundary of the PDA (as described in Appendix B and Section 8.3). The accidental release of hazardous materials could conceivably adversely affect drinking water resources if contamination reaches the groundwater table, due to the presence of drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6) as well as several existing and proposed drainage systems within the PDA.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on surface water and groundwater resources **could be significant** (depending on the magnitude of the accidental spill or leak).

Table 8.9 Potential Significance of the Residual Impacts of an Accidental Spill or Leak of Hazardous Materials on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Flora and Fauna	• A residual Project-related change in terrestrial habitat that would alter its status or integrity within the RSA	There is an IBA located within the RSA, approximately 1.2 km to the south of the PDA, and birds are particularly vulnerable to potential injury or mortality when exposed to hydrocarbon contamination. Due to the proximity of the IBA and ponds in the area, there is potential for several species of birds to occur in the vicinity of the PDA, including restricted-range birds. However, they would not be expected to use the PDA as there is no water to attract them. Thus, even a large accidental spill of petroleum hydrocarbons would not be anticipated to alter the status or integrity of the PDA as terrestrial habitat for birds within the RSA.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on flora and fauna are predicted to be **not significant**.
Visual Environment	• A residual Project-related change to the environment that results in high-intensity glare with the potential to cause permanent eye damage if observed by receptors beyond the PDA, or glint and glare impacts that otherwise represent a public health and safety hazard	Potential accidental spills/leaks of hazardous materials would not be anticipated to result in glint or glare impacts, nor would they be anticipated to interact with the Visual Environment VC since they would likely not be visible to off-site receptors beyond the PDA.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on the visual environment are predicted to be **not significant**.

Table 8.9 Potential Significance of the Residual Impacts of an Accidental Spill or Leak of Hazardous Materials on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Agriculture and Other Land Uses	• A residual Project-related change to the environment that results in non-compliance with established land use plans, policies, or by-laws • A residual Project-related change to the environment that results in incompatibility with adjacent or historical land use activities as designated through a regulatory land use process.	Both the current PDP (Government of Barbados 2003) and the draft amended PDP (Government of Barbados 2017) designate Harrow Plantation (including the PDA) as agricultural land and contain policy requirements related to the conservation of designated agricultural lands. Harrow Plantation (including the PDA) also falls within the boundaries of a designated Soil Protection Overlay that is identified in the 2017 draft amended PDP and is intended to safeguard agricultural lands. It is therefore anticipated that the residual impacts of a large accidental spill of hazardous materials at Harrow Plantation could constitute non-compliance with the PDP or other established land use plans, policies, or by-laws, and/or could be otherwise incompatible with adjacent or historical land use activities as designated through a regulatory land use process.	The residual adverse impacts of a potential accidental spill or leak of petroleum products, hydraulic fluids, lubricants, KOH solution, or transformer oil on agriculture and other land uses **could be significant** (depending on the magnitude of the accidental spill or leak).

Note:

* This table presents only those significance criteria/thresholds that are considered to be the most relevant in the context of this assessment of potential residual environmental impacts that could arise as a result of Project-related accidents, malfunctions, emergencies, or disasters. The other VC-specific significance criteria/thresholds (i.e., those that are identified in Section 8.1.2.4 but not presented in this table) are considered less relevant for the purposes of this assessment, given the nature of the potential residual impacts and their pathways; it is assumed that none of those other significance criteria/thresholds will be exceeded for any VC in the event of a potential Project-related accident, malfunction, emergency, or disaster.

With respect to the potential consequences in the event of an accidental LOC of flammable vapours from the BESS or an accidental LOC of hydrogen gas from the HESS during the operation and maintenance phase of the Project, the results of the risk modelling conducted as part of the QRA (Appendix D) were compared to criteria published in NFPA 59a that are commonly used to assess risk acceptability throughout North America and the Caribbean. NFPA 59a recommends risk criteria based on the chances of a fatality or irreversible harm, otherwise known as individual risk. These risk criteria, or thresholds, are presented in Table 8.10.

Table 8.10 Risk Thresholds for Fatalities and Irreversible Harm

NFPA 59a Risk Zone	Permitted Developments	Individual Risk (Chances in a Million)	
		Fatalities	Irreversible Harm
1.	All land uses under the control of the plant operator or subject to an approved legal agreement	> 50	> 500
2.	General public areas excluding sensitive establishments	0.3–50	3–500
3.	No restrictions	< 0.3	< 3
Source: NFPA 2019.			

NFPA 59a Zone 3 applies to areas that have broadly acceptable risk levels without permitting restrictions; it is defined as the zone in which the individual risk of fatality is less than 0.3 chances in a million. Table 8.11 provides a comparison of common individual fatality risk levels for Barbados relative to the NFPA 59a Zone 3 individual fatality risk threshold. The fatality risk posed to the public in NFPA 59a Zone 3 is small in comparison to other risks.

Table 8.11 Comparison of Common Individual Fatality Risks in Barbados Relative to the NFPA 59a Zone 3 Individual Fatality Risk Threshold

Causes	Individual Risk of Fatality (Chances in a Million)
Motor Vehicle Accidents	77.7
Falls	14.4
Drowning	3.3
Fires	1.7
NFPA 59a Zone 3	< 0.3
Note: The individual risk data for motor vehicle accidents, falls, drowning, and fires is based on 2018 data for Barbados (WHO 2018).	

Individual incremental risk contour plots are presented in the QRA (Figures 7.2 and 7.3 in Appendix D). These modelled risk contours indicate that Project-related risk is predicted to be largely localized within the PDA, with risk levels for fatality or irreversible harm predicted to be less than the NFPA 59a Zone 3 risk thresholds at all locations beyond the PDA site boundary. Accordingly, the individual risk of fatality from the Project (i.e., in the event of an accident, malfunction, emergency, or disaster entailing LOC of flammable vapours from the BESS or LOC of hydrogen gas from the HESS) is estimated to be less than 0.3 chances per million outside of the PDA. The nearest permanent residence is located outside of the PDA boundary, at a distance of approximately 230 m from the HyPCe area fenceline. The Project is therefore considered to be appropriately sited for public safety.

With the application of proposed mitigation, the residual Project-related environmental impacts of a potential accidental LOC of flammable vapours from the BESS or a potential accidental LOC of hydrogen gas from the HESS are predicted to be adverse in direction, moderate to high in magnitude, ranging in

geographic extent from the PDA to the AOI, short-term in duration, and reversible. The probability of occurrence is considered low.

In consideration of the VC-specific significance criteria defined in Section 8.1.2.4, the residual impacts of a potential accidental LOC of flammable vapours from the BESS or a potential accidental LOC of hydrogen gas from the HESS could be significant for the Surface Water and Groundwater Resources VC and the Agriculture and Other Land Use VC but are predicted to be not significant for the remaining biophysical/ecological and anthropogenic VCs. These significance determinations are based on the considerations outlined in Table 8.12.

Table 8.12 Potential Significance of the Residual Impacts of an Accidental LOC of Flammable/Explosives Substances from the BESS or HESS on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Atmospheric and Acoustic Environment	• A residual Project-related reduction in air quality beyond the PDA such that the maximum ground-level air contaminant concentration associated with the Project, in combination with the conservative background concentration, frequently exceeds the applicable ambient air quality standard. • Noise emissions from routine activities that exceed background sound pressure levels by more than 5 dBA beyond the PDA.	Although an accidental LOC of flammable/explosive substances from the BESS or HESS could conceivably cause a one-time, temporary residual reduction in air quality if the incident results in a flash fire, jet fire/fireball, or explosion, the associated air emissions would not be anticipated to frequently exceed the applicable ambient air quality standard(s). Additionally, while an explosion could cause a one-time exceedance in sound pressure levels, it would be temporary and not a routine exceedance.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on the atmospheric and acoustic environment are predicted to be **not significant**.
Surface Water and Groundwater Resources	• A residual Project-related reduction in groundwater quality to the point where the yield from an established groundwater supply aquifer or well is no longer suitable or adequate for its intended use • A residual Project-related contravention of an applicable watershed management target	One or both of the identified significance criteria/thresholds could be exceeded in the event that a flash fire, jet fire/fireball, or explosion associated with an accidental LOC of flammable/explosive substances from the BESS or HESS directly or indirectly results in an accidental spill of a large volume of hazardous materials, or the release of large volumes of other contaminants, that infiltrate	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on surface water and groundwater resources **could be significant** (if it results in an accidental spill of hazardous materials, depending on the magnitude of the spill).

Table 8.12 Potential Significance of the Residual Impacts of an Accidental LOC of Flammable/Explosives Substances from the BESS or HESS on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
		and percolate to groundwater zones via existing and proposed on-site drainage systems. Such an accidental release of hazardous materials could conceivably adversely affect drinking water resources if contamination reaches the groundwater table, due to the presence of drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6) as well as several existing and proposed drainage systems within the PDA.	
Flora and Fauna	• A residual Project-related change in terrestrial habitat that would alter its status or integrity within the RSA	For the same reasons as discussed in Table 8.9 regarding the residual impacts of a large accidental spill of hazardous materials, the residual impacts of a flash fire, jet fire/fireball, or explosion associated with an accidental LOC of flammable/explosive substances from the BESS or HESS would similarly not be anticipated to alter the status or integrity of the PDA as terrestrial habitat for birds within the RSA.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on flora and fauna are predicted to be **not significant**.
Visual Environment	• A residual Project-related change to the environment that results in high-intensity glare with the potential to cause permanent eye damage if observed by receptors beyond the PDA, or glint and glare impacts that otherwise represent a public health and safety hazard	Although a flash fire, jet fire/fireball, or explosion associated with an accidental LOC of flammable/explosive substances from the BESS or HESS could be visible to off-site receptors beyond the PDA, such an incident would not be anticipated to result in off-site glint or glare impacts that could represent a public health and safety hazard.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on the visual environment are predicted to be **not significant**.

Table 8.12 Potential Significance of the Residual Impacts of an Accidental LOC of Flammable/Explosives Substances from the BESS or HESS on the Environment

Valued Component	Most Relevant* Significance Criteria/Thresholds from Section 8.1.2.4	Discussion	Significance Determination
Agriculture and Other Land Uses	• A residual Project-related change to the environment that results in non-compliance with established land use plans, policies, or by-laws • A residual Project-related change to the environment that results in incompatibility with adjacent or historical land use activities as designated through a regulatory land use process.	For the same reasons as discussed in Table 8.9 regarding the residual impacts of a large accidental spill of hazardous materials at Harrow Plantation, it is similarly anticipated that the residual impacts of a flash fire, jet fire/fireball, or explosion at Harrow Plantation associated with an accidental LOC of flammable/explosive substances from the BESS or HESS could constitute non-compliance with the PDP or other established land use plans, policies, or by-laws, and/or could be otherwise incompatible with adjacent or historical land use activities as designated through a regulatory land use process.	The residual adverse impacts of a potential accidental LOC of flammable/explosive substances from the BESS or HESS on agriculture and other land uses **could be significant**.

Note:

* This table presents only those significance criteria/thresholds that are considered to be the most relevant in the context of this assessment of potential residual environmental impacts that could arise as a result of Project-related accidents, malfunctions, emergencies, or disasters. The other VC-specific significance criteria/thresholds (i.e., those that are identified in Section 8.1.2.4 but not presented in this table) are considered less relevant for the purposes of this assessment, given the nature of the potential residual impacts and their pathways; it is assumed that none of those other significance criteria/thresholds will be exceeded for any VC in the event of a potential Project-related accident, malfunction, emergency, or disaster.

8.7.2 Climate Change and Natural Disasters

With Barbados proposing to move to 100% renewable energy production by 2030 (Government of Barbados 2019), it is critical that the Project and other proposed renewable energy systems are resilient to the potential impacts of climate change and natural disasters.

8.7.2.1 Climate Change

The Intergovernmental Panel on Climate Change defines climate change as “a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in

the composition of the atmosphere or in land use" (IPCC 2012). This definition differs from that of the *United Nations Framework Convention on Climate Change*, where climate change is defined as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (United Nations 1992). GHGs are known to contribute to human-induced climate change (IPCC 2021).

Due to their size and location, Caribbean small island developing states – including Barbados – are particularly susceptible to the potential adverse impacts of climate change (IADB 2016, in Government of Barbados 2019), such as increased temperatures; sea-level rise; and more frequent and/or severe extreme weather and climate events, potentially including heat waves, droughts, wildfires, heavy rainfall, and intense storms.

General Circulation Models (GCMs) are mathematical models of the physical and dynamic processes within and between the Earth's atmosphere, ocean, cryosphere, and land masses. Although they are accepted tools for projecting future climate information, GCMs are limited by their coarse resolution relative to the higher resolution detail found in specific regional scales and therefore 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 can be combined with Regional Climate Models (RCMs) to improve the model's mathematical representations of physical processes (IPCC 2007).

Relevant climate change information for Barbados was derived from a combination of recently observed climate data sources and climate model projections of future scenarios using an ensemble of 15 GCMs and the RCM known as PRECIS. RCM simulations from PRECIS were driven by two different GCMs (ECHAM4 and HadCM3) to project climate to the Barbados level (Simpson et al. 2012). This modelling represents future change under the following three different GHG emissions scenarios (Simpson et al. 2012):

- High Emission Scenario (A2)
- Medium Emissions Scenario (A1B)
- Lower Emissions Scenario (B1)

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 one-day rainfall totals by the 2080s. Of particular relevance to the Project is the potential for increases in tropical storms and hurricanes, to which solar PV farms are generally vulnerable. Climate change models are deemed relatively primitive with respect to representing tropical storms and hurricanes, and by extension primitive in their ability to predict future changes in the frequency and intensity of such events. Recent studies indicate that the frequency of storms may decrease; however, in some of the same studies the intensity of hurricanes is expected to increase (despite reductions in frequency) (Simpson et al. 2012).

8.7.2.2 Natural Disasters

The United Nations Office for Disaster Risk Reduction defines a disaster as “a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability, and capacity, leading to one or more of the following: human, material, economic, [or] environmental losses and impacts” (UNDRR n.d.).

There are three broad categories of natural hazards that could result in a natural disaster:

- Hydrometeorological hazards (e.g., tropical storms and hurricanes, storm surges, droughts, floods, landslides/mudflows), which may be exacerbated by climate change
- Geological or seismic hazards (e.g., earthquakes, volcanic eruptions, tsunamis)
- Biological hazards (e.g., epidemics and wildfires), which may be exacerbated by climate change

Barbados is exposed to each of the natural hazards identified above. Although there are no volcanoes in Barbados, the ash flow from potential volcanic eruptions in surrounding Caribbean countries (e.g., St. Vincent and the Grenadines, Montserrat, Dominica, and St. Lucia) could adversely impact Barbados. Additionally, the potential eruption of “Kick ‘em Jenny”, the underwater volcano off the coast of Grenada, could cause a tsunami affecting Barbados (Government of Barbados n.d.).

8.7.2.3 Potential Impacts of Climate Change and Natural Disasters on the Project

Given that the PDA is located more than 3 km inland, at elevations ranging from 43 m to 56 m AMSL, potential sea-level rise associated with climate change is not anticipated to adversely affect the Project over its lifetime. However, the Project is susceptible to potential adverse impacts associated with climate-related and other natural hazards, such as tropical storms and hurricanes, droughts and floods, earthquakes, volcanic eruptions, tsunamis, and wildfires.

The Rocky Mountain Institute (RMI) conducted research related to the resilience of ground-mounted solar PV systems in the Eastern Caribbean against strong hurricanes during the 2017 hurricane season (Burgess and Goodman 2018). According to the World Meteorological Organization, the 2017 hurricane season in the Caribbean was “unprecedented” and included three “exceptionally destructive” hurricanes that occurred in rapid succession in late August and September: Hurricanes “Maria”, “Harvey”, and “Irma” (WMO 2018). Hurricanes Irma and Maria peaked at category five intensity, with Irma maintaining that intensity for 60 hours, which is longer than any North Atlantic hurricane in the satellite era (WMO 2018).

The RMI reported that, despite the record 180 mile/hour (approximately 290 km/hour) wind speeds, several ground-mounted solar PV systems in the Caribbean survived. However, there were others that did not, including some ground-mounted solar PV systems in Puerto Rico, the US Virgin Islands, and Barbuda that suffered major damage (e.g., airborne solar modules, broken equipment, and twisted metal racking) or complete failure (Burgess and Goodman 2018). Some similarities were identified among the ground-mounted solar PV systems that failed during the 2017 hurricane season, including the following weaknesses (Burgess and Goodman 2018):

- Top-down or T-clamp failure of modules
- Undersized rack or rack not designed for wind load

- Lack of lateral racking support (rack not properly designed for wind loading from the side)
- Undersized bolts
- Under-torqued bolts
- Lack of vibration-resistant connections
- PV module design pressure too low for environment
- Use of self-tapping screws instead of through bolting

Several common attributes were identified among the ground-mounted solar PV systems that survived the 2017 hurricane season, including the following (Burgess and Goodman 2018):

- Dual post piers
- Through-bolting of solar modules (no top-down or T-clamps)
- Lateral racking supports
- Structural calculations on record
- Oversight of construction by Engineer of Record with quality assurance and control program
- Vibration-resistant module-bolted connections such as Nylocs

Tropical storms, hurricanes, and other natural hazards (e.g., earthquakes, tsunamis, and wildfires) also have potential to cause damage to various other Project components, including equipment in the HyPCe area, Project agricultural facilities, and various supporting infrastructure, facilities, and utilities. Depending on the intensity of an extreme weather event or the severity of a natural disaster, the resultant damage could conceivably be substantial enough to cause an accident, malfunction, or emergency such as those assessed in Section 8.7.1 above.

A drought or a flood could also adversely affect Project, particularly with respect to water supply requirements for the Project energy facility and agricultural operations, while volcanic ash could adversely affect operation of the solar PV power plant by blocking incoming solar radiation.

8.7.2.4 Mitigation

The potential impacts of climate and natural disasters on the Project will be considered and incorporated into the planning and design of Project components and the scheduling of Project activities.

RMI's recommendations regarding the construction of resilient ground-mounted solar PV systems in the Caribbean included recommendations pertaining to proper specifications for systems and recommendations pertaining to design collaboration between developers and module suppliers. Below are some key recommendations from RMI regarding proper specifications for ground-mounted solar PV systems (Burgess and Goodman 2018):

- Specify high-load (up to 5,400 Pascal uplift) PV modules, based on structural calculations; these are currently available from a number of Tier-1 module manufacturers.
- Require structural engineering in accordance with ASCE 7 and site conditions, with sealed calculations for wind forces, reactions, and attachment design (ground-mount foundation).
- Specify through-bolting of modules as opposed to top-down or T clamps, or if top clamping is required, use clamps that hold modules individually or independently.

- Require structural engineer review of lateral loads due to racking and electrical hardware. Often lateral loads are missed, and recent failures have proven them to be a critical source of weakness (e.g., combiner boxes attached to end solar array posts caused increased loading and led to failure).
- Specify bolt quality assurance and quality control processes.
- Specify all hardware be sized based on 25 years (or project life) of corrosion.
- Do not recommend any self-tapping screws.
- Specify dual post fixed tilt ground mounts, which significantly reduce foundation failure risk.

The above recommendations will be considered during detailed design of the solar PV power plant for the Project. In addition, as indicated in Section 3.2.1, the solar panel structures for the Project will be designed in accordance with local and international standards and to withstand Category 4 hurricanes. A certified engineer will review the selected structures for compliance with applicable codes from ASCE.

The design of the BESS and HESS will incorporate several safety features, as described in Section 8.7.1.2 above. These safety features will help maintain the safe operation of the Project energy facility in the event of a climate-related or other natural disaster.

The risk of drought conditions adversely affecting the Project will be mitigated through the planned re-use of the mineralized water by-product of reverse osmosis, the planned recirculation of process water from the HESS to the electrolysers for re-use in the electrolysis process, and potential harvesting of rainwater via water tanks located beneath Project buildings/infrastructure (refer to Section 3.2.3.5), while the risk of flood conditions adversely affecting the Project will be mitigated through the planned establishment of drainage reserves for runoff management (refer to Section 3.2.3.6).

As described in Chapter 4, the Project EMS will enable RSB to calculate the solar irradiance forecast and notify the grid operator 24 hours in advance regarding the availability of power so that storage can be optimized as necessary to deliver the maximum amount of power to the grid and reduce energy losses.

An Emergency and Disaster Management Plan has been prepared as part of the ESMP (Appendix I) and identifies recommended procedures and protocols to be carried out in the event of a natural, accidental, or human-induced emergency or disaster (e.g., explosion, fire, spill, or hurricane) at the Project facility. This Plan will be developed in consideration of the QRA (Appendix D), which identifies the maximum predicted distances to selected emergency planning endpoints based on the results of consequence modelling.

8.7.2.5 Characterization of Residual Impacts and Significance Determination

As noted above, depending on the intensity of an extreme weather event or the severity of a natural disaster, the resultant damage could conceivably be substantial enough to cause an accident, malfunction, or emergency such as those assessed in Section 8.7.1. The potential residual impacts of such incidents on the environment are characterized, and associated determinations of significance are provided, in Section 8.7.1.3.

With application of the design considerations and proposed mitigation described above, climate change and natural disasters are not anticipated to result in substantial delays to the Project schedule, damage to

Project components, or disruption to Project activities that could compromise the long-term technical or economic viability of the Project. The residual impacts of climate change and natural disasters on the Project are therefore predicted to be not significant.

9.0 SOCIAL IMPACT ASSESSMENT AND MITIGATION

This chapter documents the approach, methods, and results of the Social Impact Assessment (SIA) portion of the ESIA, which focuses on potential interactions between the Project and the social VCs (including economic and cultural aspects) identified in Section 6.2.

9.1 BASELINE STUDY

9.1.1 Survey Methods and Spatial Boundaries

The baseline was established from interviews with samples of the residents within a 1-km radius of the Harrow site (Figure 9.1). The Bushy Park Barbados Racing Facility and the Sunbury Greathouse are the closest commercial facilities to the Harrow site. Contact was made and interviews conducted. There is a small corner shop in Harrow, but the proprietor was not available for the interview. There is also a shop attached to a home in Padmore Village, but the owner preferred to complete the residential interview. The development to the south of the PDA has a covenant that prohibits the operation of businesses. Just outside of the 1 km zone to the Northwest is the Government Industrial School, a residential rehabilitative facility for children and teens designed to support them and their families and to reintegrate the children into the community. It should be noted that this facility caters to a vulnerable community, defined as such because of their potentially diminished capacity to anticipate, cope with, resist, and/or recover from the impact of a natural or man-made hazard. However, it is not anticipated that there would be any contact between the Project and the residents at the school.

Bing Maps was used to obtain aerial views of the surrounding communities and estimate the number of buildings. Based on an estimate of 367 structures, the Raosoft sample size calculator was used to determine a statistically representative sample size of 188 households using a 5% margin of error at the 95% confidence level with a response distribution of 50%. Every household within the survey zone was approached. Considering several unoccupied buildings, homes where no one was present after multiple attempts, and households that declined to participate in the survey, ultimately, a final total sample of 155 households was achieved, comprising interviews with 82 females (52.9%) and 73 males (47.1%). Table 9.1 lists the road/communities captured within the 1-km radius of the PDA.

Figure 9.1 1-km Radius Surrounding the Harrow Site

Table 9.1 Names of Roads and Communities Included in the Survey

Name of Road/Community	Number of respondents		Percentage		Total %
	Female	Male	Female	Male	
Padmore Village	19	17	12.3%	11.0%	23.2%
Circular Road	14	17	9.0%	11.0%	20.0%
Marchfield Village Road	12	12	7.7%	7.7%	15.5%
Harrow Land	10	5	6.5%	3.2%	9.7%
Neil Kirk Gardens	6	5	3.9%	3.2%	7.1%
Farm Road	6	3	3.9%	1.9%	5.8%
Harrow Road	1	6	0.6%	3.9%	4.5%
Crescent Drive	5	2	3.2%	1.3%	4.5%
Farm Gardens	4	1	2.6%	0.6%	3.2%
Farm Road Terrace	2	1	1.3%	0.6%	1.9%
Harrow Park	2	1	1.3%	0.6%	1.9%
Green Way / Farm Gardens	1	1	0.6%	0.6%	1.3%
Bushy Park Road	0	1	0.0%	0.6%	0.6%
Neil Kirk Road	0	1	0.0%	0.6%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

More than 70% of the sample have lived in their respective communities for over ten years (Table 9.2). Therefore, these respondents were well placed to provide a long-term perspective on issues in their community.

Table 9.2 Length of Time Respondents Have Lived in Their Communities

Years of Residence	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Less than one year	0	1	0.0%	0.6%	0.6%
1 – 5 years	11	3	7.1%	1.9%	9.0%
6 – 10 years	9	15	5.8%	9.7%	15.5%
10 – 20 years	22	20	14.2%	12.9%	27.1%
Over 20 years	17	12	11.0%	7.7%	18.7%
Over 30 years	6	8	3.9%	5.2%	9.0%
Over 40 years	7	5	4.5%	3.2%	7.7%
Over 50 years	10	9	6.5%	5.8%	12.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

9.1.2 Demographic Profile

Interviews were conducted with the head of household or adult household members, with the head of household being defined as the adult who makes the decisions in the home and has primary responsibility for taking care of the household members and or finances[9]. Within the 155 households in the study, 70.3% were female-headed, 10.3% were male-headed, and 19.4% jointly managed (Table 9.3). This result is reflective of the national trend where female-headed households are predominant.

Table 9.3 Heads of Households

Head of Household	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Female-headed Household	56	53	36.1%	34.2%	70.3%
Joint responsibilities	14	16	9.0%	10.3%	19.4%
Male-headed Household	12	4	7.7%	2.6%	10.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

The 155 households in the survey represented a total population of 431 persons, 73.5% of whom live in one, two or three-person households (Table 9.4).

Table 9.4 Number of Persons Per Household

No. Persons Per Household	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
One person	29	15	18.7%	9.7%	28.4%
Two persons	16	22	10.3%	14.2%	24.5%
Three persons	15	17	9.7%	11.0%	20.6%
Four persons	7	9	4.5%	5.8%	10.3%
Five persons	7	5	4.5%	3.2%	7.7%
Six persons	3	3	1.9%	1.9%	3.9%
Seven persons	2	1	1.3%	0.6%	1.9%
Eight persons	2	1	1.3%	0.6%	1.9%
Nine persons	0	0	0.0%	0.0%	0.0%
Ten persons	1	0	0.6%	0.0%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.5 shows that, amongst the respondents, representation in the younger age groups between 18–34 was low. Across the higher age groups, representation was relatively evenly distributed, with the

[9] This definition was based on similar ones found online at https://sociologydictionary.org/head-of-household/ https://www.encyclopedia.com/social-sciences-and-law/law/law/head-household.

largest proportion in the 65+ range. This distribution is unsurprising since the latter represents the retirement age, and these individuals are more likely to be at home and accessible during a survey.

Table 9.6 shows the employment status of the respondents. Just over half, 56.1% are fully employed, 5.8% are in part-time employment, 27.7% are retired and 3.2% are unemployed. 27.7% of the respondents are retired. Older individuals represent one of the age groups most impacted by construction and operational activities at nearby project sites since they are more likely be at home during working hours.

Table 9.5 Respondents' Age Ranges

Age Group	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
18-24	3	3	1.9%	1.9%	3.9%
25-34	8	5	5.2%	3.2%	8.4%
35-44	16	12	10.3%	7.7%	18.1%
45-54	19	14	12.3%	9.0%	21.3%
55-64	13	25	8.4%	16.1%	24.5%
65+	23	14	14.8%	9.0%	23.9%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.6 Respondents' Current Employment Status

Employment Status	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Full-time employment					
Privately employed (full-time)	27	24	17.4%	15.5%	32.9%
Government employee (full-time)	9	13	5.8%	8.4%	14.2%
Self-employed (without paid employees)	4	9	2.6%	5.8%	8.4%
Self-employed (with paid employees)	1	0	0.6%	0.0%	0.6%
Part-time employment					
Privately employed (part-time)	5	4	3.2%	2.6%	5.8%
Retired					
Retired	24	19	15.5%	12.3%	27.7%
Unemployed					
Unemployed	4	1	2.6%	0.6%	3.2%

Table 9.6 Respondents' Current Employment Status

Employment Status	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Other					
Unable to work due to a disability	3	1	1.9%	0.6%	2.6%
Housewife/Househusband/Contributing Family Member/Unpaid Family Worker	3	0	1.9%	0.0%	1.9%
Other	0	2	0.0%	1.3%	1.3%
Student/In-training	2	0	1.3%	0.0%	1.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Figure 9.2 shows the employment status of the other persons living within the households that were surveyed. Just under half, 48.5% are fully employed, 30.1% are unemployed, and 21.4% are retired. This may be compared to the results from the Continuous Household Labour Force Survey, which show an overall national unemployment rate of 15.9% (14.1% for males, 17.8% for females) (BSS 2021). Currently, unemployment is high because of the extended negative economic effects of the Covid-19 pandemic. Amongst the children 17 years and younger, living within these households, 90% are attending school (Figure 9.3).

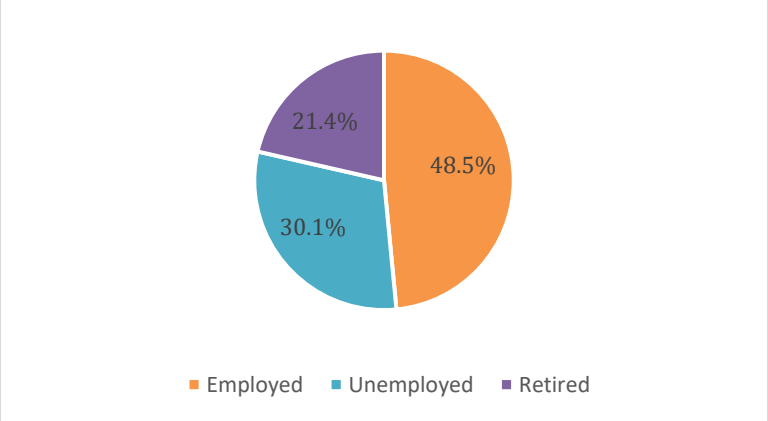


Figure 9.2 Employment Status of Other Household Members

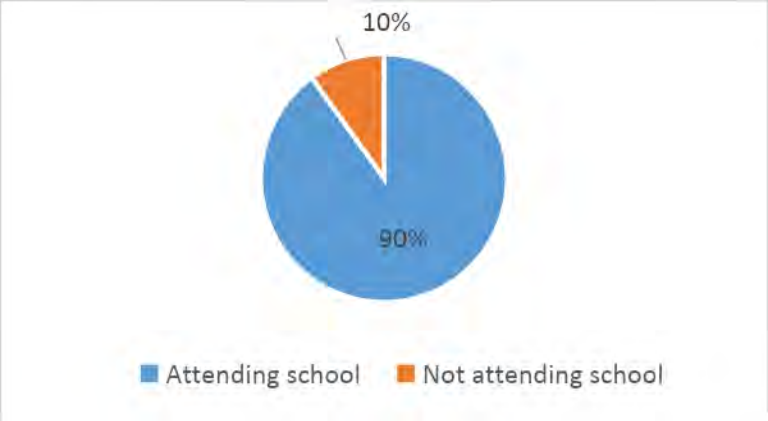


Figure 9.3 School Attendance

Amongst the 155 respondents, 41.9% had attained secondary education as their highest level of formal education (Table 9.7).

Table 9.7 The Highest Level of Education Attained by Respondents

Education	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Secondary education	30	35	19.4%	22.6%	41.9%
Vocational education (e.g., Polytechnic)	9	19	5.8%	12.3%	18.1%
Undergraduate degree	13	4	8.4%	2.6%	11.0%
Continuing Professional Development	10	4	6.5%	2.6%	9.0%
Post-graduate degree	7	4	4.5%	2.6%	7.1%
Primary education	7	3	4.5%	1.9%	6.5%
Associate degree	5	4	3.2%	2.6%	5.8%
No Response	1	0	0.6%	0.0%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

9.1.3 Housing and Community Information

The majority of the respondents, 91%, stated that they owned their homes (Table 9.8). Consequently, Table 9.9 shows that most of the sample, 92.9%, live in privately owned single-dwelling houses, compared to 4.5% who live in government units and 2.6% who live in apartments. In addition, 79.4% of the homes are constructed from concrete blocks and concrete (Table 9.10).

Table 9.8 Homeownership Status

Homeownership	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Owned	78	63	50.3%	40.6%	91.0%
Rental	3	6	1.9%	3.9%	5.8%
Using but not paying rent	1	3	0.6%	1.9%	2.6%
Prefer not to say	0	1	0.0%	0.6%	0.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.9 Housing Types

Dwelling Type	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Private House	76	68	49.0%	43.9%	92.9%
Government Unit	5	2	3.2%	1.3%	4.5%
Flat/Apartment	1	3	0.6%	1.9%	2.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.10 Materials Used to Construct the Homes in the Sample

Dwelling Material	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Concrete block	41	43	26.5%	27.7%	54.2%
Concrete	20	19	12.9%	12.3%	25.2%
Wood	13	6	8.4%	3.9%	12.3%
Wood and Concrete block	7	4	4.5%	2.6%	7.1%
Wood and Concrete	1	1	0.6%	0.6%	1.3%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

The respondents were asked to indicate what attributes were desirable within their communities. This information identifies the characteristics within the surrounding areas that should be maintained throughout the construction and operation of the proposed Project. Table 9.11 shows that the peaceful and quiet nature of the communities is the primary feature valued by 64.5% of the respondents. Just over half, 54.2%, also like that their neighbours are friendly, and 40.6% appreciate the proximity to commercial, social and community services. Only 30.4% identified safety and security as a valued attribute in the area.

Table 9.11 Community Attributes Valued by Respondents

Attributes	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
It is peaceful and quiet	60	40	38.7%	25.8%	64.5%
The people who live in the area are friendly	48	36	31.0%	23.2%	54.2%
Proximity to commercial, social and community services (e.g., businesses, healthcare, schools, church, recreational spaces, social clubs)	34	29	21.9%	18.7%	40.6%
It is safe and secure	33	28	21.3%	18.1%	39.4%
It is an attractive area	16	20	10.3%	12.9%	23.2%
It is breezy	1	1	0.6%	0.6%	1.3%
Nothing	0	1	0.0%	0.6%	0.6%

Table 9.12 displays the results of the respondents' ratings of various services and amenities in their communities. Amongst the services and amenities that received a rating of "good" or "excellent" from a total of 50% or more of the respondents were the electricity supply (71.6% good, 9.7% excellent), the water supply (76.1%, 13.5% excellent), the telephone and internet service (67.7% good, 2.6% excellent), the garbage collection service (66.5% good, 11.0% excellent), street lighting (52.3% good, 26% excellent), access to commercial services (51% good, 20.6% excellent), access to health care services (49.7% good, 25.2% excellent), and proximity to schools (48.4% good, 13.5% excellent). Noticeably, amongst these are the primary utilities of electricity, water, and communication services, indicating that these communities enjoy convenient service most of the time.

On the other hand, services and amenities that were rated "poor" by 50% or more of the respondents were pedestrian walkways and bicycle paths (54.8%) and road conditions (51%). Unfortunately, bicycle paths are not common in Barbados, and sidewalks can typically be non-existent, too narrow or in a state of disrepair. Similarly, residents from across the island have noted their displeasure with the quality of the nation's roads in print, electronic, and social media regularly. A look at the remaining services and amenities shows the following:

- Public transport is deemed "good" by only 31.0% and "average" by 33.5%; an area for improvement.
- Employment opportunities scored as "poor" by 32.3% and "average" by 30.3%. With 30% unemployment within the households, this is an area for urgent attention.
- Recreational facilities scored as "poor" by 44.5% and "average" by 27.1%; an area for investment.
- Dining opportunities scored as "poor" by 35.5% and "average" by 26.5%; an area for improvement.

Table 9.12 Rating of Community Services and Amenities

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
The condition of the roads					
Poor	41	38	26.5%	24.5%	51.0%
Average	21	16	13.5%	10.3%	23.9%
Good	18	19	11.6%	12.3%	23.9%
Excellent	2	0	1.3%	0.0%	1.3%
Don't know	0	0	0.0%	0.0%	0.0%
Public transportation					
Average	29	23	18.7%	14.8%	33.5%
Good	21	27	13.5%	17.4%	31.0%
Poor	20	13	12.9%	8.4%	21.3%
Don't know	12	7	7.7%	4.5%	12.3%
Excellent	0	3	0.0%	1.9%	1.9%
Recreational facilities					
Poor	35	34	22.6%	21.9%	44.5%
Average	22	20	14.2%	12.9%	27.1%
Good	15	13	9.7%	8.4%	18.1%
Don't know	9	5	5.8%	3.2%	9.0%
Excellent	1	1	0.6%	0.6%	1.3%
Garbage collection service					
Good	58	45	37.4%	29.0%	66.5%
Average	14	18	9.0%	11.6%	20.6%
Excellent	9	8	5.8%	5.2%	11.0%
Poor	1	1	0.6%	0.6%	1.3%
Don't know	0	1	0.0%	0.6%	0.6%

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Employment opportunities					
Poor	30	20	19.4%	12.9%	32.3%
Average	25	22	16.1%	14.2%	30.3%
Don't know	19	15	12.3%	9.7%	21.9%
Good	7	16	4.5%	10.3%	14.8%
Excellent	1	0	0.6%	0.0%	0.6%
Lighting of the streets					
Good	39	42	25.2%	27.1%	52.3%
Average	34	22	21.9%	14.2%	36.1%
Poor	5	7	3.2%	4.5%	7.7%
Excellent	3	1	1.9%	0.6%	2.6%
Don't know	1	1	0.6%	0.6%	1.3%
Pedestrian walkways, bicycle paths					
Poor	45	40	29.0%	25.8%	54.8%
Average	22	14	14.2%	9.0%	23.2%
Good	14	14	9.0%	9.0%	18.1%
Don't know	1	5	0.6%	3.2%	3.9%
Excellent	0	0	0.0%	0.0%	0.0%
Telephone and internet service					
Good	56	49	36.1%	31.6%	67.7%
Average	17	19	11.0%	12.3%	23.2%
Poor	4	4	2.6%	2.6%	5.2%
Excellent	4	0	2.6%	0.0%	2.6%
Don't know	1	1	0.6%	0.6%	1.3%

Table 9.12 Rating of Community Services and Amenities

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Dining opportunities					
Poor	28	27	18.1%	17.4%	35.5%
Average	25	16	16.1%	10.3%	26.5%
Good	21	19	13.5%	12.3%	25.8%
Don't know	6	8	3.9%	5.2%	9.0%
Excellent	2	3	1.3%	1.9%	3.2%
Water supply					
Good	66	52	42.6%	33.5%	76.1%
Excellent	9	12	5.8%	7.7%	13.5%
Average	7	9	4.5%	5.8%	10.3%
Poor	0	0	0.0%	0.0%	0.0%
Don't know	0	0	0.0%	0.0%	0.0%
Electricity supply					
Good	59	52	38.1%	33.5%	71.6%
Average	14	12	9.0%	7.7%	16.8%
Excellent	8	7	5.2%	4.5%	9.7%
Poor	1	2	0.6%	1.3%	1.9%
Don't know	0	0	0.0%	0.0%	0.0%

Ratings of Services / Amenities	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Proximity to schools and day-care facilities					
Good	42	33	27.1%	21.3%	48.4%
Average	18	21	11.6%	13.5%	25.2%
Excellent	10	11	6.5%	7.1%	13.5%
Poor	7	6	4.5%	3.9%	8.4%
Don't know	5	2	3.2%	1.3%	4.5%
Access to commercial services such as banks, supermarkets					
Good	43	36	27.7%	23.2%	51.0%
Average	19	15	12.3%	9.7%	21.9%
Excellent	15	17	9.7%	11.0%	20.6%
Poor	5	4	3.2%	2.6%	5.8%
Don't know	0	1	0.0%	0.6%	0.6%
Access to health care services, clinic, pharmacy, doctor's office					
Good	43	34	27.7%	21.9%	49.7%
Excellent	19	20	12.3%	12.9%	25.2%
Average	17	15	11.0%	9.7%	20.6%
Poor	3	4	1.9%	2.6%	4.5%
Don't know	0	0	0.0%	0.0%	0.0%

9.1.4 Perceptions of the Project Energy Facility

In this survey segment, an assessment was made of the respondents' knowledge and aptitude for renewable energy before discussing their awareness of and attitude towards the Project. The majority, 91%, indicated that they had heard the term "Renewable Energy". While 47.7% of respondents reported using solar water heaters, only 2.6% reported using solar lights, and 1.9% reported using solar PV, i.e., complete electrical home installation (Table 9.13).

Table 9.13 Respondents' Use of Renewable Energy Products

Renewable Energy	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
None	43	34	27.7%	21.9%	49.7%
Solar Water Heater	36	38	23.2%	24.5%	47.7%
Solar lights / security lights	2	2	1.3%	1.3%	2.6%
Solar PV (home electrical installation)	1	2	0.6%	1.3%	1.9%
Don't know	1	1	0.6%	0.6%	1.3%
Wind System	1	0	0.6%	0.0%	0.6%

The respondents also reported using energy-efficient devices and appliances in their homes. Table 9.14 shows that the majority, 87.7%, used LED bulbs, and 36.8% used Energy Star certified appliances.

Table 9.14 Energy-Efficient Devices and Appliances Used by Respondents

Energy-efficiency	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
LED bulbs	71	65	45.8%	41.9%	87.7%
Energy Star appliances	31	26	20.0%	16.8%	36.8%
Fluorescent bulbs	15	24	9.7%	15.5%	25.2%
Incandescent bulbs	11	11	7.1%	7.1%	14.2%
None	7	2	4.5%	1.3%	5.8%
Solar lights	3	2	1.9%	1.3%	3.2%
Don't know	3	1	1.9%	0.6%	2.6%

More than half of the respondents, 59.4%, knew about the Government's new energy policy to have Barbados using 100% renewable energy by 2030 (Table 9.15).

Table 9.15 Respondents' Knowledge of Government's New Energy Policy

Heard about Energy Policy	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Yes	41	51	26.5%	32.9%	59.4%
No	41	22	26.5%	14.2%	40.6%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

With specific reference to the Project, Table 9.16 shows that only 16.1% of the respondents had knowledge about it prior to the visit from the enumerators.

Table 9.16 Respondents' Knowledge of the Proposed Energy Facility at Harrow

Knowledge of Project	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Yes	11	14	7.1%	9.0%	16.1%
No	71	59	45.8%	38.1%	83.9%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Of those 25 respondents who knew of the proposed Project, Table 9.17 shows that 36% had heard about it from television, 32% by word of mouth, 32% by the newspaper, and 24% the radio.

Table 9.17 Source of Information About the Proposed Project

Medium	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
Television	6	3	24.0%	12.0%	36.0%
Word of mouth	4	4	16.0%	16.0%	32.0%
Newspaper	4	4	16.0%	16.0%	32.0%
Radio	3	3	12.0%	12.0%	24.0%
Social Media/Internet	2	2	8.0%	8.0%	16.0%

Respondents were provided with a flyer that offered a brief description of the Project. They were then asked to suggest positive benefits from the construction and operation of the Project. Table 9.18 shows that more than half of the sample, 52.3%, agreed that there could be positive benefits, and these are listed in Table 9.19. The two leading options were reduced or more competitive cost of electricity and employment opportunities during the construction phase. In addition, one resident called Stantec to enquire whether he could bring his sheep over to the facility when it is up and running.

Table 9.18 Number/Percentage of Respondents Who Believe that Benefits will Accrue from the Project

Positive Impact	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Yes	39	42	25.2%	27.1%	52.3%
Don't know	32	23	20.6%	14.8%	35.5%
No	11	8	7.1%	5.2%	12.3%
Total	82	73	52.9%	47.1%	100%

Table 9.19 Potential Benefits from the Project

Project Benefits	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
Reduced or more competitive cost of electricity	27	35	33.3%	43.2%	76.5%
Employment opportunities during the construction phase	22	23	27.2%	28.4%	55.6%
Energy independence	10	16	12.3%	19.8%	32.1%
Economic development for the island	13	12	16.0%	14.8%	30.9%
Protection for the environment	12	10	14.8%	12.3%	27.2%
Reduced greenhouse gases	11	10	13.6%	12.3%	25.9%
Don't know	1	2	1.2%	2.5%	3.7%
N=81					

The respondents were also asked to indicate whether they felt that there could be adverse effects from the construction and operation of the facility at Harrow, and Table 9.20 shows that only 7.1% said yes. Table 9.21 shows that the main concerns were noise and dust pollution during construction. One respondent followed up with a call to Stantec to specifically ask for more detailed information about the Project. He was especially interested in the use of agricultural lands, the proposed layout for the Project identifying the planned location and dimensions of the areas for the PV panels placement, the black belly sheep and the hydrogen generators, storage, and the planned safety management system for such storage. He expressed concern about the risk and dangers posed by hydrogen storage both in gas and in liquefied form. It should be noted that there will be no storage of liquid hydrogen on-site.

Table 9.20 Number/Percentage of Respondents Who Believe that there will be Adverse Effects from the Project

Negative Impact	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
No	41	41	26.5%	26.5%	52.9%
Don't know	36	26	23.2%	16.8%	40.0%
Yes	5	6	3.2%	3.9%	7.1%
Total	**82**	**73**	**52.9%**	**47.1%**	**100%**

Table 9.21 Potential Adverse Effects of the Project

Project Concerns	Frequency of Response		Percentage		Total %
	Female	Male	Female	Male	
Noise pollution during construction	4	4	36.4%	36.4%	72.7%
Dust pollution during the construction phase	2	4	18.2%	36.4%	54.5%
Removal of trees and other vegetation during the during construction phase	1	1	9.1%	9.1%	18.2%
Unsafe/hazardous work sites	1	1	9.1%	9.1%	18.2%
Don't know	0	2	0.0%	18.2%	18.2%
Noise from livestock during the operational phase	0	1	0.0%	9.1%	9.1%
Vibration damage to structures nearby during construction phase	0	1	0.0%	9.1%	9.1%
Lower water pressure in area due to water usage by the power plant during the operational phase	0	1	0.0%	9.1%	9.1%
Odours from the animals during the operational phase	1	0	9.1%	0.0%	9%
Release of hazardous emissions and products from the power plant during the operational phase	1	0	9.1%	0.0%	9.1%
N=11					

In closing the interview, respondents were asked whether they currently use the lands at Harrow Plantation, and only five respondents, or 3.2% of the total, said yes. Table 9.22 shows that these activities are growing vegetables and fruits and livestock rearing, and houses situated on past plantation land.

Table 9.22 Activities Currently Done at Harrow Plantation by Respondents

Type of Land Use	Number of Respondents		Percentage		Total %
	Female	Male	Female	Male	
Growing vegetables or fruits	1	0	20.0%	0.0%	20.0%
House is situated on past plantation land	0	2	0.0%	40.0%	40.0%
Livestock rearing	0	2	0.0%	40.0%	40.0%
Total	**1**	**4**	**20.0%**	**80.0%**	**100%**

Thirty-six or 23.2% of the respondents indicated that they would like to participate in the Public Consultation and provided their contact details for follow-up.

9.1.5 The Commercial Enterprises

Interviews were conducted with representatives of the Bushy Park Racetrack and Sunbury Greathouse. One was a male supervisor and the other a female manager. Both confirmed that neither property currently uses renewable energy. Bushy Park Barbados had heard of the RSB Barbados Project because a representative from the Project had informed them. However, the Sunbury Greathouse had not heard of the Project. The Supervisor at Bushy Park Racetrack was unable to state whether the Project would create any positive or negative impacts on the business. However, he indicated that they are willing to participate by renting the roof of their facility to house PV panels. It should be noted that it is outside of the scope of the Project to install PV panels on third-parties' roofs. The Manager at Sunbury raised concerns about the potential for dust and noise impacts during the construction phase and the possibility of effects from glare during the operational phase.

9.2 IMPACT ANALYSIS

Section 3.7 outlines the design mitigation and environmental protection measures that would be in place for the Project. The SIA that follows considers these measures in predicting residual impacts of the Project. Further information on proposed mitigation measures specific to the social environment are described in Section 9.2.3

The potential emissions, discharges and wastes that could affect the social components, are presented in Table 9.23. Refer to Section 3.6 for additional details regarding anticipated Project-related emissions, discharges, and wastes.

Table 9.23 Potential Emissions, Discharges, and Wastes

Project Components	Potential emissions discharges and wastes
Construction phase	• Clearing of lands for construction could create dust, noise, and vibrations • Construction debris • Garbage and sewage from workers on site
Operational phase	• Sheep grazing and grass harvesting could cause odours and dust • Glint and glare from the panels could affect the well-being and safety of residents and road users in the vicinity of the site • Garbage and sewage from workers on site
Accidental (non-routine) events	• Spills, leakages, fires, or explosions from the long-term use and/or storage of various hazardous products

Determination of the valued social components that could be affected by the Project was based on three factors: the Project activities likely to impact social features, reports reviewed, and data collected during the surveys. The valued social components are explained in Table 9.24.

Table 9.24 Valued Social Components

Valued Social Components	Justification
Health and safety	The development of the site and the operation of the Project could directly or indirectly affect human health.
Human capital	Construction and operation of the Project can provide opportunities for human capital development.
Economy	The Project may provide new economic and employment opportunities.
Cultural values	The Project will alter the aesthetic of the area.
Infrastructure and services	The Project could affect local infrastructure and services.
Social dynamics	In-migration of temporary workers could affect social networks and dynamics in nearby communities.

Impacts have been evaluated based on the following criteria:

- Nature
  - Positive – the action will result in benefits to the community or the country
  - Negative – the action will have undesirable consequences to the community or the country
- Geographic extent
  - Site – contained within PDA
  - Local – extends to at least a 1-km radius of the PDA
  - Parish – extends to the wider Parish of Saint Philip
  - Island-wide – extends to the entire island
- Duration
  - Intermittent – occurring sporadically
  - Short-term – within the two-year construction period
  - Medium-term = > two years and up to five years
  - Long-term = > five years
  - Irreversible

- Significant
  - No mitigation required
  - Can be mitigated – can be compliant with standards or laws through mitigation measures
  - Significant – will not be compliant with standards or laws even if mitigation measures are implemented
- Likelihood
  - Likely to occur
  - Unlikely to occur
  - Uncertain of its occurrence due to insufficient information

9.2.1 Potential Social Impacts During Construction of the Project

The proposed Project can facilitate employment as well as economic opportunities and benefits for local businesses. It is estimated that there could be a maximum of 150 construction jobs over two years. There could also be opportunities for capacity-building and skills development for local workers, particularly youth, since training will be offered. In addition, collaboration and working relationships with foreign companies involved in the Project's construction could increase the technological capacity of local businesses. These are all benefits that should accrue during the construction phase and require no mitigation measures.

However, the influx of many temporary workers during the construction phase could affect social networks and dynamics in nearby communities, should there be negative interactions with residents. Moreover, care must be taken to establish fair employment and decent work conditions to prevent perceptions of unequal employment benefits and conditions between local workers and equivalent foreign personnel. These potential adverse effects can be readily mitigated and made compliant with local labour laws and regulations. To enhance the employment benefits of the Project, the hiring process will be transparent and allow eligible locals to apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas. Further mitigation, including gender sensitization training for workers, is described in Section 9.2.3. There is no expectation of significant residual impacts.

The Project could support local businesses that provide supplies for the construction and renewable energy sectors. The construction phase is typically a boost to local entrepreneurs operating small retail businesses near the Project, especially food and beverage, because the construction workers will provide additional customers. In addition, accommodation and rental car companies could also gain business from foreign personnel working on the Project. The construction phase could therefore boost the economy and have a positive effect on local livelihoods. The provision of employment is a particularly positive impact given that 30% of the residents in the sampled householders were reported as unemployed. Moreover, the economic opportunities would be a considerable benefit 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. These benefits require no mitigation measures. To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas.

However, the noise, dust, and vibration during the construction of the Project may have adverse effects on the physical and psychological well-being of people in surrounding communities, especially individuals with a sensitivity to dust and noise. In this regard, 21% of the residents in the sample households were retired and would likely be at home during the construction activities. In addition, the peaceful and quiet nature of the communities is the primary feature valued by 64.5% of the respondents. There was also a concern raised about the removal of trees and other vegetation. Construction sites also tend to reduce visual amenity. There is typically debris such as concrete and scrap iron, and human activities on-site will generate garbage. However, a well designed and implemented construction management plan that includes a waste handling component (refer to Section 3.7.2 and 9.2.3), should mitigate these adverse effects and keep emissions within the required local standards for health and safety. Refer to Section 8.2 for the assessment of Project effects on the atmospheric and acoustic environment, including the planned mitigation and monitoring procedures. With these mitigation measures in place, there is no expectation of significant residual impacts.

The potential impacts from the construction vehicles and equipment are also a concern. There is potential for further damage to the roads, already rated as “poor” by 51% of the respondents. In addition, the absence of adequate sidewalks or bicycle paths place these users at risk if construction drivers do not drive with due care and within the required speed limit. Road restoration and the implementation of traffic management measures should address these potential adverse effects and protect health and safety. Traffic management measures would address on-site traffic, as well as the practices of construction drivers to and from the construction site. With mitigation in place, there is no expectation of significant residual impacts.

A further potential concern is that of persons accessing the PDA without authorization. They could be both subject to and the possible cause of health and safety risks. In addition, there will be health and safety risks to workers, including falls and injuries that might arise from the inappropriate use of machinery or improper handling of chemicals or flammable substances. Implementation of appropriate safety measures on-site should reduce or eliminate these occurrences (refer to Sections 3.7.2, 3.8, and 9.2.3 for measures to mitigate impacts on worker and public health and safety). During construction and operation, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. With mitigation measures in place, there is no expectation of significant residual impacts.

Finally, appropriate preservation measures will be taken if archaeological and cultural heritage features are encountered during Project activities. These measures could delay the construction timeline of the Project. Timely involvement of local heritage specialists would reduce delays and assist the construction with staying on time. Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the PDA. In this event, the Contractor will work with the Museum to develop and implement a plan to protect the artefacts.

Table 9.25 provides a characterization of the potential benefits and adverse effects that could occur during the construction phase.

Table 9.25 Characterization of Social Impacts During the Construction Phase

Potential Impacts	Phase	Nature	Geographic Extent	Duration	Significant	Likelihood
Construction-related jobs	Construction	Positive	Site specific	Short-term	No mitigation required	Likely
Capacity-building and skills development for local workers	Construction	Positive	Site specific	Long-term	No mitigation required	Likely
Increased technological capacity of local businesses	Construction	Positive	Site specific	Long-term	No mitigation required	Likely
Support for local suppliers in the construction and renewable energy sectors	Construction	Positive	Local	Short-term	No mitigation required	Likely
Increased retail business, primarily food-related from construction workers	Construction	Positive	Local	Short-term	No mitigation required	Likely
Business for accommodation and car rental companies	Construction	Positive	Island wide	Short-term	No mitigation required	Likely
Noise and vibrations from construction vehicles and equipment	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Impaired air quality from dust and other emissions from construction vehicles and equipment	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Reduced visual amenity due to construction activity	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Damage to roads from construction vehicles and equipment	Construction	Negative	Local	Short-term	Can be mitigated	Likely
Health and safety risks to on-site workers	Construction	Negative	Site	Short-term	Can be mitigated	Unlikely
Health and safety risks to adjacent communities and general public	Construction	Negative	Local	Short-term	Can be mitigated	Unlikely
Influx of temporary workers affect social dynamics	Construction	Negative	Local	Short-term	Can be mitigated	Unlikely
Perceptions of inequitable labour conditions	Construction	Negative	Site	Short-term	Can be mitigated	Unlikely
Delays to construction if any archaeological and cultural heritage features are found within the PDA	Construction	Negative	Site	Short-term	Can be mitigated	Uncertain
Accidental spill or leak	Construction and operational phase	Negative	Local	Long-term or irreversible	Can be mitigated but could be significant if it occurs	Unlikely

9.2.2 Potential Social Impacts During the Operational Phase

The Project provides the opportunity to produce a clean, reliable, environmentally friendly source of energy in comparison to traditional fossil fuels. It can therefore 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 100% renewable energy and carbon-neutral by 2030. In addition, the added value of the sheep facility addresses the issue of replacing productive agricultural lands with an industrial use and will be a benefit to the national agricultural productive capacity. There will also be a corresponding positive effect on food and nutrition security and the sustainability of the national food system. These benefits should accrue during the construction phase and require no mitigation measures.

The energy facility will provide an estimated twenty permanent jobs when fully operational, and the sheep facility is expected to employ ten people. Thus, it will provide employment opportunities to the community. These benefits require no mitigation. As indicated in Section 9.2.1, however, the hiring process will be transparent and allow eligible locals to apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas.

However, the transformation of the rural landscape with a large-scale solar PV power plant could have a negative visual impact if persons or groups perceive the arrays to affect the existing landscape's aesthetic negatively. In addition, the potential impact of "glint and glare" from the panels could adversely affect the well-being and safety of neighbouring residents and roads users in the vicinity of the site. Judicious use of thick vegetation (e.g., hedges) and/or trees with heights of at least 3 m (10 feet) should reduce the visual impact and address the reflection from the panels. Refer to Section 8.5 for the assessment of the Project's impacts on the visual environment and proposed mitigation. With proposed mitigation in place, there is no expectation of significant residual impacts.

A variety of hazardous products will be stored at the site. These include potassium hydroxide, pressurised gaseous hydrogen, lithium-ion batteries, and transformer oils. The presence of these substances was raised as a concern by one resident. Storage of the products according to industrial specifications and strict site security should reduce the likelihood of negative impacts, including potential health and safety impacts on workers and adjacent communities. Refer to Section 3.5 for further information on the safe handling, use, storage, and disposal of hazardous materials associated with the Project.

A Project-specific Quantitative Risk Assessment (Appendix D) was conducted to examine the potential consequences in the event of an accidental LOC of flammable vapours from the BESS or an accidental LOC of hydrogen gas from the HESS during the operation and maintenance phase of the Project. As explained in Section 8.7.1.3, the individual risk of fatality from the Project (i.e., in the event of an accident, malfunction, emergency, or disaster entailing LOC of flammable vapours from the BESS or LOC of hydrogen gas from the HESS) is estimated to be less than 0.3 chances per million outside of the PDA. The nearest permanent residence is located outside of the PDA boundary, at a distance of approximately 230 m from the HyPCe area fenceline. The Project is therefore considered to be appropriately sited for public safety.

A further potential concern is that of persons accessing the PDA without authorization. They could be both subject to and the possible cause of health and safety risks. In addition, there will be health and safety risks to workers, including falls and injuries that might arise from the inappropriate use of machinery or improper handling of chemicals or flammable substances. Implementation of appropriate safety measures on-site should reduce or eliminate these occurrences (refer to Sections 3.7.2, 3.8, and 9.2.3 for measures to mitigate impacts on worker and public health and safety). During construction and operation, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. With mitigation measures in place, there is no expectation of significant residual impacts.

Although the water supply was rated as good or excellent by a total of 89.6% of the respondents, a concern was raised about the potential for lower water pressure in the area due to water usage by the Project during the operational phase. It is unlikely that the Project will impact on the water pressure. As described in Section 3.2.3.5, standard Project-related operational water consumption requirements are estimated to be 64.5 m^3 per day. Although it is anticipated that the Project water supply will primarily be sourced from existing public water main pipelines that are owned and operated by BWA, on-site water storage tanks for operations water will smooth out the flow of withdrawal from BWA's public water mains during the day. The water in these storage tanks can be drawn upon as needed during Project operations to supplement the water supply from BWA, thereby reducing the Project's reliance on that external resource, and/or as a contingency reserve in the event of interruption to water service from BWA. The planned re-use of the mineralized water by-product from the water treatment plant for irrigation and washdown, and the planned recirculation of the process water from the HESS to the electrolysers for re-use in the electrolysis process, will reduce Project-related consumption of potable water. An evaluation of the viability of rainwater harvesting as a mechanism for reducing Project-related potable water use will be performed. Water from this storage would be captured during the rainy season for use throughout the year, thus offsetting the quantity of potable water that may be required from the public mains.

There was also a concern about the odours from the animals during the operational phase. The odours from the sheep would have to be controlled by regular cleaning of the farm. Sheep manure from the pens will be collected in skips and sold to soil mix and landscape companies as needed. Sheep manure typically dries out and breaks down quickly without producing strong odours, unlike chicken and pig waste.

If complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related impacts (e.g., glint and glare, reduced water pressure, odour, noise), RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

There is also the possibility that the Project could have an impact the values of surrounding property. There are no local studies on property value impacts in the Barbadian setting and international studies offer conflicting perspectives. For example, economists at the University of Rhode Island have concluded that solar development is having a negative impact on nearby home values (Vasundhara and Lang 2020). However, a survey by the University of Texas at Austin was much less conclusive and the National Director of CohnReznick Advisory's Valuation Practice, said that based on property value impact studies involving solar studies, no consistent negative impact was found on residential property value that could be attributed to nearby solar farms (ASFMRA 2021). In a Policy Research Project paper published in 2018 by the LBJ School of Public Affairs at the University of Texas at Austin, Leila Al-Hamoodah et al. concluded that "*while a majority of survey respondents estimated a value impact of zero, some estimated a negative impact associated with close distances between the home and the facility, and larger facility size. Regardless of these perceptions, geospatial analysis shows that relatively few homes are likely to be impacted. Though only one component of a larger analysis, these property value impacts are likely to be of growing interest as more solar facilities are built*" (Al-Hamoodah 2018). Therefore, it is too early to make a judgement on the potential impact of the Project on the property values of the neighbouring properties.

Table 9.26 provides a characterization of the potential benefits and adverse effects that could occur during the construction phase.

Table 9.26 Characterization of Social Impacts During the Operational Phase

Potential Impacts	Phase	Nature	Geographic Extent	Duration	Significant	Likelihood
The generation of clean, renewable energy	Operation	Positive	Island-wide	Long-term	No mitigation required	Likely
Employment at the energy facility	Operation	Positive	Local/parish	Long-term	No mitigation required	Likely
Employment at the sheep farm	Operation	Positive	Local/parish	Long-term	No mitigation required	Likely
Improvement in national agricultural productive capacity	Operation	Positive	Island-wide	Long-term	No mitigation required	Likely
Reduced visual amenity due to the presence of Project components and perceived negative aesthetic impacts	Operation	Negative	Local	Long-term	Can be mitigated	Uncertain
Potential health and safety impacts on workers	Operation	Negative	Site	Long-term	Can be mitigated	Unlikely
Potential health and safety impacts on adjacent communities	Operation	Negative	Local	Long-term	Can be mitigated	Unlikely
Decreased water pressure due to Project-related water usage	Operation	Negative	Local	Intermittent	Can be mitigated	Uncertain
Odours from the sheep farm	Operation	Negative	Local	Intermittent	Can be mitigated	Likely
A change in property values	Operation	Unknown	Local	Long-term	Cannot be determined based on available information	Uncertain
Accidents (non-routine) events from hazardous products	Operation	Negative	Site	Long-term	Could be significant if they occur	Unlikely

9.2.3 Mitigation Measures

As indicated in Sections 9.2.1 and 9.2.2, there are a number of mitigation measures proposed to reduce the impacts of the Project on the social environment. These are summarized below. In addition, many of the mitigation measures identified in Section 3.7 and Chapter 8 will serve to indirectly reduce Project impacts on the social environment.

The Project is intended to provide jobs for at least 150 persons during construction and up to 20 full-time-equivalents during its operational phase. In addition, the sheep facility is expected to employ ten persons. To enhance the employment benefits of the Project, the hiring process will be transparent and designed so that eligible locals can apply for and have a fair chance of acquiring work at the Project. In addition, consideration will be given to employment opportunities being available to some of the unemployed residents of neighbouring areas.

The Project will be a new addition to a previously agricultural location in a rural community. Concerns about the potential change to the aesthetics of the area will be addressed through a carefully planned and implemented public awareness campaign to address the typical concerns raised about the construction of solar facilities on the scale of the Project. An important component of this campaign will be to clearly explain the design of the energy facility and the potential benefits that could accrue to Barbados.

To reduce negative impacts on neighbouring residents, action will be taken to reduce and mitigate potentially adverse effects from the construction of the Project. The Project must also be compliant with the legal and statutory labour requirements, to safeguard community and worker safety and health. Construction will therefore be based on an approved construction management plan (i.e., a component of the ESMP for the Project) that includes measures to reduce the impacts of noise, dust, vibration, wastes, and traffic (refer to Chapter 11 and Appendix I). Standard environmental protection procedures and mitigation measures that will be implemented for the management of noise, dust, vibration, wastes, and traffic are also outlined in Section 3.7.2, as are measures to mitigate potential impacts on the use of public roadways.

OHS plans will be developed and approved, detailing appropriate operating procedures and safety provisions based on the type of machinery and materials being used, and contractors will be required to operate in compliance with these plans. All personnel will be required to use protective gear to guard against on-the-job injuries. Suitable ergonomic devices, e.g., for lifting and carrying, will be available to workers. Only trained and/or certified persons will use specialised equipment and handle dangerous chemicals. There will be appropriate supervision to prevent workers from causing harm to themselves or others on the site. Daily OHS meetings will occur.

There will be adequate 24-hour security to prevent unauthorized entry into restricted Project areas, through CCTV or equivalent monitoring systems. Additional provisions that will be made to enforce safety in and around construction areas include the installation of sufficient and appropriate lighting, the installation of clearly visible signage that meet the universal design environmental access requirements/standards for persons with disabilities, and the installation of open and unobstructed passageways. Hazardous products will be stored according to industrial requirements and standards and safely secured so that access is limited to authorised personnel. An emergency and disaster

management plan (Section 11.3) will be developed, with emergency drills regularly conducted so that Project personnel are able to respond swiftly and appropriately in the event of an incident. Additional measures to mitigate potential impacts to public health and safety are identified in Section 3.7.2.

Public service announcements will be provided so that commercial operators, residents, and the public are updated on and given appropriate advance notice of the construction activities, especially those, such as construction activities planned outside of typical work hours, such as late evening or night, that could be disruptive.

In addition to regular OHS training and the proposed capacity-building and skills development, Contractors will be required to provide gender sensitization training to address critical on-the-job issues and facilitate positive interactions between workers and the surrounding residents. Topics to be included in the training include gender-responsive behaviour and interactions, avoiding sexual harassment, and conflict resolution skills. In addition, there will be transparent disclosure of the requirements for adequate work facilities and decent work, to allow employees to be apprised of their worker rights and benefits.

Contact will be made with the Barbados Museum and Historical Society if archaeological and cultural heritage features are found within the PDA. In this event, the Contractor will work with the Museum to develop and implement a plan to protect the artefacts.

When operational, the Project will meet national and international standards to protect the health and safety of workers and the surrounding communities. In addition to addressing the impacts of noise, air quality, vibrations, worker health and safety, and public health and safety, the ESMP (Appendix I) includes a SMP that comprises both a stakeholder engagement plan and a grievance redress mechanism, which are designed to allow the best interests of relevant stakeholders to be considered during the Project. The ESMP also includes a Social Monitoring Plan.

10.0 CUMULATIVE IMPACT ASSESSMENT AND MITIGATION

This chapter is the cumulative impact assessment (CIA) portion of the ESIA. The CIA identifies other past, present, and likely (i.e., certain or reasonably foreseeable) future developments within the AOI whose residual environmental impacts could interact cumulatively with the residual environmental impacts of the Project, and assesses the significance of those potential cumulative impacts on relevant VCs.

10.1 CUMULATIVE IMPACT ASSESSMENT SCOPING CONSIDERATIONS AND APPROACH

Where applicable, a CIA is conducted to identify and evaluate the potential cumulative impacts of the Project in combination with other identified developments in the AOI and determine if those cumulative impacts could be significant.

The spatial and temporal boundaries that are presented in Section 6.3 remain applicable for the CIA. As the area in which Project-related impacts will be experienced and can be predicted or measured with a level of confidence that allows for assessment, the AOI is also the area in which residual Project-related

residual impacts have potential to interact with residual impacts from other (non-Project) developments and in which Project contributions to cumulative environmental impacts are likely to be measurable.

A CIA scoping exercise was conducted to identify other past, present, and future developments that:

- Are outside the scope of the Project
- Have been, are being, or are likely to be carried out in the AOI
- Have potential to result in residual environmental and/or social impacts that may interact cumulatively with (i.e., overlap spatially and temporally with) the residual environmental and/or social impacts of the Project

The PDD's statutory map register was reviewed on January 20, 2022 to identify relevant development proposals within the AOI, based on the Applications for Planning Permission (Planning Applications) that have been submitted to the PDD. The search revealed that the PDD has received several hundred Planning Applications for developments proposed within the AOI over the past approximately 20 years. The majority of those Planning Applications pertain to proposed residential and commercial developments within Six Roads and other settlements that are consistent with local land use designations. It was determined that considering hundreds of Planning Applications would be impractical, and in all likelihood would not benefit the purpose of the exercise to identify those developments that could interact cumulatively with the Project. Accordingly, the approach taken was to interview an experienced and knowledgeable Planning Officer (R. Grant, personal communication, 2022), who is familiar with the AOI and the developments therein, regarding the most relevant existing and proposed developments that should be considered in the CIA. The interview was conducted with reference to the PDD's electronic map register to facilitate the identification of specific developments of interest (Table 10.1), the approximate locations of which are shown on Figure 10.1. However, because the PDD does not generally provide third parties with access to submitted Planning Applications, the ESIA Study Team was unable to review planning or other details associated with these existing and proposed developments.

Table 10.1 Developments of Interest for the Cumulative Impact Assessment

Planning Application Number	Application Submission Date (mm/yyyy)	Proposed Development	Location	Project Status
Undetermined Applications				
1857/12/2016D	12/2016	Subdivision of Land into Lots for Residential, Commercial, and Recreational Purposes	Bushy Park (Satellite reference point #1 on Figure 10.1)	Under Review
0159/02/2019D	02/2019	Two Wind Turbines	Sunbury Plantation (Satellite reference point #2 on Figure 10.1)	Under Review
0042/01/2020D	01/2020	1-MW Solar Farm	Sunbury (Satellite reference point #3 on Figure 10.1)	Under Review

Table 10.1 Developments of Interest for the Cumulative Impact Assessment

Planning Application Number	Application Submission Date (mm/yyyy)	Proposed Development	Location	Project Status
1737/11/2020D	11/2020	495-kW Solar Farm	Grove Plantation (Satellite reference point #4 on Figure 10.1)	Under Review
1932/12/2020E	12/2020	495-kW Solar Farm	Congo Road (Satellite reference point #5 on Figure 10.1)	Under Review
0184/03/2021D	03/2021	Change of Use and Subdivision of Land for Residential and Commercial Purposes	Oughterson Plantation (Satellite reference point #6 on Figure 10.1)	Under Review
1574/09/2021E	09/2021	Solar Farm	Sterling Plantation (Satellite reference point #7 on Figure 10.1)	Under Review
Approved Applications				
2091/12/2012	12/2012	Quarry	Padmore (Satellite reference point #8 on Figure 10.1)	Implemented
1171/08/2018D	08/2018	Solar PV Panels	St. Philip Parish Church (Satellite reference point #9 on Figure 10.1)	Not Yet Implemented
1586/11/2018E	11/2018	Solar Farm	Grove Plantation (Satellite reference point #10 on Figure 10.1)	Implemented
0789/06/2019D	06/2019	Biomass Power Generating Facility	Sunbury Plantation (Satellite reference point #11 on Figure 10.1)	Not Yet Implemented

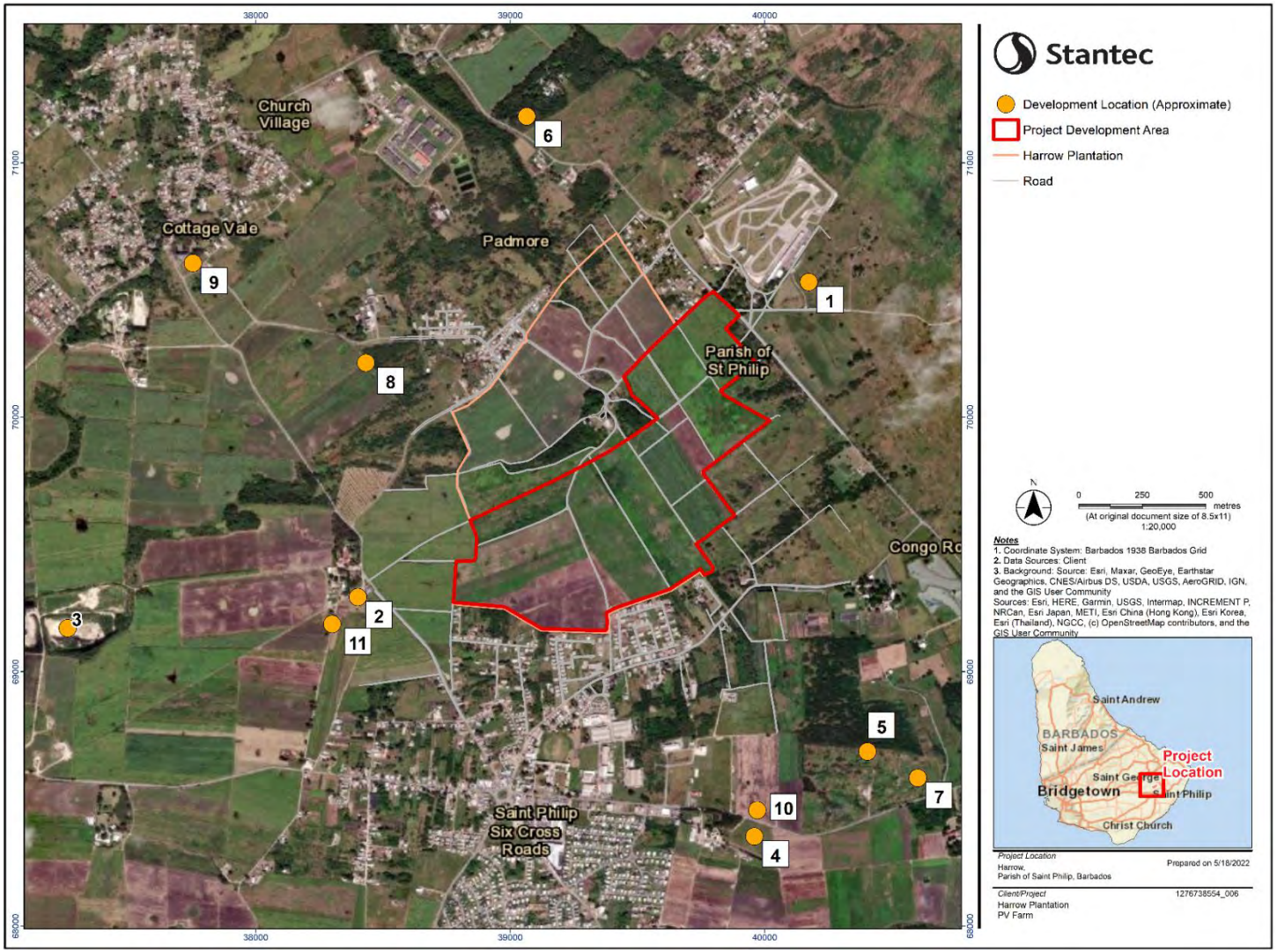


Figure 10.1 Locations of Other Developments of Interest in the AOI, Relative to the Project Development Area

Table 10.1 indicates the statuses of the relevant Planning Applications associated with the developments of interest that have been identified in the AOI, and is broken down into undetermined applications (i.e., applications that are currently under review) and approved applications. Two of the developments that received Planning Permission have already been implemented (i.e., a quarry at Padmore Village and a solar farm at Grove Plantation). Table 10.1 excludes those Planning Applications for which Planning Permission was refused, and for which no appeal against the refusal has been lodged; such developments are excluded from the scope of the CIA.

Existing conditions for each of the VCs in the AOI have been, and continue to be, shaped by the cumulative impacts of historical developments and physical activities previously carried out, as well as ongoing developments and physical activities presently being carried out, in the AOI. Likewise, future developments and physical activities will influence future environmental and social conditions in the AOI. Table 10.1 excludes various agricultural, residential, commercial, recreational, and institutional developments that have historically influenced, and continue to influence, the area. The description of existing conditions that is presented in Chapter 7 characterizes the setting for the Project, supports an understanding of the receiving environment, and provides context for the CIA. It is assumed that the existing status or baseline conditions of each VC reflect the past and present influence of other past and present developments and physical activities within the AOI – including associated cumulative residual environmental and social impacts. Accordingly, the past and present agricultural, residential, commercial, recreational, and institutional developments that have been omitted from Table 10.1 are not considered further in the CIA.

10.2 POTENTIAL CUMULATIVE IMPACTS

For the purposes of this assessment, the potential residual impacts associated with construction, operation and maintenance, and eventual decommissioning (where applicable) of the developments of interest identified in Table 10.1 are generally assumed to be similar to those considered in Chapter 8 and Chapter 9 with respect to the construction, operation and maintenance, and decommissioning phases of the Project. This is expected to be particularly true regarding the construction, operation and maintenance, and eventual decommissioning (if applicable) of other solar PV power projects within the AOI. As is the case for the Project, it is generally assumed that activities associated with other proposed developments in the AOI (where applicable) will be as outlined in Table 10.2.

Table 10.2 Likely Activities Associated with Other Proposed Developments

Phase	Activities
Construction	• Site preparation (e.g., clearing, grubbing, excavation and other ground-disturbing activities), including potential alteration of site topography, vegetation, terrestrial habitat, and drainage conditions • Physical construction and/or installation of various components (e.g., buildings, facilities, equipment, and/or infrastructure) • Construction-related vehicle traffic within the Parish of Saint Philip • Presence and operation of construction-related vehicles, heavy equipment, and machinery on-site, including associated noise, vibration, dust, GHGs, and other air emissions • Generation and management of construction-related emissions, discharges, and/or wastes • Employment and presence of construction personnel
Operation and Maintenance	• Presence and operation of various components (e.g., buildings, facilities, equipment, and/or infrastructure) • Operational vehicle traffic within the Parish of Saint Philip • Presence and operation of maintenance vehicles, heavy equipment, and machinery on-site, including associated noise, vibration, dust, GHGs, and other air emissions • Generation and management of operational emissions, discharges, and wastes • Employment and presence of operational and maintenance personnel
Decommissioning (Where Applicable)	• Dismantling and removal of various components (e.g., buildings, facilities, equipment, and/or infrastructure) • Restoration of disturbed areas as necessary to facilitate the desired end land use of the development site by the landowner • Decommissioning-related vehicle traffic within the Parish of Saint Philip • Presence and operation of vehicles, heavy equipment, and machinery on-site, including associated noise, vibration, dust, GHGs, and other air emissions • Generation and management of decommissioning-related emissions, discharges, and waste • Employment and presence of decommissioning personnel

Ways in which the construction, operation and maintenance, and eventual decommissioning (where applicable) of the other developments of interest in the AOI could vary from the construction, operation and maintenance, and eventual decommissioning of the Project include potential differences in the following:

- The nature and extent of site preparation activities
- The nature and extent of activities associated with the construction / installation, and/or eventual dismantling / removal (where applicable), of various components
- The volume of vehicle traffic within the Parish of Saint Philip and the sizes / types of vehicles used
- The sizes / types and numbers of vehicles, equipment, and machinery required on-site
- The quantities / volumes and types of emissions, discharges, and wastes
- The number of people employed and their demographics

Despite these potential differences, the mechanisms / pathways for residual impacts associated with the other developments of interest in the AOI are generally anticipated to be similar to the mechanisms / pathways for residual Project-related impacts. The other developments of interest in the AOI are therefore

anticipated to interact with the biophysical / ecological, anthropogenic, and social VCs identified in Section 6.2 in such a way that results the same residual environmental and social impacts that are predicted for the Project in Chapter 8 and Chapter 9.

Table 10.3 summarizes the predicted residual impacts of the Project, which are generally anticipated to also be applicable for the other developments of interest in the AOI. However, the characteristics (i.e., direction, magnitude, geographic extent, duration, frequency, reversibility, and probability) of some or all of the residual impacts of the other developments of interest in the AOI may vary – and in some cases may vary considerably – from the characteristics of Project-related residual impacts, as demonstrated by the following examples:

- It is assumed that several of the residual impacts associated with the proposed residential, commercial, and recreational developments at Bushy Park and Oughterson Plantation will be relatively greater in magnitude and/or geographic extent than the corresponding Project-related residual impacts.
- It is assumed that the magnitude, frequency, duration, and/or probability of several potential residual impacts associated with quarry operations at Padmore Village (e.g., residual changes in air quality, the acoustic environment, surface water quantity / quality, groundwater quantity / quality, flora / flora habitat, flora health / survival, flora habitat quantity / quality / use, and non-agricultural land use) will be relatively greater than the magnitude, frequency, duration, and/or probability of those Project-related residual impacts. This is because quarrying operations may entail activities such as blasting, the extraction and crushing rock, the presence of overburden and aggregate stockpiles, potential excavation below the groundwater table and the pumping of water to maintain a dry quarry floor, and the complete removal of vegetation and terrestrial habitat within the quarry footprint.
- It is assumed that operation of the proposed biomass power generation facility at Sunbury Plantation will produce stack emissions and that the resultant residual changes in air quality, and GHG emissions will therefore have a relatively greater magnitude than the residual changes in air quality and GHG emissions that are predicted for the Project in Chapter 8.

It is generally assumed that the residual impacts of the existing and proposed solar PV power projects identified in Table 10.1 will be the most directly comparable to Project-related residual impacts and will have the most similar characteristics.

Table 10.3 Residual Impacts of the Project and Other Developments of Interest in the AOI

Potential Residual Environmental Impacts	Potential Residual Social Impacts
Construction Phase and Potential Decommissioning Phase (Where Applicable)	
• Change in air quality • Change in GHG emissions • Change in acoustic environment • Change in surface water quantity / quality • Change in groundwater quantity / quality • Change in flora / flora habitat • Change in flora health / survival • Change in fauna habitat quantity / quality / use • Change in visual landscape / aesthetics • Change in reflection conditions (i.e., glint and glare)[1] • Change in lighting conditions • Change in quantity / quality of agricultural land • Change in other (non-agricultural) land use	• Construction-related jobs • Capacity-building and skills development for local workers • Increased technological capacity of local businesses • Support for local suppliers in the construction and other relevant sectors[2] • Increased retail business, primarily food-related from construction workers • Business for accommodation and car rental companies • Noise and vibrations from construction vehicles and equipment • Impaired air quality from dust and other emissions from construction vehicles and equipment • Reduced visual amenity due to construction activity • Damage to roads from construction vehicles and equipment • Health and safety risks to on-site workers • Health and safety risks to adjacent communities and general public • Influx of temporary workers affect social dynamics • Perceptions of inequitable labour conditions • Delays to construction if any archaeological and cultural heritage features are found on-site
Operation and Maintenance Phase	
• Change in air quality • Change in GHG emissions • Change in acoustic environment • Change in surface water quantity / quality • Change in groundwater quantity / quality • Change in flora / flora habitat • Change in flora health / survival • Change in fauna habitat quantity / quality / use • Change in visual landscape / aesthetics • Change in reflection conditions (i.e., glint and glare)[1] • Change in lighting conditions • Change in quantity / quality of agricultural land • Change in other (non-agricultural) land use	• The generation of clean, renewable energy[3]Employment • Improvement in national agricultural productive capacity[4] • Reduced visual amenity due to the presence of Project components and perceived negative aesthetic impacts • Potential health and safety impacts on workers • Potential health and safety impacts on adjacent communities • Decreased water pressure due to operational water usage • A change in property values

Notes:

[1] A residual change in reflection conditions (i.e., glint and glare) is only anticipated to be applicable with respect to the proposed solar farms at Sunbury Planation, Grove Plantation, Congo Road, and Sterling Plantation, as well as the existing solar PV panels at St. Philip Parish Church and the existing solar farm at Grove Plantation.

[2] This residual social impact is identified in Chapter 9 as "support for local suppliers in construction and renewable energy sectors", but has been generalized here, for the purposes of the CIA, to be more broadly applicable to the other developments of interest in the AOI.

Table 10.3 Residual Impacts of the Project and Other Developments of Interest in the AOI

Potential Residual Environmental Impacts	Potential Residual Social Impacts
[3] This residual social impact (i.e., the generation of clean and/or renewable energy) is only applicable to the Project, the various other existing and proposed solar PV power projects in the AOI, and the proposed wind turbines and biomass power generation facility at Sunbury Plantation.	
[4] Although the Project and the other developments of interest in the AOI are generally anticipated to result in adverse residual impacts on agricultural land use, the proposed use of the PDA for sheep farming will result in a positive (i.e., beneficial) Project-related change in the quantity / quality of agriculture land that will partially offset the residual adverse Project-related change in the quantity / quality of agricultural land associated with the loss of arable production at Harrow Plantation. Similarly, there is potential for the other developments of interest in the AOI to be designed in such a way that partially offsets their residual impacts on agricultural land use and helps improve national agricultural productive capacity.	

The main potential cumulative impacts that could arise due to interactions between the residual impacts of the Project and the residual impacts of other developments of interest in the AOI are as follows.

- The **Atmospheric and Acoustic Environment VC** could be affected by cumulative changes in air quality, GHG emissions, and the acoustic environment if residual Project-related atmospheric and acoustic emissions (i.e., noise, vibration, dust, GHGs, and other air contaminants) interact cumulatively with:
  - residual atmospheric and acoustic emissions from the construction, operation and maintenance, and/or decommissioning (where applicable) of the other developments of interest in the AOI.
  - residual dust, vibration, and other residual atmospheric and acoustic emissions from current quarrying operations at Padmore Village.
  - residual stack emissions and other residual atmospheric and acoustic emissions from future operation of the proposed biomass power generation facility at Sunbury Plantation.

  The residual impacts of the Project on the atmospheric and acoustic environment have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on the atmospheric and acoustic environment due to:
  - the proximity of the other developments of interest to the PDA.
  - the potential for Project and non-Project residual air emissions to disperse in the atmosphere.
  - the potential for Project and non-Project residual acoustic emissions to be perceptible at a distance from the source.
- The **Surface Water and Groundwater Resources VC** could be affected by cumulative changes in surface water quantity / quality and groundwater quantity / quality if residual Project-related impacts on surface water and groundwater resources interact cumulatively with residual drainage and water balance impacts associated with current quarrying operations in Padmore Village.

  The residual impacts of the Project on surface water and groundwater resources have potential to overlap spatially with the residual impacts of the quarry at Padmore Village on surface water and groundwater resources due to:
  - the proximity of the quarry to the PDA and the drinking water wells in the vicinity of the PDA (refer to Figure 7.5 in Section 7.1.6).
  - the location of the quarry within the North Watershed, which drains into the PDA (as described in Section 7.1.5.1).

- The **Flora and Fauna VC** could be affected by cumulative changes in flora / flora habitat, flora health / survival, fauna habitat quantity / quality / use, and fauna mortality risk due to the cumulative loss/alteration of terrestrial habitat within the AOI in general as well as the potential for residual Project-related impacts on flora and fauna to interact cumulatively with:
  - residual sensory disturbance to fauna from the construction, operation and maintenance, and eventual decommissioning (where applicable) of other developments of interest in the AOI.
  - residual risks of collisions between birds / fauna and the vehicles, heavy equipment, machinery, and/or infrastructure (including solar panels and wind turbines) associated with the other developments of interest in the AOI.

  The residual impacts of the Project on flora and fauna have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on flora and fauna due to:
  - the proximity of the other developments of interest to the PDA.
  - the potential for Project and non-Project residual air emissions to disperse in the atmosphere.
  - the potential for Project and non-Project residual acoustic emissions to be perceptible at a distance from the source.
  - the potential for birds / fauna that travel around the AOI throughout their life histories to repeatedly encounter or become exposed to residual sensory disturbance and/or residual collision risk from multiple Project and non-Project sources.
- The **Visual Environment VC** could be affected by cumulative changes in visual landscape / aesthetics, reflection conditions (i.e., glint and glare), and lighting conditions if residual Project-related impacts on the visual environment interact cumulatively with:
  - residual visual impacts from the presence of buildings, facilities, equipment, and/or infrastructure associated with the other developments of interest in the AOI, including residential and commercial buildings and associated infrastructure, solar panels at several sites, wind turbines at Sunbury Plantation, the operational area of the quarry at Padmore Village, and the biomass power generation facility at Sunbury Plantation.
  - residual glint and glare from other solar PV power projects in the AOI.
  - residual artificial night lighting from the other developments of interest in the AOI.

  The residual impacts of the Project on the visual environment have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on the visual environment due to:
  - the proximity of the other developments of interest to the PDA.
  - the possibility that some of the same off-site receptors may be subject to residual visual impacts from both Project and non-Project sources.

- The **Agriculture and Other Land Use VC** could be affected by a cumulative change in quantity / quality of agricultural land due to the cumulative loss / alteration of agricultural land within the AOI in general, as many of the other existing and proposed developments in the AOI are located on agricultural lands, including at Sunbury Plantation, Grove Plantation, Oughterson Plantation, and Sterling Plantation.

  The **Agriculture and Other Land Use VC** could also be affected by a cumulative change in other (non-agricultural) land use if residual Project-related impacts on other (non-agricultural) land use interact cumulatively with residual sensory disturbance and nuisance impacts from the other existing and proposed developments in the AOI.

  The residual impacts of the Project on agriculture and other land use have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on agriculture and other land use due to:
  - the proximity of the other developments of interest to the PDA.
  - the designation of Harrow Plantation (including the PDA) and other lands within the AOI as agricultural lands in the current PDP (Government of Barbados 2003) and the draft amended PDP (Government of Barbados 2017). These lands also fall within the boundaries of a designated Soil Protection Overlay that is identified in the 2017 draft amended PDP and is intended to safeguard agricultural lands.
- The **Social VCs** could be affected by cumulative changes in health and safety, human capital, economy, cultural values, infrastructure and services, and social dynamics if Project-related residual social impacts interact cumulatively with the residual social impacts of the other developments of interest in the AOI.

  The residual impacts of the Project on agriculture and other land use have potential to overlap spatially with the residual impacts of the other developments of interest in the AOI on agriculture and other land use due to:
  - the proximity of the other developments of interest to the PDA.
  - the possibility that some of the same off-site receptors may be subject to residual social impacts from both Project and non-Project sources.
  - the likelihood that the Project and some or all the other developments of interest in the AOI may draw from the same local workforce; interact with the same local infrastructure and services; and/or affect the local economy, local human capital, local cultural values, and/or local social dynamics within the same area.

The residual impacts of the Project on all VCs have potential to overlap temporally with the residual impacts of the other developments of interest in the AOI on all VCs if the timing of Project construction, operation and maintenance, and/or decommissioning activities coincides with the timing of construction, operation and maintenance, and/or decommissioning (where applicable) activities associated with the other developments of interest in the AOI.

10.3 MITIGATION

Section 3.3 summarizes the design mitigation measures, general standard environmental protection procedures, and VC-specific mitigation measures that will be implemented to mitigate potential Project-related environmental and social impacts. VC-specific mitigation measures are also described in Chapters 8 and 9.

Where applicable, it is assumed that each of the other developments of interest in the AOI will be carried out in accordance with the requirements of the PDP and other relevant plans, policies, and legislation pertaining to land use and environmental / social considerations, including in accordance with requirements related to the assessment of potential environmental, social, and/or agricultural impacts associated with each respective development. It is also anticipated that each of the other developments of interest in the AOI will be required to have the following in place:

- measures to manage their emissions, discharges, and wastes, including mitigation measures to reduce the noise, vibration, dust, GHGs, and other air emissions potentially generated from their activities
- measures to mitigate potential erosion and sedimentation, surface water runoff and other drainage and water balance impacts, impacts to flora and fauna, visual impacts, agricultural impacts, and social impacts.

If complaints are received from community members, surrounding land users, or other stakeholders regarding perceived Project-related residual impacts or the Project's perceived contribution to cumulative impacts, RSB will work with the affected stakeholders to address their concerns through the grievance redress mechanism outlined in the ESMP (Appendix I) and the potential implementation of additional mitigation measures as needed.

10.4 CHARACTERIZATION OF RESIDUAL CUMULATIVE IMPACTS AND SIGNIFICANCE DETERMINATION

In general, with application of the mitigation considered in Section 10.3, the potential cumulative environmental impacts of the Project in combination with the other developments of interest in the AOI are predicted to be adverse in direction, low to moderate in magnitude, to range in geographic extent from the PDA to the RSA, to occur occasionally to continuously in frequency over a medium-term duration, and to be reversible. However, residual cumulative changes in air quality and GHG emissions have potential to extend beyond the RSA due to the potential for certain types of air emissions, including GHG emissions, to disperse in the atmosphere.

The residual impacts of the proposed residential, commercial, and recreational developments at Bushy Park and Oughterson Plantation may interact cumulatively with the residual impacts of the Project on various VCs. As is generally anticipated to be the case for the various developments of interest identified in Table 10.1, their construction will likely entail atmospheric and acoustic emissions, physical disturbances and associated drainage impacts and alteration / loss of terrestrial habitat, risk of wildlife collisions with construction vehicles and equipment, alteration of the visual landscape, artificial night

lighting, potential sensory disturbance and nuisance impacts to surrounding receptors, and the alteration/loss of agricultural land. Following their construction, they may contribute to cumulative adverse impacts due to the increased presence of traffic, artificial night lighting, and infrastructure within the AOI. (The potential cumulative adverse change in fauna mortality risk associated with the increased presence of infrastructure within the AOI is considered in the following paragraph.) However, these proposed developments are consistent with local land use designations and may also contribute a residual positive change in non-agricultural land use within the AOI, as well as other residual social and economic benefits (e.g., an increase in property values), once their construction is complete.

As described in Section 8.4.3.2, solar PV panels may attract migratory bird species through the “lake effect”, where some birds may perceive the reflective surfaces as bodies of water, which may lead to collisions as they try to land (ECO Consult 2020, Hathcock 2018, and Walston et al. 2016). There are nearby ponds that are already used as rest sites (within the Project AOI, as well as the IBA), and therefore this could be an issue for birds in the area. There may also be a collision risk for birds associated with certain infrastructure, potentially including power lines. Accordingly, when the Project and the other existing and proposed solar PV power projects identified in Table 10.1 are operational, the presence of their PV arrays and supporting infrastructure is anticipated to result in a cumulative adverse change in fauna mortality risk. The two wind turbines that are proposed at Sunbury Plantation are also anticipated to pose a potential collision risk for birds, as well as bats, that will contribute to this cumulative adverse change in fauna mortality risk, as is the infrastructure associated with several of the other proposed developments identified in Table 10.1. The presence and operation of Project components, such as the PV arrays and supporting infrastructure, may have a direct effect on fauna mortality risk that contributes incrementally to the residual cumulative change in fauna mortality risk in the AOI. Avian deterrents may be installed to reduce bird attraction to or collisions with Project infrastructure, should high-risk areas be identified during the course of Project operations.

As is the case for the Project, the other existing and proposed solar PV power projects in the AOI are also anticipated to result in residual changes in the visual landscape / aesthetics and reflection (i.e., glint and glare). Although some of the same off-site receptors may be subject to residual visual impacts from both Project and non-Project sources, it is considered unlikely that any receptors would be simultaneously exposed to potential glint and glare from multiple solar PV power projects.

The Project may interact cumulatively with operation of the quarry at Padmore Village to result in residual cumulative adverse changes in surface water quantity / quality and groundwater quantity / quality. However, the potential contribution of the Project to any such residual cumulative impacts is anticipated to be negligible since the PDA is located downstream of the quarry and is also located downstream of the drinking water wells that are in the vicinity of the quarry (i.e., to the north of the PDA) (refer to Figure 7.5 in Section 7.1.6). Furthermore, by way of analyses conducted in the Project-specific Drainage Impact Assessment (Appendix B), it was demonstrated that the infiltration trench that is proposed along the southern boundary of the PDA could result in downstream runoff volumes from the PDA being slightly less than the baseline scenario during the operational phase of the Project.

The Project and the other developments of interest in the AOI are generally anticipated to result in cumulative residual adverse impacts on agriculture land use due to the occupation, alteration, and use of existing or historical agricultural lands for non-agricultural purposes (i.e., for the purposes of carrying out the Project as well as for the purposes of carrying out most of the other existing and proposed developments in the AOI that are identified in Table 10.1). However, the proposed use of the PDA for sheep farming will partially offset the residual adverse Project-related change in the quantity / quality of agricultural land associated with the loss of arable production at Harrow Plantation. Since the ESIA Study Team was unable to review the proposed planning details associated with the other developments of interest in the AOI, it is unknown whether Sunbury Plantation will continue to support agricultural land use following construction of the proposed wind turbines and the proposed biomass power generation facility identified in Table 10.1, or the extent to which the other developments of interest identified in Table 10.1 may be designed to mitigate or partially offset residual changes in the quantity / quality of agricultural land in the AOI. In the absence of this information, the residual cumulative change in quantity / quality of agricultural land is conservatively estimated to range from moderate to high in magnitude.

The predicted residual cumulative adverse change in the quantity / quality of agricultural land could be significant if the residual impacts of the Project combine with the residual impacts of the other developments of interest in the RSA to result in a cumulative change or disruption that widely restricts or degrades present land use capability to a point where agricultural or other land use activities cannot continue at or near current levels in the RSA. However, this is not expected to occur since, as indicated in Section 10.3, it is assumed that each of the other developments of interest in the AOI will be carried out in accordance with the requirements of the PDP and other relevant plans, policies, and legislation pertaining to land use and environmental / social considerations, including in accordance with requirements related to the assessment of potential environmental, social, and/or agricultural impacts associated with the development (where applicable). The current PDP (Government of Barbados 2003) requires that, under exceptional circumstances, non-agricultural development may be considered on agricultural land (subject to an ESIA and amendment to the current PDP in instances where the land area is greater than 10 ha), but only if the proposal provides significant economic, social, or environmental benefits, and if suitable sites are not available in urban areas or rural settlements. Where there are no alternatives to development on agricultural land, development will be directed to lower quality agricultural land. The draft amended PDP (Government of Barbados 2017) states that a change of use or subdivision of agricultural land for a site greater than two acres (approximately 0.8 ha) or more than five residential lots will require an Agricultural Impact Assessment to determine impacts on or incompatibilities with agricultural use. It is also anticipated that each of the other developments of interest in the AOI will be required to have mitigation in place to reduce potential agricultural impacts.

In general, with application of the mitigation considered in Section 10.3, the potential cumulative social impacts of the Project in combination with the other developments of interest in the AOI are predicted to range from positive to adverse in direction, from low to moderate in magnitude, from the PDA to the RSA in geographic extent, and from occasionally to continuously in frequency. These residual cumulative social impacts are also generally predicted to be medium-term in duration and reversible.

As is the case for the Project, it is similarly anticipated that each of the other developments of interest in the AOI will be required to have mitigation in place to reduce the noise, vibration, dust, GHGs, and other air emissions potentially generated from their activities. These measures will help mitigate the potential cumulative adverse changes in air quality, GHGs, and the acoustic environment; potential cumulative adverse changes in flora / flora health and fauna habitat quantity / quality / use; potential cumulative adverse changes in the quantity / quality of agricultural land; potential cumulative adverse changes in other (non-agricultural) land use; and potential adverse cumulative changes to the health and safety of the residents in the adjacent communities that might otherwise occur at a greater magnitude due to the cumulative noise, vibration, dust, GHGs, and other air emissions that could result from the simultaneous construction of multiple projects. However, as several of the Planning Applications identified in Table 10.1 are still under review and there is no indication of the schedule for construction of the proposed developments that have already received approval, it is assumed to be unlikely that all of the other proposed developments in the AOI will be under construction simultaneously with each other and/or with the Project.

The positive residual cumulative social impacts that may be associated with the construction and decommissioning phases of the Project in combination with construction, operation and maintenance, and/or decommissioning (where applicable) of the other developments of interest in the AOI include beneficial cumulative changes related to jobs, capacity-building and skills development for local workers, technological capacity of local businesses, support for local suppliers in the construction and renewable energy sectors, retail business, and business for accommodation and car rental companies. The positive residual cumulative social impacts that may be associated with the operation and maintenance phase of the Project in combination with construction, operation and maintenance, and/or decommissioning (where applicable) of the other developments of interest in the AOI include beneficial cumulative changes related to the generation of clean, renewable energy and employment.

When they are all constructed, the Project and the other solar PV power projects in the AOI will cumulatively represent a substantial change in the existing visual character of the AOI from agricultural, residential, and minimal commercial, to an increase in solar generating use and transmission infrastructure. Some residents could perceive the increased arrays as negatively affecting the landscape’s aesthetic.

As is the case for the Project, several of the other developments of interest in the AOI (i.e., the existing and proposed solar PV power projects throughout the AOI, the proposed wind turbines at Sunbury Plantation, and the proposed biomass power generation facility at Sunbury Plantation) are anticipated to contribute towards positive cumulative social impacts related to the generation of clean and/or renewable energy; these positive residual cumulative social impacts are predicted to extend beyond the RSA to result in island-wide benefits. In addition to representing an enhancement in the production of reliable energy for the island, the cumulative increase in renewable energy developments will further the national goal of transitioning to 100% renewable energy and carbon-neutrality by 2030. There will also be an attendant increase in employment in the local renewable energy industry.

In conclusion, with the application of the mitigation considered in Section 10.3, residual cumulative environmental and social impacts on the atmospheric and acoustic environment, surface water and groundwater resources, flora and fauna, the visual environment, agriculture and other land uses, health and safety, human capital, cultural values, infrastructure and services, and social dynamics are predicted to be not significant. Table 10.4 characterizes the predicted residual cumulative impacts of the Project in combination with the residual impacts of the other developments of interest in the AOI (as identified in Table 10.1). No additional mitigation measures are considered necessary to address potential cumulative impacts on those VCs – beyond the general standard environmental protection procedures and VC-specific measures that have been proposed to mitigate Project-related impacts, as well as the standard mitigation measures that are assumed to be required for the other developments of interest in the AOI (as described in Section 10.3).

The residual cumulative impact predictions summarized in Table 10.4 have been made with a moderate level of confidence based on a good understanding of the general environmental and social impacts of Project activities, the general environmental and social impacts of the main activities that are likely to be associated with the other developments of interest in the AOI, and the effectiveness of standard mitigation measures, but in the absence of details regarding the timing, scale, or specific activities associated with the other developments of interest in the AOI.

The potential environmental and social impacts of various Project-related accident, malfunction, emergency, or disaster scenarios are assessed in Section 8.7 and Section 9.2. All of the scenarios are considered unlikely to occur. Of the identified scenarios, the most likely Project-related accidental events that could occur are small spills or leaks of petroleum products, hydraulic fluids, lubricants, or coolants from Project vehicles, heavy equipment, or machinery. Spill prevention and response procedures will be in place to reduce the risk of spills, including small spills, and associated environmental impacts (refer to Section 8.7 and Section 3.3 for additional information). It is assumed that the proponents of other developments of interest in the AOI will also implement spill prevention and response measures. A small Project-related spill within the PDA would not be expected to interact cumulatively with the other developments of interest in the AOI because the residual impacts of the spill would not be expected to overlap spatially and temporally with the residual impacts of the other developments of interest in the AOI. As described in Section 8.7 and Section 9.2, the residual adverse impacts of a potential accidental spill or leak of a large volume of hazardous substances could be significant, depending on the magnitude of the accidental spill or leak. However, given the low likelihood of a major spill event occurring for the Project, the likelihood of spills occurring from multiple projects in the AOI in such a way that residual environmental impacts have potential to overlap spatially and temporally is even more remote.

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Atmospheric and Acoustic Environment									
Residual Change in Air Quality and Residual Change in GHG Emissions									
Construction	A	L–M	L–R+	MT	S–C	R	L	N	M
Operation and Maintenance	A	L–M	L–R+	MT	O–C	R	L	N	M
Operation and Maintenance	P	M	L	MT	C	R	L	N	M
Decommissioning	A	L–M	L–R+	MT	S–C	R	L	N	M
Residual Change in Acoustic Environment									
Construction	A	L–M	L	ST–MT	S–C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	O–C	R	L	N	M
Decommissioning	A	L–M	L	MT	S–C	R	L	N	M
Surface Water and Groundwater Resources									
Residual Change in Surface Water Quantity / Quality and Groundwater Quantity / Quality									
Construction	A	L–M	L	MT	S–C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	S–C	R	L	N	M
Decommissioning	A	L–M	S–L	MT	C	R	L	N	M
Flora and Fauna									
Residual Change in Flora / Flora Habitat									
Construction	A	L–M	L	LT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	LT	C	R	L	N	M
Decommissioning	A	L–M	L	LT	C	R	L	N	M
Residual Change in Flora Health / Survival and Fauna Habitat Quantity / Quality / Use									
Construction	A	L–M	L	LT	C	R	L	N	M
Operation and Maintenance	A	L	L	LT	C	R	L	N	M
Decommissioning	A	L–M	L	LT	C	R	L	N	M
Residual Change in Fauna Mortality Risk									
Construction	A	L–M	S–L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	S–L	LT	C	R	L	N	M
Decommissioning	A	L–M	S–L	LT	C	R	L	N	M

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Visual Environment									
Residual Change in Visual Landscape / Aesthetics									
Construction	A	M	L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	L	N	M
Decommissioning	A	M	L	LT	C	R	L	N	M
Residual Change in Reflection Conditions (i.e., Glint and Glare)									
Construction	No pathways for potential Project-related changes in reflection conditions have been identified for the construction phase of the Project (refer to Section 8.5.1). Project construction activities are therefore not anticipated to result in a residual change in reflection conditions, nor to contribute to a residual cumulative change in reflection conditions.								
Operation and Maintenance	A	M	L	MT	C	R	L	N	M
Decommissioning	No pathways for potential Project-related changes in reflection conditions have been identified for the decommissioning phase of the Project (refer to Section 8.5.1). Project decommissioning activities are therefore not anticipated to result in a residual change in reflection conditions, nor to contribute to a residual cumulative change in reflection conditions.								
Residual Change in Lighting Conditions									
Construction	A	L–M	L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	L	N	M
Decommissioning	A	L–M	L	MT	C	R	L	N	M
Agriculture and Other Land Use									
Residual Change in Quantity / Quality of Agricultural Land									
Construction	A	M–H	L	MT	S–C	R	L	N	M
Operation and Maintenance	A	M–H	L	MT	S–C	R	L	N	M
Decommissioning	A	M	L	MT	C	R	L	N	M
Residual Change in Other (Non-Agricultural) Land Use									
Construction	A	M	L	ST–MT	S–C	R	L	N	M
Operation and Maintenance	A	M	L	MT	C	R	L	N	M
Decommissioning	A	M	L	MT	C	R	L	N	M

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Social VCs									
Residual Change in Health and Safety									
Construction	A	L– M	S–L	MT	C	R	U	N	M
Operation and Maintenance	A	L– M	S–L	MT	C	R	U	N	M
Decommissioning	A	L– M	S–L	MT	C	R	U	N	M
Residual Change in Human Capital									
Construction	P	L–M	S–L	MT	C	R	L	N	M
Operation and Maintenance	P	L–M	S–L	MT	C	R	L	N	M
Decommissioning	P	L–M	S–L	MT	C	R	L	N	M
Residual Change in Economy									
Construction	P	L–M	L	MT	C	R	L	N	M
Operation and Maintenance	P	L–M	L	MT	C	R	L	N	M
Decommissioning	P	L–M	L	MT	C	R	L	N	M
Residual Change in Cultural Values									
Construction	A	L–M	S–L	MT	O–C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	L	N	M
Decommissioning	A	L–M	S–L	MT	O–C	R	L	N	M
Residual Change in Infrastructure and Services									
Construction	A	L–M	L	MT	C	R	L	N	M
Operation and Maintenance	A	L–M	L	MT	S–C	R	L	N	M
Operation and Maintenance	P	M	R+	MT	C	R	L	N	M
Decommissioning	A	L–M	L	MT	C	R	L	N	M

Table 10.4 Residual Project-related and Cumulative Environmental and Social Impacts

Project Phase	Residual Environmental and Social Impact Characteristics								
	Residual Cumulative Impacts								
	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Probability	Significance	Prediction Confidence
Residual Change in Social Dynamics									
Construction	A	L–M	L	MT	C	R	U	N	M
Operation and Maintenance	A	L–M	L	MT	C	R	U	N	M
Decommissioning	A	L–M	L	MT	C	R	U	N	M

KEY

Refer also to Section 8.1.2.3 and Table 8.2 for detailed definitions of the residual environmental impact characterization criteria and associated ratings.

Direction of Residual Impact:

P Positive
A Adverse
N Neutral

Magnitude of Residual Impact:

N Negligible
L Low
M Moderate
H High

Geographic Extent of Residual Impact:

S (Site): Within the PDA
L (Local): within the AOI
R (Regional): Within the RSA
R+ (Extra-Regional): Extends beyond the RSA

Duration of Residual Impact:

Quantitative measure; or
ST (Short-term): Occurs for a portion of the duration of the applicable phase(s) of the Project
MT (Medium-term): Occurs for the entire duration of the applicable phase(s) of the Project.
LT (Long-term): Extends beyond the life of the Project

Frequency of Residual Impact:

Quantitative measure; or
O (Occasional): Once per month or less
S (Sporadic): Occurs sporadically at irregular intervals
R (Regular): Occurs on a regular basis and at regular intervals
C (Continuous): Occurs continuously

Reversibility of Residual Impact:

R Reversible
I Irreversible

Probability

L Likely
U Unlikely
? Uncertain

Significance of Residual Impact:

S Significant
N Not Significant

Prediction Confidence:

L Low level of confidence
M Moderate level of confidence
H High level of confidence

11.0 MONITORING AND MANAGEMENT PLANS

11.1 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

The Environmental and Social Management Plan (ESMP) for the Project (Appendix I) is intended to be a "living" document that is revised as necessary to remain relevant to the applicable stage of Project planning, design, and execution. The ESMP defines mitigation, management, and monitoring requirements for the Project by phase (i.e., construction, operation and maintenance, and decommissioning) and provides a framework for the specific responsibilities, tasks, and schedule for implementing, supervising, monitoring, and reporting the prescribed environmental and social impact mitigation and management measures. It is based on the results of the ESIA and provides practical guidance on how commitments made in the ESIA will be implemented during Project execution. As identified in the TOR, additional consideration has been given to environmental concerns from the use of hydrogen manufacturing, hydrogen storage and utility-scale batteries including disposal, recycling and fire / explosion mitigation.

11.2 CONSTRUCTION MANAGEMENT PLAN

As per the TOR, the purpose of the Construction Management plan is to outline the approach to be taken for managing construction works. A comprehensive description of expected activities, techniques, laydown yard location, hours of operation and timeframes for different phases has been presented. The purpose of the plan is to appropriately identify, manage, and mitigate potential impacts that may arise due to the Project. The impacts addressed include construction-related noise, vibrations, dust, storm-water run-off, safety, traffic flows and any other relevant matters.

The Construction Management Plan is included within the overall ESMP (Appendix I).

11.3 EMERGENCY AND DISASTER MANAGEMENT PLAN

As per the TOR, the Emergency and Disaster Management Plan has been prepared to identify recommended procedures and protocols to be carried out in the event of a natural, accidental, or human-made disaster at the Project energy facility. The plan includes protocols for emergencies and disasters such as explosions, fire, spills, and hurricanes. It has been developed in consideration of the results of the Project-specific Hazard Study and Quantitative Risk Assessment (Appendix D).

The Emergency and Disaster Management Plan is included within the overall ESMP (Appendix I).

12.0 CONCLUSION AND RECOMMENDATIONS

RSB is proposing to construct and operate a hybrid solar PV energy facility with hydrogen storage at Harrow Plantation in the Parish of Saint Philip, Barbados. The Project will deliver non-intermittent, carbon-free, and renewable electrical power to the national grid and will also accommodate a large-scale Blackbelly sheep farming facility within the solar power plant and surrounding green areas. The Project will generate approximately 56,000 megawatt-hours (MWh) per year of solar power with hydrogen storage, thereby providing non-intermittent renewable power to the equivalent of approximately 16,000 homes annually[10].

With the release of the BNEP (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 help Barbados achieve its renewable energy and carbon neutrality targets. Where other solar PV approaches provide intermittent power with little or no storage, the Project offers a baseload solution that combines solar power with hydrogen and lithium technologies.

The electricity generated by the Project will be purchased by BLPC at an agreed rate through a power purchase agreement for 25 years following the commissioning of the power plant. The tentative Project schedule is for construction to occur between June 2023 and June 2025. Operation and maintenance would begin in July 2025 with the designed operational lifetime of the Project being at least 25 years. The decommissioning phase of the Project will commence following the conclusion of Project operations and is anticipated to last approximately 12 months.

Project construction will be managed by an international engineering, procurement, and construction contractor that will subcontract with the local workforce. It is estimated that the construction phase of the Project will provide temporary employment for up to approximately 150 local people. Following construction, it is estimated that approximately 20 full-time-equivalent permanent local jobs will be created to support Project operation, maintenance, and security requirements. The sheep farming aspect of the Project is expected to employ an additional 10 local people as farmers and farm staff. In addition to their pay, Project personnel will also gain valuable experience and training.

This ESIA has been prepared to support the Proponent's application to Barbados' Planning and Development Department for Planning Permission to proceed with the Project. It has been developed in consideration of the TOR for the ESIA (Appendix A) and relies on several Project-specific studies that have been conducted in support of the impact assessment:

- Baseline Ecological Assessment (Appendix F)
- Baseline Noise Assessment (appended to the Acoustic Assessment in Appendix E)
- Acoustic Assessment (Appendix E)
- Drainage Assessment (Appendix B)

[10] Calculation based on an average electricity consumption of 3,480 kWh per inhabitant per year.

- Visual Impact Assessment (Appendix G)
- Glint and Glare Study (Appendix H)
- Agricultural Impact Assessment (Appendix C)
- Social Impact Assessment Baseline Study (Section 9.1)
- Quantitative Risk Assessment (Appendix D)

The ESIA describes the planned activities and components of the Project, the existing baseline conditions at the Project Property, the potential physical, biological and social impacts associated with routine Project activities, and mitigation measures and controls to reduce the potential for adverse environmental impacts during each phase of the Project. In addition, the ESIA assesses potential impacts that could occur as a result of accidents, malfunctions and disasters, as well as the potential cumulative impacts of the Project in combination with other past, present and reasonably foreseeable activities. Further, the ESIA identifies the proposed management and monitoring plans (including emergency response procedures) that would be in place to protect the environment and human health and safety.

Specifically, the ESIA assesses potential Project impacts for the following VCs:

- Atmospheric and Acoustic Environment
- Surface Water and Groundwater Resources
- Flora and Fauna
- Visual Environment
- Agriculture and Other Land Uses
- Health and Safety
- Human Capital
- Economy
- Cultural Values
- Infrastructure and Services
- Social Dynamics

Table 12.1 summarizes the results of the impact assessment for each VC, in consideration of the design mitigation and environmental protection procedures identified in 3.7.

Table 12.1 Summary of VC Impact Assessment in Consideration of Identified Mitigation

VC	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters	Cumulative Effects
Atmospheric and Acoustic Environment	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.

Table 12.1 Summary of VC Impact Assessment in Consideration of Identified Mitigation

VC	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters	Cumulative Effects
Surface Water and Groundwater Resources	Residual adverse impacts are predicted to be low in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of a worst-case accidental spill, leak or LOC could be **significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Flora and Fauna	Residual adverse impacts are predicted to be neutral to low in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Visual Environment	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Agriculture and Other Land Uses	Residual adverse impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a high degree of confidence.	Residual impacts of a worst-case accidental spill, leak or LOC could be **significant**.	Residual cumulative impacts are predicted to be moderate to high in magnitude, reversible and **not significant** with a moderate degree of confidence.
Health and Safety	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impact of a worst-case accidental spill, leak or LOC could be **significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Human Capital	Positive impacts are predicted.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.

Table 12.1 Summary of VC Impact Assessment in Consideration of Identified Mitigation

VC	Routine Activities (Construction, Operation and Decommissioning)	Accidents, Malfunctions and Disasters	Cumulative Effects
Economy	Positive impacts are predicted.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Cultural Values	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Infrastructure and Services	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.
Social Dynamics	Negative impacts can be mitigated and are therefore predicted to be **not significant**.	Residual impacts of an accidental spill, leak or LOC is predicted to be **not significant**.	Residual cumulative impacts are predicted to be low to moderate in magnitude, reversible and **not significant** with a moderate degree of confidence.

Follow-up and monitoring is proposed only for the Flora and Fauna VC and will include regular monitoring for evidence of avian mortalities / collisions with Project infrastructure during the operation and maintenance phase.

No VC-specific follow-up and monitoring plans are proposed for Surface Water and Groundwater Resources, Visual Environment, and Agriculture and Other Land Uses. A Social Monitoring Plan has been proposed as described in the ESMP (Appendix I).

The implementation of the design mitigation and environmental protection procedures identified in Section 3.7 are formalized through the ESMP, which is intended to be a “living” document that is revised as necessary to remain relevant to the applicable stage of Project planning, design, and execution. The ESMP includes a Construction Management Plan and an Emergency and Disaster Management Plan. Through these plans, RSB will manage and reduce the potential adverse environmental and social impacts of the Project and enhance benefits to the community and Barbados as a whole. RSB is committed to developing and operating this Project in keeping with best practices and in a manner that is protective of the environment and public health and safety.

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13.2 PERSONAL COMMUNICATIONS

Carrington, Sean – Retired professor specialized in plant Biology at UWI Cave Hill Campus. Personal Communication, October 2021. Contact: sean.carrington@cavehill.uwi.edu

Grant, Ron – Senior Planning Assistant, Government of Barbados (Planning and Development Department). Personal Communication, January 20, 2022.